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ROSE AND CARLESS

MANUAL OF SURGERY



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ROSE & CARLESS

MANUAL OF

SURGERY

For Students and Practitioners

BY

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SEVENTEENTH EDITION

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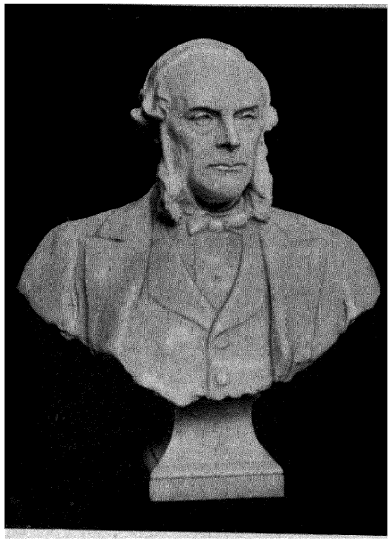
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The bust of Lord Lister now in the Royal College of Surgeons of England. It was made posthumously and is the work of Sir Thomas Brock. The photograph is taken from a copy in the National Portrait Gallery.

TO

LORD LISTER, LL.D., F.R.S.

President of the Royal Society,

THE FATHER OF ANTISEPTIC SURGERY,

THIS WORK IS, WITH PERMISSION,

Dedicated by the Authors,

IN GRATEFUL ACKNOWLEDGMENT OF THE MANY ADVANTAGES

THEY HAVE DERIVED

WHILST ASSOCIATED WITH HIM IN HIS WORK

AT KING'S COLLEGE HOSPITAL.

This dedication is a facsimile of the original dedication which appeared in the first Edition in 1898

PREFACE TO THE SEVENTEENTH EDITION

THIS seventeenth edition is the second edition to be published during the present war, and practically forty-five years have elapsed since the first edition made its appearance So the book is well on its way towards its half-century

The book has been revised, but not as thoroughly as we should have liked, for war-time activities, the difficulty of printing and the shortage of paper have all contributed to the difficult task of thorough revision Nevertheless, whole sections have been re-written and extended in this edition, including blood transfusion, war burns, blast, compression syndrome, and war surgery

Numerous new illustrations have been added, and these all come from the able pen and brush of Mr A K Maxwell

The war is now well into its fourth year, and new methods which have stood the test of time and experience have been incorporated in this edition

To members of the medical branches of the fighting forces, the Emergency Medical Service, and to those who are about to join one of these branches, either at home or abroad, this book covers all their many and varied requirements, and to them it should continue to be a standard reference book, as also it has been to many generations of general practitioners in every part of the British Empire and in the United States

Diagnosis, treatment and post-operative arrangements are each clearly described, prognosis is also indicated in most cases Where treatment other than operative treatment is available it, too, is given and, where necessary, alternative methods are described

The preparation of the patient for operation is included, and guidance with regard to the use of anæsthetics is given in such cases as require specific information, in addition to the general instruction to be found in the chapter on Anæsthetics

Surgeon-Commander G P McCullagh has given me great help in the preparation of this edition, and I wish to tender him my very grateful thanks I also wish to thank all those surgeons both at home and abroad who have given me useful advice and criticism on many and varied surgical subjects This advice has been most valuable, and is very much appreciated

And, finally, my thanks are due to the publishers for their real interest in the book and for all the care and attention they have given to it in its passage through the press at a time which must have been the most troublesome in history

CECIL P G WAKELEY

14, Devonshire Street,
Portland Place,
London, W 1
January, 1943

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A MANUAL OF SURGERY

CHAPTER I

INFECTION—IMMUNITY AND SUSCEPTIBILITY.

A KNOWLEDGE of bacteria and of the infective processes which are associated with their activities is of primary importance to the surgeon Many surgical diseases are due, in the first place, to the action of bacteria, while many others follow their entrance into the body through wounds Hence the necessity for a familiar acquaintance with the distribution and mode of life of the more important species of bacteria and the mechanism by which they give rise to morbid processes in the human body A practical ability to apply this knowledge in the matter of diagnosis and treatment is essential, but for this purpose a detailed study of Pathological Bacteriology is not necessary here, and we shall therefore confine ourselves to the more general considerations of the subject in so far as they are referable to surgical practice

Bacteria, their Morphology and Physiology.—Bacteria are the most widely distributed of all living organisms They are minute structures, measuring, usually, less than 1 μ, and possessing a definite form which consists of a tiny particle of cytoplasm surrounded by a cell wall They vary in shape and size, and in this respect are commonly grouped under three main headings (1) **the Coccus,** having a globular form, (2) **the Bacillus,** in the shape of a short rod, (3) **the Spirochæte,** possessing a true spirality or series of undulations

The Coccus—There are many varieties of cocci, but the more important members of this group consist of the following

(1) **The Diplococcus,** or cocci arranged in pairs, *e g* the pneumococcus or gonococcus

(2) **The Staphylococcus,** or cocci occurring in bunches This organism is the common causal agent to be found in localized suppuration

(3) **The Streptococcus,** or cocci growing in the form of a chain Of this variety there are two main sub-groups—namely, **Hæmolytic** and **Non-hæmolytic** organisms, depending on whether they do, or do not, possess the ability to hæmolyze the red blood corpuscles The former is of great surgical importance and is commonly found in most types of spreading inflammation with or without suppuration

The Bacilli.—These are short, straight, rod-shaped organisms with rounded or square ends They may be motile or non-motile and may

possess flagellæ Many surgical diseases are associated with their activities and will be referred to in their respective places Occasionally the rod is curved, in which case it is termed a 'spirillum' or 'vibrio' There is only one type of vibrio which is of surgical importance, and that is the *vibrio choleræ*, the organism which is the cause of Asiatic cholera

The Spirochætes.—These are less numerous than the bacilli From the surgical standpoint there are two only of importance—namely, the *Spirochæta pallida*, or organism of **Syphilis**, and the *Spirochæta pertenue*, the organism of Yaws

Conditions of Bacterial Life—Bacteria respond to environmental conditions in the same way as other living organisms and may, therefore, be subject to a variety of influences In circumstances adverse to their growth or welfare, many species, usually bacilli, undergo what is termed **spore-formation.** This process consists of the development of a minute highly refractile body in the protoplasm of the bacterium to which the vital characteristics of the organism are transferred In favourable circumstances it will reassume its original form Spores possess the notable feature of possessing a great resistance to damaging external influences, such as extremes of heat and cold or prolonged immersion in solutions of antiseptic and are, therefore, liable to constitute a source of infection if great care is not taken in the course of sterilization

There are three main environmental factors which are concerned in the development of bacteria—namely, temperature, oxygen and food requirements With reference to temperature it may be said briefly that bacteria grow best at or about body heat (37° C), but will also thrive within the limits of 15° C and 42° C Beyond these degrees growth is uncommon, but these temperatures will not destroy spores, which, in some cases, are capable of surviving boiling for several hours, although they are effectively killed by steam at high pressure in an autoclave within twenty minutes Hence it is fortunate that very few spore-forming bacilli are pathogenic to man, the main exceptions being the organisms which produce tetanus, anthrax and gas-gangrene It may be stated here that light is also injurious to bacteria, this is especially the case with the tubercle bacillus, which succumbs after a short exposure to direct sunlight Hence the importance of well-lighted rooms in the treatment of sickness

Taking next the question of oxygen requirements, it may be stated that many pathogenic organisms require **free oxygen** for their development, and are then spoken of as being **aerobes** In other cases a few, such as the tetanus bacillus, will grow only in the complete absence of oxygen, ceasing to develop, though remaining alive, when that gas is admitted, such organisms are called anaerobes and derive their oxygen from those compounds in the surrounding medium which contain it

Bacteria which grow best in air, but which will also grow in its absence, are called facultative anaerobes, and those which grow best under anaerobic conditions, but are capable of some growth in presence of oxygen, are called facultative aerobes In the living body both strict aerobes and strict anaerobes are capable of growth. Moreover,

a strict anaerobe may grow in a fluid freely exposed to air in the presence of other organisms which have a great affinity for oxygen and rapidly absorb it In this way tetanus bacilli may flourish even in superficial wounds, if such other bacteria are present

With regard to food, bacteria make use of organic nitrogenous compounds for their development, obtaining these from the decay or decomposition products of animal and plant life or from their excretions It has been customary to class bacteria as being either **parasitic,** *i e* thriving on live tissues, or **saprophytic,** meaning those which will develop on dead material The distinction is really artificial, as the majority of parasitic bacteria can be cultured in a test-tube, and, on the other hand, organisms which are commonly saprophytic may sometimes produce pathological alterations *in vivo* In addition to food requirements, all bacteria need a certain percentage of moisture for their growth Both absolute dryness and pure water (on account of osmotic difficulties) will cause bacteria to die in a few hours or days, although some, *e g* the tubercle bacillus, are very resistent to dryness, and anthrax spores have been known to germinate after exposure for a period of ten years

Mode of Action of Bacteria —When pathogenic organisms are introduced into the tissues and establish themselves therein, two pathological processes are set in motion—namely, one consisting of local alteration at the site of inoculation which is termed the **local infective process,** or **infection,** and the other consisting of general systemic effects, or **intoxication** Both these processes result from the presence of toxins which are evolved by the bacteria, but there are also two other factors which play a part in the production of general ill-effects One of these is the formation of toxic products from the tissues as a result of bacterial activity which become absorbed into the blood-stream The other factor is occasioned by the passage of the micro-organisms themselves into the circulation, giving rise to the condition known as **septicæmia**

Toxins are divided into two distinct classes (*a*) Certain organisms, of which the most important are the bacilli of tetanus and diphtheria, produce soluble **exotoxins** which accumulate in the fluid in which they are grown, and not in the bacterial cells (*b*) In the case of many other organisms, the specific poison appears to be contained within the bodies of the bacteria, they are known as **endotoxins** For example, the soluble products secreted by the tubercle bacillus have but little toxic action, whereas the bodies of the bacilli themselves are extremely poisonous

The pathological effects of these toxins are highly diverse, but in nearly all cases they include the production of fever Some are selective in their action, affecting only a certain class of cell, *e g* the cells of the central nervous system in the case of tetanus Others, such as those of the pyogenic bacteria, affect any tissues they may happen to reach Under natural conditions the results vary with the amount of toxin present in the body, and with the susceptibility of the animal and of the tissues in question Thus a very powerful toxin may immediately destroy the vitality of a part *en masse,* whilst one

that is somewhat less intense in its action may kill the tissues after causing an acute inflammation In another group of cases the inflammation may produce the slower but progressive death of the tissues, followed by suppuration or by fibrosis A similar but usually slower process leads to necrotic caseation, or, if a very feeble toxin acts for prolonged periods, it may serve as a stimulant to the growth and proliferation of the fibrous tissues, etc , without the development of any external signs of inflammation Certain organisms, especially some of the streptococci, possess also the power of breaking up the red blood-corpuscles (hæmolysis), and as a general rule the hæmolytic variety of bacteria are more dangerous than the non-hæmolyzing type It follows, therefore, that the local infected process will be well developed when the infection is caused by organisms which are characterized by the formation of intra-bacterial poisons, or endotoxins, with a tendency to remain localized, thus a boil (which is a localized staphylococcal abscess) may be associated with few or no general symptoms On the other hand, an infection with a virulent streptococcus may give rise to a fatal septicæmia in a few days without producing any marked local change In other cases the organism, *e g* tetanus, is of the type that does not produce much local reaction, as it gives rise mostly to soluble exotoxins which are absorbed by the blood-stream But in general it may be said that the two processes of local tissue alteration and generalized ill-effects are much more evenly balanced, although one feature usually predominates more than the other

The question of **virulence** is one of the greatest importance, since differing strains of the same organism may vary much in the degree of virulence, as may also the same strain under varying conditions Thus rabbits are often but little affected by the injection of large amounts of a pure culture of some particular strain of *Streptococcus pyogenes*, and yet it is possible so to exalt the virulence of this strain that an extremely small dose may produce death This exaltation of virulence is usually accomplished by ' passage ' through a series of susceptible animals, the disease appears more rapidly and runs its course more acutely in each successive animal, up to a certain point of maximum intensity, which may then persist Probably something of the sort occurs under natural conditions, for an organism taken directly from a patient is usually much more virulent than one that has been cultivated in the laboratory Thus even a slight accidental wound incurred by the surgeon or pathologist during an operation or post-mortem upon a case of, say, streptococcal peritonitis may lead to a very rapid and severe infection, indicating a very high degree of virulence in the organism

Cultures of an organism of diminished virulence are said to be ' attenuated ' The artificial attenuation of pathogenic bacteria is a subject of great importance in connection with the production of immunity, and it may be laid down as a general rule that the cultivation of an organism under slightly disadvantageous conditions tends to diminish its virulence, and *vice versa* For example, much work has recently been carried out in connection with the production of

diminished virulence of tubercle bacilli (see p 175) The anthrax bacillus grows best at 37° C , and retains its virulence for long periods at this temperature, but if it is cultivated for several weeks at 42° to 43° C it becomes attenuated Cultures thus treated constituted Pasteur's vaccine against anthrax, when injected into animals it caused transient ill-effects, but the animal became immune to the disease The gonococcus is another organism the vitality of which is much influenced by heat Growing best at a temperature of about 36° C , and capable of growth between 25° and 38° C , cultures are injuriously affected by a temperature of 40° or 40 5° C , and inasmuch as the normal tissues are not seriously harmed by such a degree of heat, it is possible to employ diathermy with the object of raising the local temperature of parts such as the prostate, cervix uteri, or deep urethra, as well as of joints, when infected with these organisms, and thereby attenuating their activities, and enabling the tissues to deal effectively with them Similarly, growth in a resistant animal also tends to produce attenuation of the causal organisms of certain diseases

The organism must be **pathogenic** if infection is to occur, and by this we mean capable of producing disease in the animal in question Thus, the inoculation of the gonococcus into the urethra of the lower animals leads to no results, and infection does not take place Hence two factors must be present the organism must be virulent and the host susceptible

Lastly, an essential feature of infection is that the toxins of the organism must act on the tissues of the host Thus, it is quite possible, and not uncommon, for streptococci to be present in the outer layers of the skin, and the diphtheria bacillus in the mouth, etc , and yet for no harmful effects to arise, since either the organisms do not form toxins, or else these toxins do not affect the tissues This is not technically ' infection,' although in such cases any slight lesion or any condition leading to local or general lowering of resistance may bring it about

The terms **specific** and **non-specific** as applied to infective diseases also require explanation A specific disease is defined as one which is always produced by a particular species of micro-organism, and by no other Thus, tetanus is a well-marked pathological entity, always due to *Clostridium tetani* (bacillus tetani), and may be taken as the type of a specific infection Suppuration, on the other hand, is caused by many different species of bacteria, and is therefore termed non-specific The boundaries of these divisions are constantly changing with the advance of pathological research, and certain diseases which were previously regarded as homogeneous may thus come to be split up into specific groups, each due to its own organism

Immunity and Susceptibility.

In ordinary circumstances all living animals are constantly exposed to possible sources of infection The ability to withstand these attacks depends upon the degree of resistance to infection which is possessed by the individual This quality of resistance is termed ' immunity,'

and is of two kinds, depending on whether it is possessed naturally, in which case it is called 'natural immunity,' or whether it has been acquired Man possesses the natural immunity to many diseases, in particular those which affect animals, but there is no absolute standard of immunity, since the reaction of the tissues may vary between the highest degree of susceptibility and the highest degree of immunity Thus, if several animals are inoculated with equal doses of the same bacterial culture, one may show no ill-effects, another may exhibit a slight amount of inflammation at the site of inoculation, a third may acquire a [illegible] inflammation, which may progress to suppuration or gangrene, whilst a fourth may develop a fatal general infection Further, an animal may be immune to an organism of ordinary virulence, although susceptible to the same organism when its virulence is exalted

Immunity is influenced by a variety of factors, which, in brief, may be said to comprise anything which tends to lower the vitality of the individual in general or of the tissues locally Of general causes may be mentioned such factors as exposure to wet and cold, malnutrition, chronic alcoholism and certain constitutional diseases, such as diabetes and Bright's disease Local causes would comprise all conditions capable of producing local damage to the tissues, such as burns or bruises, and all forms of irritants including foreign bodies and strong antiseptics In addition one may add that a defective supply of fresh blood, whether due to disease of the bloodvessels or to venous stagnation, due to tight bandaging or pressure, will also appear less resistant to infection

Acquired Immunity is of two kinds—active and passive

Active immunity results from a previous attack of the disease, from a subinfection or repeated subinfections with a dose of organisms too few in numbers or too low in virulence to cause any appreciable disease, or, thirdly, from artificial inoculation The exanthemata are good illustrations of diseases conferring an active immunity The permanence of the resulting immunity varies greatly With some infections, such as small-pox, second attacks of the disease are very rare, and the immunity is, as a rule, complete and lifelong With other infections, such as those due to pneumococci or streptococci, the immunity tends to be of short duration All intermediate grades are found

The following are the most important artificial methods of producing active immunity (1) Inoculation of the disease as it occurs in Nature This is of course a dangerous method, since the attack may be as severe as one acquired in the normal way Before the introduction of vaccination it was formerly practised in the hope of preventing a more severe attack of small-pox (2) Inoculation with the causal micro-organism in an attenuated condition Pasteur applied this method in the prevention of anthrax in sheep and cattle, the 'vaccines' employed being living cultures of *B anthracis* attenuated by growth at 42° to 43° C (p 5) He also employed an attenuated virus for the prevention and treatment of hydrophobia (p 129) In the case of vaccination against small-pox, the lymph employed con-

brief, it may be stated that a contest which may be very prolonged is waged between the bacteria and the defensive forces, and may result in much damage to the tissues Thus it follows that the body must also possess the power of repairing the damage caused or at least of patching up the injured parts, a process which will be referred to again in connection with the pathology of inflammation The practical applications of the phenomena of immunity are twofold diagnostic and therapeutic

The chief examples of their **diagnostic application** are (*a*) the agglutination reaction in the diagnosis of typhoid, paratyphoid, the undulant (Mediterranean or Malta and abortus, etc) and other fevers, bacillary dysentery, etc , (*b*) the complement-fixation test in syphilis (the Wassermann reaction), tuberculosis, gonorrhœa, and a few other diseases, and (*c*) the use of toxins in the diagnosis of particular diseases, such as tuberculosis, diphtheria, and scarlet fever Introduction into a patient suffering from a particular disease of some of the toxin of the specific organism which causes that disease often gives rise to local inflammation or general disturbance Thus in a tuberculous subject hypodermic injection of a small quantity of 'old tuberculin' (the concentrated filtrate of a broth culture of the tubercle bacillus) may cause a sharp rise of temperature, and sometimes headache, shivering, and pains in the limbs The same preparation scratched into the skin gives rise to local inflammatory reaction (von Pirquet's test, p 171), or, if dropped into the eye, causes severe conjunctivitis (Calmette's test) A similar reaction is induced in those who are susceptible to diphtheria infection by introducing into the skin a small quantity of diphtheria toxin (the Schick test), and also in those susceptible to scarlet fever by the intradermal injection of the toxin of the streptococcus scarlatinæ, this is termed the Dick test

The **therapeutic applications** consist of the prophylactic immunization and the curative treatment of disease, and fall under three main headings

1 **Vaccines** consist of emulsions of dead bacteria* which are injected —usually subcutaneously, sometimes intramuscularly or intravenously —with a view to influencing beneficially infections in other parts of the body due to a similar organism Such injections stimulate the defensive powers of the tissues, not merely locally, but generally, the antibodies so produced being thus available in increased amount to antagonize or neutralize the organisms and their products at the site of the disease It usually happens, however, that the reaction of a living tissue is greater than the stimulus demands, and thus, just in the same way as a fracture frequently leads to a formation of callus greater than is necessary for ultimate repair, so a vaccine results in a development of antibodies greater in amount than is required locally, and the superabundance thus created is available to combat infections in other parts of the body

The doses of vaccines vary greatly with different organisms, a

* Vaccinia, or cow-pox vaccine, from which the generic term 'vaccine' was originally derived, contains the *living* micro-organism—a filter-passer—of that disease

normal dose of staphylococci would consist of 500 million or more, but a much smaller dose would have to be employed with other organisms in order to avoid severe local and general symptoms As a rule the patient acquires some degree of tolerance, and the dose may easily be increased gradually or more rapidly as the treatment progresses It is always advisable, where practicable, to prepare the vaccine for each patient from the organisms which are attacking him **(autogenous vaccine)**, since there are often considerable differences between the various strains of bacteria, and a stock vaccine may not prove efficacious against an infection with apparently the same species

Of recent years evidence has accumulated to show that, in addition to their action in stimulating the production of specific antibodies, vaccines may also have non-specific effects Wright and his co-workers and others have shown that, following the subcutaneous or intravenous inoculation of a suitable dose of vaccine, marked increase in the bactericidal power of the blood is produced, which reaches a maximum within about four hours This bactericidal action is non-specific, an injection of killed staphylococci increases the bactericidal power of the blood against all organisms indiscriminately This rapid production of bactericidal substances, which have been demonstrated in the laboratory, furnishes us with an explanation of the immediate improvement sometimes seen in febrile conditions after inoculation of a small dose of a vaccine—an improvement which occurs too soon to be due to specific immune bodies This phenomenon is also utilized in **immuno-transfusion** A healthy donor of an appropriate blood-group is inoculated with a large dose of a vaccine, which may be of any organism, but usually staphylococci (say 1,000 million) are employed Five hours later, when the bactericidal substances are at a maximum, the donor is bled, and 500 to 700 c c of his defibrinated blood are injected intravenously into an acutely ill patient whose response to his infection is failing The addition of the healthy leucocytes and blood rich in bactericidal substances may enable him to cope with the infection A non-specific effect of a vaccine—probably of the nature of protein shock—is also utilized in treatment of some more chronic conditions, such as rheumatoid arthritis, asthma, disseminated sclerosis, etc Here a large dose of vaccine sufficient to cause a sharp febrile reaction is administered With the pyrexia is associated a considerable polymorphonuclear leucocytosis, and the beneficial effect seems to be proportional to the severity of the reaction produced

2 **Antitoxic Sera*** are prepared against the toxins of tetanus, diphtheria, gas-gangrene (*Clostridium welchii*), and some varieties of bacillary dysentery, and also for the treatment of botulism These, as has already been explained, contain substances which neutralize the extracellular toxins of the organisms in question It is essential that antitoxic sera in sufficient amount should be administered as early as possible, in order that they may render the toxins inert before

* Various modifications and improvements in the preparation of antitoxic and antibacterial sera have now been introduced, *e g* refined and concentrated high-potency forms, separated antitoxin-globulins, etc , for the technical details of which reference should be made to the special literature on the subject

the latter have combined with and injured the living cells Time may be saved by intravenous injection, since it has been found that diphtheria antitoxin is not fully absorbed from the subcutaneous tissues for twenty-four hours or more Antitoxin is most rapid in its action when introduced directly into the circulation, and the intravenous route should therefore be used in the more urgent cases Absorption after intramuscular is more rapid than after subcutaneous injection, and these routes may be used for subsequent treatment, the effects, although slower, being more lasting

3 **Antibacterial Sera** contain antibodies which act, not upon the toxins, but upon the organisms themselves, by (1) bactericidal or bacteriolytic action, (2) opsonic action, and (3) agglutination Of these sera, the most important in surgical practice are

(*a*) *Anti-streptococcal Serum* —A polyvalent serum prepared by employing a variety of strains of hæmolytic streptococci (*Str pyogenes* and its allies) is commonly utilized A specific antiserum is now also prepared against the streptococcus of scarlet fever, for prophylactic and therapeutic, as well as diagnostic, use, and sera are also made against special strains of streptococci, *e g* those isolated from cases of puerperal septicæmia, or of erysipelas

The dose of serum may be 25 to 50 or 100 c c , administered intravenously, intramuscularly, or subcutaneously, according to the urgency of the case, and this may be repeated as often as necessary

(*b*) *Anti-anthrax Serum* —This has given excellent results in the treatment of localized anthrax (malignant pustule), and the improvement is often manifested within twenty-four hours It should be given intravenously in large doses

(*c*) *Anti-pneumococcal Serum* —Much work has been recently carried out on the typing of pneumococci and the preparation of sera specific against these types Felton's refined and concentrated serum is, so far, the most satisfactory product, both Type I and Type II pneumococcal infections, especially the former, being amenable to treatment with it The treatment of Type III infections with serum has not yet been successful, and further work is required upon antisera for these and also infections due to the heterogeneous Type IV group, which has now been subdivided into a large number of further types

(*d*) *Anti-dysentery Serum* —The action of this serum is probably partly antitoxic and partly antibacterial It is usually prepared in polyvalent form, and may be used for the treatment of ulcerative colitis due to dysentery bacilli

(*e*) *Anti-meningococcal serum* is given intrathecally and intravenously for the treatment of cerebro-spinal meningitis due to meningococci

(*f*) An *anti-staphylococcal serum* is under trial, as are also numerous other sera

Anaphylaxis and the closely allied phenomenon known as **allergy** are conditions of supersensitiveness to various foreign proteins, such as the serum of another animal, egg-albumen, grass-pollen, etc Supersensitiveness manifesting on the administration of a subsequent dose of an antiserum is usually the result of an injection ten or twelve days or more previously of serum from the same species of animal

(commonly the horse), and depends on the ordinary serum proteins, not on the antibody content If a minute quantity (0 01, 0 001, or even, in some cases, only 0 000001 c c) of horse serum be injected into a guinea-pig, the animal will become sensitized to horse serum If, after an interval of usually not less than twelve to fourteen days, a second dose of 5 c c (non-toxic to a normal guinea-pig) be then injected intraperitoneally, or one-tenth of that dose intravenously (subcutaneous injection being more uncertain in its results), the condition of acute anaphylactic shock rapidly supervenes with collapse, dyspnœa, and frequently death The symptoms appear to be due to a toxic effect on smooth muscle Man is much less susceptible than the guinea-pig, but anaphylaxis may occur as the result of an injection ten days to six months or more before, or rarely in horse-asthma patients with no history of previous injection Acute anaphylactic shock in man causes extreme distress, with dyspnœa, cyanosis, and collapse, death may ensue, but the number of fatal cases on record is very small If there is any reason to suspect supersensitiveness, the patient should be tested beforehand by injecting intradermically, not hypodermically, a small amount, *e g* 0 1 c c , of the serum If no urticarial or erythematous reaction occurs round the site of injection within forty minutes, the administration may be proceeded with, but, should a positive reaction, which usually occurs in from five minutes to half an hour, be obtained, desensitization must first be effected If there is no urgency, 0 025 c c of serum, suitably diluted with saline, should be administered hypodermically, and the dose should be doubled every half-hour If no reaction follows when the amount of 1 c c is reached, the following doses are given intravenously, beginning with 0 1 c c , and doubling the dose every half-hour until the total amount of, say, 25 c c has been given In urgent cases, *e g* in tetanus, a more rapid method must be adopted, even though it entail some risk A War Office Committee recommended the following method 5 c c of the serum are diluted with 50 c c of normal salt solution Of this mixture, 1 c c is injected intravenously, followed four minutes later by 3 c c , two minutes later by 10 c c , and two minutes later again by 25 c c Then in ten or fifteen minutes the full dose may be given intravenously or intrathecally All such injections must be given very cautiously and slowly If any reaction occurs during this procedure, the administration must be delayed In cases where anaphylactic shock has developed, atropine sulphate ($\frac{1}{60}$ grain) or a 1 in 1,000 solution of adrenalin (0 3 to 0 5 c c or 5 to 8 minims) should be given intravenously in 10 c c of sterile normal saline

Serum Disease, apart from the more serious phenomena described above under Acute Anaphylaxis, is another condition which may follow the administration of a foreign serum, and is probably an analogous phenomenon Its frequency and intensity are in direct relation to the volume of serum given The first symptom is usually an urticarial or erythematous rash, which appears between the seventh and tenth day, at the site of injection, and may become generalized This may be accompanied by malaise, slight fever, adenitis, pains in

the joints perhaps with effusion, and albuminuria The condition causes considerable discomfort, but is never serious, and recovery occurs within a few days It is stated that intravenous injection of 1 to 2 c c of the patient's own serum causes rapid disappearance of the symptoms, but this is not reliable Calcium lactate in 15-grain doses at the time of the injection and for a day or two subsequently may be given as a prophylactic measure, but is not of great value Otherwise the treatment is purely symptomatic An **immediate** reaction may occasionally supervene after a **second** injection, almost at once or within six hours, or an **accelerated** reaction may occur between the eighteenth hour and the fifth day, with the appearance of rash, joint-pains, vomiting, pyrexia, and even convulsions and collapse

Allergy, which is a condition probably closely allied to anaphylaxis, is the supersensitiveness, exhibited by some patients suffering from certain diseases, to the products of the corresponding organism, *e g* tuberculin or mallein in tuberculosis and glanders respectively This state is probably gradually produced by the bacterial products set free within the body of the patient, and, in a similar way, hay-fever, and hypersensitiveness to various food-proteins both animal and vegetable, hairs, feathers, and other epidermal structures or débris of animals, etc , are probably due to previous sensitization by the absorption of grass-pollen, etc , or the other foreign proteins involved In certain cases, the condition of supersensitiveness appears to be natural, rather than acquired It may be hereditary, and run in families, and it may take different forms in the different members of such families

CHAPTER II

INFLAMMATION AND REPAIR.

THESE two series of processes are so intimately associated with each other that no advantage is gained by endeavouring to describe them separately In this series of processes sometimes one set, sometimes the other, may predominate, but in most cases a more or less definite sequence of events may be observed

'Inflammation is the succession of changes which occur in a living tissue when it is injured, providing the injury is not of such a degree as at once to destroy its structure and vitality' Such was the definition given in 1870 by Burdon Sanderson, and it is sufficiently accurate if it be remembered that the term 'injury' includes bacterial invasion, and that the 'succession of changes' is presumed to appear soon after the application of the injury If such injury has not completely destroyed the vitality of the tissues or killed them outright, changes occur in and around the injured area, by which Nature endeavours to limit and localize the effects of the irritant, to antagonize, eliminate, or enclose it if still present, and to make good the damage, either by restoring the tissues to normal or patching them up as far as possible—casting off the debris if at a surface absorbing and removing it if within the body, or, if this cannot be completely accomplished, transforming it to, or enclosing it by, fibrous tissue within the living tissues In the past, a great variety of opinions existed as to the position of the dividing line between inflammatory and reparative processes Occasionally the tissue reaction called into existence by bacterial invasion is so severe as to increase, rather than diminish, the risks of the patient

The **causes** of inflammation are numerous and varied, and most frequently are infective in nature We have already alluded (pp 6-8) to the conditions, local and general, which predispose an individual to such invasion, and render him more liable to an inflammatory attack Apart from bacteria, inflammation may be set up by (*a*) mechanical lesions, such as blows, sprains, tension, pressure, etc , (*b*) burns or scalds, (*c*) toxic substances, such as acids, alkalies, irritating vapours or gases, or vegetable and animal poisons, (*d*) the action of the electric current, and (*e*) the irritating influence of X-rays, radium emanation, sunlight, ultra-violet rays, etc , and (*f*) new growth

The actual **phenomena** of inflammation may be studied in the web of a frog's foot If this is spread out and examined under the microscope, the following evidences of normal physiological activity may be seen (*a*) the flow of blood through the vessels (Fig 11), as indicated by the movement of the formed blood-elements—the red

it probably assists the emigration of the leucocytes, which might otherwise find difficulty in attaching themselves to the walls when floating freely in a rapid blood-stream The extravascular rôle of the leucocytes has already been considered

II **Tissue-Changes.**—The reaction of the tissues in **acute bacterial** inflammations depends on the one hand upon the irritative power and nature of the toxins, and, on the other, upon the power of resistance of the patient's tissues It may be laid down as a general rule that any irritant, if weak enough, *e g* when very diluted, acts as a stimulant to the function and growth of cells, on the other hand, if more powerful, it will cause changes varying from slight degeneration up to complete necrosis or death of the tissues

If the toxins are sufficiently active, death of the tissue may result This is often brought about by the process termed **coagulation necrosis.** In this condition the tissues and cells become soaked in the coagulable plasma which exudes from the vessels, and the activity of the toxins causes coagulation and death of the whole mass The result is that, on microscopical examination, structural details are found to be obliterated in the area involved, the nuclei can no longer be stained with hæmatoxylin or other basic dyes, and the tissues now stain uniformly with acid dyes such as eosin The further history of the lesion depends largely on the nature of the causal organisms If these are pyogenic, the necrotic mass becomes infiltrated with **polymorphonuclear leucocytes,** many of which may be killed by the toxins, *i e* **suppuration** occurs, perhaps with softening and the formation of an abscess (see p 47)

Mononuclear cells of various sizes and types appear in inflammatory exudates, sometimes earlier, sometimes later, and for the full discussion of the nature and functions of these reference must be made to the larger textbooks of pathology It is sufficient to state here that the **large hyaline mononuclear cells** may be derived either from the blood or from tissue-endothelial cells They often appear comparatively early in the course of many inflammatory conditions, especially of serous surfaces, and, as the condition improves, they usually increase as the polymorphs diminish in numbers They are actively amœboid, and are concerned especially with the phagocytosis and removal of dead cells and débris, though they may also englobe bacteria Later still, '**small round cells,**' regarded by many as identical with lymphocytes, appear, and may gradually replace the larger mononuclears, from which some believe them to be partially derived, as all intermediate sizes may be found in the same exudate, *e g* in a recovering pleurisy or meningitis These 'small round cells,' and also the closely related 'plasma-cells,' are found especially in chronic inflammations, and particularly in tuberculous and syphilitic conditions

In any given case, the above-described processes overlap and are intermingled in varying degree, whilst the processes usually classed under 'repair' may also supervene, early or late as the irritant and its effects are overcome and neutralized

In the more **chronic** inflammations, active cell-proliferation is an

important element in the process, resulting in **fibrosis** and induration of the parts This affects mainly the interstitial tissues, and the specialized structure of an organ may thereby be impaired

III **Lymphatic System.**—It is important to realize the part played by the lymphatic system in the mechanism of inflammation In the first place it is chiefly by means of the lymph channels that the greater part of the inflammatory exudate is absorbed, and, secondly, the spread of the inflammatory process which occurs in these channels is, in a favourable case, checked by the barriers of lymphoid tissue in the lymphatic glands and subdued In some cases the lymphatic vessels are attacked during the process and their subcutaneous course becomes visible as a thin red line passing from the site of inflammation to the nearest lymphatic gland The glands themselves become swollen and tender, and, in certain cases, will break down into abscess formation In virulent infections it is possible for the organisms to pass through the lymphatic system without giving rise to much local disturbance, and, in such cases, the prognosis is very grave

IV **Chronic Inflammation.**—In the chronic type of inflammation, active cell proliferation is an important element, and constitutes the greatest difference between the acute and chronic inflammatory processes The cells which owe their origin to cell proliferation are derived mainly from the endothelial cells of the vessels, perivascular lymphatics and lymph-spaces, but, in addition to these, there are large numbers of other cells, as in acute inflammation, but they differ in that they are composed mostly of lymphocytes and plasma cells The former are commonly grouped round the smaller vessels, but are also found in small collections, particularly in the granulomata The plasma cells are more uniformly disposed through the tissues, and are a more certain indication of chronicity Vascular changes are much less pronounced, the hyperæmia being much less in degree, although longer in duration The exudate is more fluid in character, containing comparatively little albumen or fibrin, and in some chronic inflammations of serous membranes the cavities are distended with fluid of a much lower specific gravity than that of blood serum

V **The Course of Inflammation.**—This may be extremely variable, as it depends on several factors which are themselves variable The constitution of the individual, the type and violence of the infecting organism, the nature and site of the tissues involved, and the kind of treatment instituted, are all factors which play an important part in the development of the inflammatory process, but which vary in every individual case In brief, it may be stated that the fate of the inflammatory process may be determined in one of three ways, namely (*a*) **Regression or Healing.** (*b*) **Progression or Spread.** (*c*) **Chronicity.** It must, however, be recognized that these three processes are not always discrete, but that they often overlap and may all be present together in a lesion at the one time For instance, it is not an unusual event to see a wound which is healing rapidly at one end to be breaking down and discharging pus at the other But it is important for the student to be in a position to appreciate and to

understand what is happening and what might happen in any given wound, and, therefore, the following classification has been adopted as one which will enable him to accomplish this in a simple yet comprehensive manner

Regression or Healing may take place before or after local destruction of the tissues has occurred In the first place it is termed '**resolution**'—that is to say, restoration of the part to its natural condition and function without the formation of scar tissue Naturally enough, this can only take place when the inflammatory process has not proceeded very far, and the phenomena which are concerned in the process will be those of inflammation in a retrograde order—namely, an oscillatory movement, which is first manifested among the corpuscles, and is later followed by a restoration of the blood-stream The red corpuscles lose their property of adhering to the vessel walls, and many of the surviving leucocytes which are present in the exudate may make their way back into the circulation either through the vessel walls or to a greater extent via the lymphatics, others are disintegrated in the tissue and absorbed The fluid of the exudate is removed by the lymphatics

Healing after local destruction of tissue has occurred is termed '**repair,**' and takes place by the removal of dead tissue and its replacement by scar tissue

(*a*) The first stage in the process consists in an abundant *exudation of small round cells*, chiefly lymphocytes and plasma cells, whose function is to remove dead or damaged tissues, as well as to break up, disintegrate, and finally absorb, any blood-clot They are derived from the surrounding vessels, and are accompanied by a certain amount of plasma, so that the early manifestations of a slight inflammatory reaction are simulated, and this, if it does not exceed certain limits, is a beneficial proceeding If much tissue has to be absorbed, or when a foreign body such as a suture is buried, giant-cells are likely to make their appearance After their work is completed they disappear, either finding their way back into the circulation, or being destroyed by the fibroblasts

(*b*) The exudation of round cells is soon followed by the appearance of a number of large oval cells with abundant protoplasm and large vesicular nuclei, known as *fibroblasts* These cells are mainly derived from those composing the tissues of the part, either from the connective-tissue corpuscles or the endothelial cells lining the capillaries, lymphatics, or lymph-spaces Whatever their origin, they soon form a layer of cellular tissue which lies upon the surface or between the lips of the wound, whilst the previously effused leucocytes disappear

(*c*) The *vascularization* of this cellular layer forms the next stage in the process This is brought about by the outgrowth from the walls of the nearest capillaries of solid rods of protoplasm, which appear first as minute buds, but rapidly increase in length, and may be single or double They soon bend over to unite with similar threads growing out from other capillaries, or with the wall of another vessel, or occasionally they unite with the vessel from which they started After a time these protoplasmic threads become canalized and a communi-

cation is established between them and the mother vessel, so that blood passes into them The new capillary wall, at first homogeneous, soon becomes lined with definite endothelial cells, and strengthened by connective tissue derived from the fibroblasts around By this means a soft vascular tissue is produced known as *granulation tissue*, consisting of loops of capillaries supported by large nucleated cells with a varying amount of intercellular substance, which becomes fibrillated in texture The capillary loops arise in leashes from small terminal arterioles, and it is to this arrangement that the granular appearance of the developing tissue is due, each granulation, as it arises, is about the size of a pin's head

(*d*) The *transformation* of this granulation tissue into *fibro-cicatricial tissue* is next proceeded with The fibroblasts become spindle-shaped, and finally long and narrow, with pointed extremities, which often branch, the nuclei also become long and narrow, and lose their vesicular appearance Around them is developed a fibrillated structure of a collagenous material, which is finally transformed into the fibrous tissue of the scar, the actual arrangement of this material varies with the physical characters and condition of the wound By the contraction of these fibres the fibroblastic cells become flattened out and compressed, and the newly-formed vessels constricted, so that as time passes the scar tissue becomes less and less vascular, and consequently firmer and denser, as well as smaller

Progression or spread of the infection will involve a diffusion of the inflammatory process, which may be local or general, and a necrosis of tissues Thus the spread of the inflammation locally may be followed by (*a*) **suppuration,** in which the affected tissues and the exudates are liquefied and transformed into pus, with the formation of an **abscess** which will require evacuation, (*b*) **cellulitis,** a condition in which the inflammatory process spreads diffusely in the subcutaneous tissues with the formation of a sero-purulent exudate (such a condition will need free incision to allow of drainage), and (*c*) **lymphangitis and lymphadenitis,** in which the lymphatics become inflamed and the lymphatic glands become swollen and tender and very often break down into abscess formation Indications of general spread will be shown by the development of a **septicæmia,** in which the organisms travel in the blood-stream, and **pyæmia,** a condition in which metastatic abscesses develop in different parts of the body Local destruction of tissue will occur to a certain extent in all the above inflammatory lesions but, when pronounced, may result in **ulceration** when the affected tissues are superficially placed and circumscribed in extent, or in **gangrene** when the destructive process is a more extensive one

Finally, a state of **Chronicity** of the inflammatory process is the remaining alternative in which the inflammation may terminate, and is prone to develop in a lesion in which the defensive forces of the body have been capable of limiting the acuteness of the infection, but not of overcoming it

Certain names are applied to inflammatory lesions when they arise in certain tissues in the body Thus

A **Catarrhal Inflammation** is one affecting mucous membranes, which in the early stages become dry, vividly red, and the seat of burning or scalding pain, whilst in the later stages there is free secretion of mucus, muco-pus, or pus At first the secretion of mucin by the hyperæmic membrane wholly or partially ceases, and any extravascular exudate passes into its substance, causing it to become swollen Cloudy swelling and proliferation of the epithelium follows, with increased formation of mucus and partial or, in severe cases, extensive desquamation of the epithelial cells, these passing into the exudate as catarrhal cells As the membrane becomes more and more infiltrated with leucocytes, these are added to the discharge, which is thus transformed into muco-pus or even almost pure pus, and ulceration may supervene from the loss of superficial epithelium

A **Croupous or Plastic Inflammation** is one characterized by the formation of a firm false membrane, due to the coagulation of the plasma exuded from the vessels, and the deposit on the surface such as the pleura, peritoneum, or synovial membrane, gives rise to a layer of plastic lymph, which may be absorbed or organized into fibrous tissue with or without the formation of adhesions A fibrinous exudate is also seen in the alveoli of the lungs in lobar pneumonia On mucous surfaces a white, or yellowish-white, flaky mass may be formed—the so-called 'false membrane'—which can be detached, exposing a red and congested surface, with no loss of substance, unless superficial necrosis has also occurred in the mucous membrane itself

The term **Parenchymatous Inflammation** indicates that, in an inflamed organ or tissue, the process is limited mainly to the actual and active substance of that organ or tissue, whilst in **Interstitial Inflammation** it is confined chiefly to the supporting fibrous tissue

Clinical Signs of Inflammation.

(A) The **Local Phenomena** may be described under the four headings suggested by Celsus (about A D 50), *viz* 'calor, rubor, tumor, dolor' —heat, redness, swelling, and pain—with the addition of a fifth, *viz.* impairment of function

Heat —An inflamed part feels hot to the touch, and the temperature, if taken by a surface thermometer, is definitely raised above that of the surrounding skin This is due to the increased amount of blood flowing through it, for the temperature of an inflamed area is never higher than that of the blood at the centre of the circulation, *i e* in the heart

Redness is due to the hyperæmic condition of the inflamed part In the early active hyperæmia the colour is a bright red, fading quickly on pressure, and returning with equal rapidity During the period of retardation the redness is more dusky, since the blood is longer in passing through the capillaries, and so loses more of its oxygen, the colour does not disappear or return so rapidly, and a slight yellowish tinge often remains from the presence of extravasated hæmoglobin When stasis is reached, and especially if thrombosis has supervened,

pressure does not remove the red colour, and, should such a state persist for long, permanent pigmentation may remain

Swelling arises from the same two causes, *viz* hyperæmia of, and exudation into, the part Necessarily, the amount of such swelling depends upon the acuteness of the disturbance and the distensibility of the tissue

Pain results from the mechanical irritation of the peripheral nerve-terminals, both by the increased arterial tension and by the pressure of the exudate, so that it is much greater if, from the density of fascial or fibrous investments, swelling cannot readily occur, *e g* in the palm of the hand, or in the eye or testicle Where the inflammatory products escape into lax tissues, pain is a less prominent symptom, although the swelling may be great

A marked feature of inflammatory pain is that it is aggravated by pressure, whether intrinsic, *i e* by increasing the blood-pressure, as by hanging down an inflamed hand, or extrinsic, from outside agencies, such as mechanical or digital pressure, the pain then being known as tenderness

The pain of suppuration is throbbing in character, of an inflamed mucous membrane, scalding, burning, or gritty, of an inflamed serous membrane, stabbing, of inflamed bone, aching or boring, and often worse at night, of an inflamed testicle, sickening When the organs of special sense are inflamed, there may be little real pain, but much exaggeration of the special sense, *e g* flashes of light in retinitis and noises in the ears in otitis interna

The pain is not necessarily limited to the inflamed part, but is sometimes experienced in distant regions, either owing to participation in the same nerve supply or from the fact that a sensory stimulus is referred by a patient to the end of the affected nerve For example, in hip disease the chief pain is often felt in the knee, because both joints derive their nerve supply from the same source In spinal caries pain is frequently experienced in the terminal branches of the nerves issuing from the part affected, *e g* the ' girdle ' pain in disease of the dorsal vertebræ, and the so-called ' belly-ache ' when the dorsi-lumbar region is affected Occasionally a sympathetic pain is experienced on the opposite side of the body, especially when a bilateral organ such as the kidney is involved

Inflammation of intra-abdominal organs is often accompanied by pain due to tension of the muscular wall of a hollow viscus Such pain may be definitely local, but is also frequently associated with pain referred to various somatic nerves (viscero-sensory reflexes), and possibly with muscular effects (viscero-motor phenomena) It will suffice here to mention that a renal calculus will produce pain in the groin and front of the thigh (genito-crural area), and perhaps retraction of the testicle, gall-bladder lesions are often productive of pain in the right shoulder Other illustrations are noted elsewhere

Impairment or Loss of Function is contributed to by the presence of two or three factors In most instances inflammatory lesions are accompanied by pain which is accentuated by movement For this

reason the muscles which control movement in the affected part will develop a protective spasm in order to ensure immobility This reflex mechanism is best seen in connection with inflammation of joints, and accounts for the classical positions of the limbs which are seen in many disorders of the joints Sometimes loss of movement is due to the mechanical hindrance produced by the presence of an inflammatory exudate Thus an orbital cellulitis may produce complete immobility of the eyeball by pressure on the orbital muscles, although the latter may not be the seat of inflammation In other instances loss of function may be due to the paralyzing effect of the inflammatory process which in infective lesions may result from the direct influence of the toxins on the protoplasm of the cells affected The best examples of this are found in connection with inflammation of the glandular organs, *e g* the liver and kidneys, in which a hepatitis or nephritis is followed by marked impairment and sometimes complete cessation of function

In **Chronic Inflammation** the symptomatology is relatively subdued The hyperæmia is less, redness is not so pronounced, heat is not a noticeable feature, and pain is much less acute and is more often of a dull, aching character Swelling is a more variable feature, and may be slight in amount or very pronounced, and is always more condensed than in the acute variety Thus, in chronic inflammation of a bone, the cancellous tissue may be completely replaced by sclerosed condensation, which may almost completely occlude the marrow cavity and cause noticeable enlargement of the bone at the same time

(B) **Constitutional Symptoms** are constantly present in inflammatory conditions, and their severity varies greatly with the cause In non-bacterial cases there is usually some slight fever which does not last long, but, when bacteria are present, the absorption of toxins may cause general symptoms varying in degree from a mild febrile reaction to a grave toxæmia which causes death It is, however, remarkable how much disturbance a small collection of pus under tension may sometimes produce

It is only necessary here to deal briefly with the subject of **Fever** or **Pyrexia** The general characteristics of the febrile state consist in an elevation of temperature, accompanied by a corresponding acceleration of the rate of the heart-beat and of the respirations If it continues, the patient loses weight and muscular power The mouth is dry and the tongue furred, and in the later stages the lips and teeth are usually covered with sordes (accumulations consisting of inspissated mucus and food debris in which bacteria grow and flourish as in a culture-medium) The appetite is impaired, digestion is imperfect, and the bowels constipated, the motions are often very offensive The urine is scanty and high-coloured, albumen may be present, and, owing to the excessive tissue metabolism, an unusual amount of urea and urates The skin is often dry

The intensity and character of the fever vary with the preceding condition of the patient, and with the nature and duration of the disease In young healthy adults the fever associated with an acute inflammation is usually of an active type, the rise of temperature and

its accompanying phenomena, including, perhaps, a noisy delirium, being well marked (sthenic inflammatory fever) In debilitated subjects, as also towards the close of a long period of pyrexia, *e g* in the third week of typhoid fever, and in grave infections, such as erysipelas and septicæmia, exhaustion and collapse manifest themselves (asthenic fever, or the typhoid state) The pyrexia is not necessarily high, and the patient is often only partially conscious, with low muttering delirium, picking at the bedclothes, and passing his excreta in bed

Treatment of Acute Inflammation.

We shall here deal only with the general principles which may be considered from local and constitutional standpoints

I **The Local Treatment of Acute Inflammation.**

(*a*) **Remove the exciting cause,** if evident and tangible This may be an embedded foreign body, such as a buried stitch at the bottom of the sinus, or a piece of shrapnel In other cases it may be possible totally to excise a local focus, *e g* the track of infected gunshot wound In some cases the cause is not evident

(*b*) **Keep the inflamed part at rest** as far as possible, not only for physical and physiological reasons, but also to prevent mechanical dissemination of the infective agent This may be effected by confining the patient to bed, or by the use of splints or slings, but special consideration must, at the same time, be given to the possible functional effect which prolonged immobility may have upon a part

(*c*) **Reduce the local congestion** and promote the removal of the inflammatory exudate which is hampering the efforts of the tissues to regain the mastery over the bacteria The congestion may be relieved by **elevation** of an inflamed limb, a movement which will aid the emptying of the veins by the help of gravity and also lead to a reflex contraction of the arterioles The elevation, however, must not be overdone or serious interference with the vitality of the limb may follow A happy medium must be chosen between the two possible effects, and thus one usually endeavours to assist the venous return without interfering with the arterial supply **Local blood-letting** by punctures, scarification, and wet and dry cupping is useful in suitable cases and sometimes gives immediate relief from pain

Cold wisely utilized is of greatest service in reducing hyperæmia by causing contraction of the arterioles It should be used only in the early stages, as it depresses the vitality of the part, and, if much congestion is present, may do more harm than good Again, in the case of elderly patients caution is required, as with its injudicious use they may be liable to the occurrence of necrosis of the skin Cold may be applied by means of an ice-bag, or by irrigation from a vessel containing iced water or lotion, from which strips of lint descend to envelop the inflamed area, or a piece of lint wrung out of evaporating lotion may be placed directly on the part, or, better still, the iced water may be run through a coil of leaden pipes (known as Leiter's tubes), fitted carefully to the inflamed region.

Heat, especially when combined with moisture, is much used in treating inflammation, and acts in a diametrically opposite way to cold by relaxing the vessels and tissues, thus reducing the tension and pain, it also favours the activity and vitality of the part by increasing the vascular supply and facilitating lymphatic absorption It may be applied in the form of hot fomentations or hot packs or, instead, the method of giving dry heat may be used

Removal of the exudate may be promoted by free incisions and effective mechanical drainage Thus, wherever the exudate may collect in spaces in and amongst the tissues, or in an abscess cavity, it is necessary to incise the collection and institute drainage If the exudate should remain held up in the tissues after incision, its escape may be hastened by applying tissue drainage, and for this purpose the most efficient remedy is the constant application of some hypertonic solution, such as saline (5 per cent) When the exudate is freely discharging, it must be removed, and this is accomplished by means of suitable dressings and, in some cases, by the use of irrigation or baths

(*d*) **Increase the supply of healthy blood to the part** by the application of heat or the employment of one of the methods of **artificial hyperæmia** These measures are of most benefit when the part is not acutely congested, when suppuration has not appeared, and when the condition shows a tendency to become chronic Artificial or induced hyperæmia, with its accompanying emigration, is useful rather than harmful, if it can be suitably controlled In acute cases the hyperæmia is usually excessive and, therefore, harmful, as it is the cause of congestion and serves to prevent the excess of fresh healthy blood to the heart

Induced hyperæmia is of two types, active and passive The **active** variety consists in determining an increased flow of blood to the part by vaso-dilatation and is, therefore, arterial in origin This may be accomplished in one of two ways (*a*) by the application of heat, (*b*)[9] by the employment of counter-irritation The measures employed for applying heat have already been mentioned Counter-irritation is based on the principle that stimulation of the sensory nerve supplies will induce a reflex vaso-dilatation deeply in an area which derives its nerve supply from the same source as the sensory branch

It is applied in many different ways, according to the character of the disease and the part involved Thus friction with the hand, or with stimulating embrocations, produces a hyperæmic condition of the skin, and promotes local activity in the superficial parts which may react beneficially on deeper structures Scott's dressing may be similarly employed, it consists in wrapping up the part, *e g* a joint, in strips of lint covered with ung hydrarg co (containing over 10 per cent of camphor), and then encircling it firmly with soap plaster, spread preferably on chamois leather Iodine paint is another useful application, whilst blisters are most valuable in suitable cases, they are produced by applying a cantharides plaster, or by painting the affected area with liquor epispasticus or a collodion blistering fluid The actual cautery is the most severe form of counter-irritant, and is

especially useful in some varieties of chronic inflammation of bones and joints Injection treatment with alcohol, saline, etc , may be used in suitable cases, *e g* inflammation of a sensory nerve Dry cupping is an example of the combined application of heat and counter-irritation

. **Passive** hyperæmia is venous in nature, and may be induced by the application of a constricting rubber bandage on the proximal side of the inflamed area It is applied with sufficient firmness to obstruct the venous return without interfering with the arterial supply, and if this is satisfactorily effected, the limb becomes reddish-blue, swollen, and œdematous, but without pain, if it becomes cold, or the patient complains of the pain being increased, the bandage has been applied too tightly By the use of a blood-pressure armlet and gauge, the amount of pressure may be accurately adjusted When the correct degree of tension has been reached the limb is comfortable, and the bandage may be retained in position for two or three hours at a stretch twice a day, being removed between the applications so as to relieve the œdema and empty the limb of the accumulated and more or less stagnant blood This method of treatment is maintained until the inflammation diminishes, and then the length of the daily application of the bandage is gradually reduced

Klapp's suction balls are employed in cases where a rubber bandage cannot be applied, *e g* for an abscess or carbuncle on the trunk or back of the neck, for an inflamed breast, or for a septic finger A suitably-shaped bell-glass (similar in type to the wet or dry cup of olden days), the edge of which is greased or moistened, is fitted over the inflamed part, and the air within rarefied by a rubber suction-pump Blood is thereby drawn into the tissues which swell up into the cup, and if there is an open wound, as in a boil or carbuncle, discharge and sloughs are sucked out The application is maintained for five or ten minutes two or three times a day Various methods of extracting by suction the exudate from infected tonsillar crypts are also now employed

(*e*) **Prevent the access of fresh or a mixed infection** to an open wound by suitable dressings and antiseptics

II Treatment of Chronic Inflammation.

The principles of treatment which apply in the treatment of acute inflammation are also employed in the chronic variety In general, it may be stated that the measure adopted will include the removal of the cause and rest to the affected part In addition, counter-irritation is very useful and may be applied in various ways, as has already been stated Pressure is an important element in the treatment of chronically inflammatory disorders, and probably acts by improving the tone of the relaxed vessels and by favouring the absorption of inflammatory exudates Firm bandaging, the use of an elastic support or plaster are the usual methods of application Artificial hyperæmia also is a useful adjunct, and may be combined with thee mployment of massage and remedial exercises In some cases surgical methods may have to be adopted Finally, general or

constitutional measures must also be considered, particularly in relation to the presence of a chronic inflammation caused by such a disease as syphilis, and vaccines may be prepared and used if the organism can be isolated

III **General Treatment.**

This may be considered from the point of view of general measures, drugs, specific therapy, and further surgical measures General measures consist in the maintenance of complete rest in a well-ventilated room and capable nursing The diet should be nourishing and ample, but light The patient should be made as comfortable as possible, and any undue rise of temperature combated by some form of hydrotherapy Drugs should be used sparingly They are of value in securing sleep and relieving pain, and may occasionally be of use in reducing the temperature, and for this purpose common antipyretics are the most suitable At the same time attention should be given to the eliminative functions of the body, and a watch kept for the development of complications such as circulatory failure Specific therapy will consist in the judicious employment of vaccines and sera, of the use of prontosil in streptococcic infections, and the giving of blood transfusions and, in certain cases, immuno-transfusion Finally, surgery may be necessary for the evacuation of pyæmic abscesses or other septic complications which may arise

CHAPTER III

THE BLOOD IN HEALTH AND DISEASE

Red Blood-Corpuscles.—In health these vary between 5 and 6 million per cubic millimetre, being slightly more numerous in the male than in the female

In surgical practice the enumeration of the red corpuscles is of special importance in connection with hæmorrhage If the blood is examined immediately after a patient has suffered from a severe hæmorrhage, it will naturally be found to be normal in composition, part has been lost, but the quality of the remainder has not yet altered After a short time the volume of blood is restored to normal by means of fluid absorbed from the tissues In this stage the blood is more diluted than normal, the red corpuscles and hæmoglobin being alike reduced, the latter more than the former There is also in most cases a temporary increase in the number of leucocytes The process of absorption of fluid from the tissues is imitated artificially by the infusion of saline solutions in collapse or after severe hæmorrhage, and it is found that this process has a beneficial effect in accelerating the subsequent regeneration of the blood as well as in raising the blood-pressure and removing the urgent symptoms

In the subsequent process of recovery the numbers of the red corpuscles increase more rapidly in comparison with the amount of their contained hæmoglobin, so that the colour-index falls The length of time necessary for full regeneration of the blood varies greatly, the process being more rapid in men than in women, and in young adults than in the old or in children Approximately 1 per cent of hæmoglobin is regenerated *per diem*, thus the blood should become normal in about twenty days after the loss of 20 per cent of hæmoglobin if the patient is kept under favourable conditions

It is not possible to lay down any definite rule as to the amount of hæmorrhage which is necessarily fatal Other things being equal, a patient will survive a much greater loss of blood if it takes place gradually than if it takes place quickly In the latter case a reduction of the hæmoglobin to 50 per cent will probably be fatal, whereas in the former it may fall to 20 per cent, or even lower, and recovery still take place Women tolerate loss of blood better than men, and men tolerate it better than children

Anæmic patients are usually bad subjects for operation, and patients with acute streptococcal lesions very often have a marked degree of anæmia Opinions differ as to the degree of anæmia which would indicate the advisability of blood transfusions, but in general it may be stated that a fall of the hæmoglobin content of the blood below 50

per cent is regarded as sufficient indication when a surgical procedure of any gravity is about to be performed

Leucocytes.—The examination of the leucocytes is often of great importance It comprises an enumeration of the total number per cubic millimetre, and a differential count of the relative number of the various kinds In health the blood contains about 8,000 leucocytes per cubic millimetre, five different forms of cell* being present—the polymorphonuclear leucocyte, the eosinophil, the basophil, the lymphocyte, and the large hyaline mononuclear (see Plate III , Figs 5 and 6)

An increase of the total leucocytes present in the blood is termed **leucocytosis.** Under most circumstances this affects mainly the polymorphonuclears, but sometimes there is an increase of the eosinophils, called **eosinophilia,** or of the lymphocytes, termed **lymphocytosis.** A diminution of the leucocytes is termed **leucopenia.**

Leucocytosis occurs under **physiological** conditions during digestion, after muscular exercise, during pregnancy, and in the new-born infant This has to be borne in mind in the making and interpretation of leucocyte-counts in disease

Pathological leucocytosis occurs in many conditions, for example after severe hæmorrhage, and in cachectic conditions, especially in that due to malignant disease, in which it is almost always due to a local inflammation excited by the new growth, and is thus rarely of differential diagnostic value More important is its occurrence in the majority of the infective diseases, and in these the highest counts are found in **pneumonia** and in **suppuration** Its occurrence in the latter is of special importance to the surgeon, as the presence of a high leucocytosis may be regarded as the most definite single sign of the presence of pus It is especially valuable in **appendicitis,** where the other evidences of suppuration are often equivocal, as, when no pus is present, the blood usually shows only a comparatively slight leucocytosis, the number not as a rule exceeding 15,000 per cubic millimetre When pus is present the number tends to be much greater, being usually not less than 18,000 to 20,000, and may rise as high as 50,000 or even higher For practical purposes a count of 20,000

* Gulland and Goodall, in their book on 'The Blood' (3rd ed , W Green and Son, Ltd , Edinburgh, p 82), and Whitby and Britton in their 'Disorders of the Blood' (Churchill, London, 1935, p 25), respectively, give the following convenient statements of the proportions of the leucocytes in normal (adult) blood

Variety of Leucocyte	*Whitby and Britton*		*Gulland and Goodall*	
	Total per c mm	*Percentage*	*Percentage*	
Polymorphonuclears	3,000-6,000	60-70	70	average
Lymphocytes	1,500-2,700	25-30	20	average
Monocytes	350-800	5-10	5	average
Eosinophils	150-400	1-4	4	maximum
Basophils	0-100	0-1	1	maximum

leucocytes per cubic millimetre may be taken as an almost certain proof of suppuration, presuming, of course, that the other causes of leucocytosis can be excluded Figures between 15,000 and 20,000 may not be absolutely conclusive of the presence of suppuration, and where they are obtained it is advisable to repeat the examination in twenty-four hours or less

Aleucocytosis and Leucopenia —The absence of leucocytosis is presumptive evidence that suppuration has not occurred, but several facts have to be considered in applying this rule in actual practice

1 The cause of the leucocytosis is the passage of the bacterial products from the inflammatory focus to the blood-stream, where they exert a positive chemiotactic action, attracting the leucocytes from the bone-marrow, whilst at the same time they stimulate the latter to an increased production of these cells As long as the abscess remains unopened and is spreading, these substances gain access to the blood- and lymph-stream with ease But when the abscess is opened so that the pus laden with bacterial toxins can drain away, the leucocytosis falls, even although the abscess may persist for a time

2 When the pyogenic bacteria have been killed, the toxins are soon carried away by the circulation and eliminated from the body, and when this has happened the leucocytosis falls, although there may still remain a collection of pus in the tissues In other words, a high leucocytosis is to be regarded as a proof of the active process of suppuration rather than as a proof of the presence of pus For example, sterile collections of unabsorbed pus often occur in cases of pyosalpinx of some duration, not necessarily accompanied by leucocytosis, although acute suppuration in the Fallopian tubes causes the usual reaction

3 When the organisms are virulent and the patient of feeble constitution, so that the infection rapidly spreads, there may be a failure of leucocytosis (aleucocytosis) or even an actual diminution in their number (leucopenia) Such deficiency is found especially in severe cases of diffuse septic peritonitis The general leucocytosis (as well as the local emigration of leucocytes) must be regarded as a conservative and defensive reaction, and indicates that the patient has sufficient resisting powers to combat the infection, or at least to limit it for a time, the absence of such leucocytosis in a case where there is suppuration renders the prognosis unusually bad

4 Leucocytosis does not occur in uncomplicated cases of chronic tuberculous or cold abscess The products of the tubercle bacillus which produces these lesions have no positive chemiotactic action on the polymorph leucocytes, the cells found in the local lesions being mostly of lymphocyte type We might, therefore, reasonably expect that an increase of the lymphocytes in the blood would occur, but, though a certain degree of this may be found in some cases, it is not often a pronounced phenomenon (see below under ' Lymphocytosis ')

Lymphocytosis, or an increase of the lymphocytes, may be absolute or relative A relative increase (*i e* such that the percentage of these cells in the adult rises above, say, 35, although the total number of the leucocytes may not exceed the normal) occurs in tuberculosis and the other diseases mentioned above as giving no leucocytosis A

great excess of 'lymphocytes' (100,000 to 260,000 or even more per cubic millimetre) occurs in lymphatic leukæmia

Mononucleosis is an acute infective disease characterized by enlargement of the lymph-nodes especially of the neck, fever and sore throat, and occurring most frequently in children, sometimes in epidemic form In some cases there is sore throat, and sometimes the development of ulceration resembling that of Vincent's angina

Agranulocytosis.—To this condition a variety of names has been applied—granulocytopenia, granulopenia, primary or idiopathic neutropenia—but the term for it at present in most general use is **Agranulocytosis,** or, when the characteristic lesion in the throat often associated with it is present, **Agranulocytic Angina.** As these names imply, the disease is characterized by a diminution, marked, very marked or extreme, or even by a total disappearance, of the finely granular polymorphonuclear cells from the circulation The hæmopoietic functions of the bone-marrow are three-fold—erythroblastic, leucoblastic, and thrombocytoblastic—for the manufacture of red corpuscles, the granulocytes or marrow-formed granular leucocytes, and the thrombocytes or blood-platelets respectively By various conditions the output of each of these groups may be increased, diminished or inhibited, and in agranulocytosis there is an inhibition or arrest of the maturation of the granulocytes at the stage of their precursors the myeloblasts, so that, in whole or in part, the ordinary finely granular myelocytes and the polymorphs derived from these cease to be produced, *i e* there is an aplasia of these cells without any corresponding aplastic anæmia affecting the red corpuscles or any thrombocytopenia The disease may follow the toxic action of some infective poison or, as already mentioned, be due to the depressant effect of the drugs of the sulphanilamide group, and in these cases it would appear that there is an undue susceptibility of the bone-marrow to the influence of these poisons

Eosinophilia, *i e* a relative increase of the eosinophils, occurs in several conditions, most of which appear to be due to the action of some 'foreign' protein

Blood-Platelets —These are minute bodies about 2 to 3 μ in diameter, and stain purplish with Leishman's stain They are formed in the bone-marrow, and are normally present to the extent of 200,000 to 300,000 or more per c mm They show a very great tendency to agglutinate upon any damaged areas within the vascular system itself, *e g* on diseased heart-valves or upon the damaged lining of blood-vessels, and they also tend to aggregate in clumps as soon as the blood leaves the vessels They are concerned in the process of coagulation and thrombosis, and are found in very much diminished numbers (thrombocytopenia) in hæmophilia, scurvy, some forms of purpura, and in pernicious anæmia

The estimation of the **clotting** or **coagulation time** and of the **bleeding time** is often of considerable importance to the surgeon If the more elaborate and exact methods are not available, the following rough way of testing the **coagulation time** may be employed The finger or the lobe of the ear is pricked and a drop of blood is transferred to

a slide A needle is drawn through it from time to time, and the time taken before any fibrin threads adhere to the point of the needle is noted This corresponds fairly accurately with the clotting time, and is normally between three and five minutes

The **bleeding time** is roughly estimated by making a small incision in the finger or the lobe of the ear with a three-cornered needle or a small lancet As the blood collects it is removed with a piece of blotting-paper without squeezing the part or rubbing the surface Bleeding usually ceases in from three to five minutes

The Examination of Blood for Bacteria is often necessary, and cultural methods are employed, for their numbers are usually so small that the chance of finding even a single organism in a stained blood-film is remote

Transfusion of Blood

Previous to the adoption of a scientific and accurate method of blood grouping, transfusion of blood met with so little success and was attended by so many mishaps that it was laid aside for a time in favour of infusion of saline solution The modern methods of blood grouping and matching have, however, rendered transfusion comparatively safe

In cases of serious hæmorrhage and severe shock, transfusion may be given with great benefit It is also valuable in chronic conditions where much destruction of blood has taken place—*e g*, in septic lesions with severe secondary anæmia, in pernicious anæmia and in certain diseases of the spleen, in coal-gas or carbon-monoxide poisoning, and also in cases of hæmophilia and analogous conditions in which coagulation of the blood is deficient In some cases it is desirable to treat the patient by repeated transfusions of blood before attempting a serious operation

The chief cause of failure in the past lay in the non-recognition of the fact that the blood of one individual may be incompatible with that of another, and before transfusion is undertaken careful tests must be made to determine this point The incompatibility may arise in two directions (1) The red corpuscles of the donor may be agglutinated by antibodies in the serum of the recipient, and (2) such agglutination may or may not be followed by active hæmolysis, the corpuscles being dissolved with a resultant haemoglobinuria Hæmolysis is always preceded by agglutination, but does not invariably follow the injection of an incompatible blood, the result depends on the degree of incompatibility It is necessary, therefore, to find out whether agglutination occurs when the donor's corpuscles are brought into contact with the recipient's plasma

It has been found that all individuals fall into four main groups as regards agglutination and hæmolysis, this is shown in the table given on page 34 It is probable that there are sub-groups of these, particularly in Group A (or II) and research is still being done on this important subject, as accidents have occurred even when the donor's group appeared to be suitable The sera used for grouping must be tested from time to time to prove that they are still active The

is tied into a vein—*e g* the saphenous vein a hand's breadth below the knee, or at the ankle, or, as recommended by Marriott and Kekwick,* who give a full description of this method of transfusion, 'one of the veins in the middle of the forearm at a spot an inch distal to where it joins another vein, and with a valve at the junction which may be tested by emptying the vein from above [Figs 16, 17A and 17B] Such a valve is useful in preventing reflux flow into the cannula The middle of the forearm is most desirable because flexion of the elbow does not then compress the cannula against the vein wall and so obstruct the flow There is no need for splinting and the patient can flex his elbow as he wishes' In the lower limb immobility may be secured by the use of a suitable splint, and care should be taken to ensure the use of a cradle as the weight of bedclothes on the thigh might tend to obstruct the saphenous vein The Hendon's needle after introduction may be stitched in place to the skin, or, if a glass cannula is used, it and the adjacent portion of the attached rubber tubing may be strapped in position with adhesive tape The solution to be introduced by this method may be placed in a large glass container which is suspended at the head or side of the bed

The most suitable rate is forty drops to the minute If blood is being administered, oxygen should be bubbled through continuously to prevent sedimentation of the corpuscles The rate of flow of the oxygen should be roughly forty bubbles per minute The blood is filtered through nickel wire gauze at the bottom of the bottle Saline or glucose may be administered in the same way, and if run in at the rate mentioned above there is no need whatever to warm these solutions Too much glucose should not be run in as it tends to cause thrombosis in the vein

In cases where several blood transfusions are to be administered to the same patient, a special double dripper should be used This will allow blood and saline to be given together or separately, and this is of special value when the blood supply becomes exhausted before a second donor has been obtained In this case the saline solution can be run in, thereby the vein and apparatus are kept patent until more blood is available

* 'Continuous Drip Blood-Transfusion,' H L Marriott and A Kekwick, *Lancet* April 27, 1935 p 977

CHAPTER IV

PYOGENIC INFECTIONS AND INFECTED WOUNDS.

In this chapter we propose to deal with a series of affections associated with or allied to suppuration, and due to organisms, usually termed **pyogenic,** which cause an inflammatory reaction in the tissues, sooner or later associated with liquefaction of both tissue and exudate, the liquefied material being known as **pus,** and the process which leads to its formation as **suppuration.** Any localized collection of pus in the tissues is known as an **abscess,** and this may be acute or chronic Sometimes the infection involves the cellular tissue of a part in a more or less diffuse manner, the pus infiltrating widely, this condition being termed **cellulitis,** or it may implicate a serous cavity such as the pleura or peritoneum Constitutional phenomena are associated with these local manifestations, and may be of two types (*a*) When toxic products alone are absorbed, resulting in **toxæmia** or some modification of the same, and (*b*) when the bacteria invade the blood-stream and become disseminated to distant parts, thereby giving rise either to **septicæmia** or to **pyæmia** Varying degrees of these three processes may occur in combination in any given case

Bacteriology.—The more important pyogenic bacteria* are

The Staphylococci
The Streptococci
The Pneumococci
The Bacillus coli (*or Bacterium coli*) Group
The Typhoid-Paratyphoid Group
The Bacillus Pyocyaneus (*pseudomonas pyocyanea*)
The Proteus Group
The Gonococcus (*Neisseria gonorrhœæ*)

(1) **Staphylococci** (*Staphylococcus aureus, citreus,* and *albus*) (Plate I , Fig 1) are very widely distributed, being common in air, dust, etc They are constantly found in or on the human skin, and suppurative inflammations of it and of the subcutaneous tissue are very frequently due to them, and even when the inflammation is caused by other organisms in the first instance a secondary infection with staphylococci almost always takes place later Impetigo contagiosa, a disease due primarily to streptococci, may be taken as one example of this, and

* For the microscopical and cultural characters of such micro-organisms textbooks of Bacteriology should be consulted The recent nomenclature has been included in brackets

the vesicles of small-pox and vaccinia as another, for in each case a secondary staphylococcal invasion takes place The chief lesions of the skin and subcutaneous tissues due to staphylococci are abscesses, boils, carbuncles, pustular acne, etc In some cases diffuse spreading cellulitis may be produced by them, but this is unusual Deep-seated suppuration, such as periostitis and osteomyelitis, perinephric abscess, empyema, etc , may also be due to staphylococci, in fact, they may cause suppuration in any part of the body Lastly, staphylococcal septicæmia, pyæmia, and ulcerative endocarditis occur, but are less common than the forms due to streptococci, and the prognosis is slightly less grave

Cases of post-operative suppuration, particularly stitch-abscesses in the skin, in which antiseptic or aseptic precautions have failed, are practically always due to staphylococci, either alone or in admixture with other organisms

(2) **Streptococci** (Plate I , Fig 2) —Streptococci form a heterogeneous group containing numerous different types or species, and it is also recognized that the *same* strain of streptococcus may at different times show all degrees of pathogenicity, and may, *e g* on passage through a series of susceptible persons or animals, become progressively more and more virulent, as the surgeon and pathologist sometimes learn to their cost when they prick or cut their fingers whilst operating upon cases of streptococcal infection, whereas, on the other hand, such virulence may be diminished or may practically vanish when the organism is passed through a succession of subcultures outside the body

Streptococci grow in longer or shorter chains, but any classification according to length of chain, whether *in vivo* or *in vitro*, is of comparatively little value, as this may vary even in the same strain, not merely with the type under investigation, but also with the culture medium They are mostly aerobic and facultatively anaerobic, but some anaerobic varieties also occur

Of the hæmolytic streptococci, *Streptococcus pyogenes* is the commonest and most important Closely allied to or possibly identical with it is the streptococcus of erysipelas The serological classification of streptococci by specific agglutinating sera and absorption tests is as yet too complex and uncertain a proceeding for ordinary routine clinical use

The lesions produced depend upon the virulence of the organism and the varying susceptibility or resistance of the patient, and may include localized abscesses, spreading forms of suppuration such as erysipelas and cellulitis, lymphangitis, lymphadenitis, etc , whilst still more fatal streptococcal affections are meningitis, septicæmia and pyæmia, puerperal fever and ulcerative endocarditis

The discovery that the dark red synthetic azo-dye known as ' prontosil ' when administered by the mouth has a distinct protective and curative action against virulent hæmolytic streptococci is a notable advance in chemotherapy The closely allied dye ' prontosil solubile ' may also be administered intramuscularly, and it has further been found that this specific protective action is due to the colourless parent

substance* (which has been given the shortened name of **Sulphonamide-P**) into which these dyes are broken up in the animal body This latter substance itself may, therefore, be administered in tablet form† by the mouth, or when this is not possible it may be tried intramuscularly, *not* intravenously, as its injection directly into the circulating blood has been followed by undesirable toxic reactions Its clinical use in the human subject has followed the successful experimental protection of mice‡ by it against virulent strains of *Streptococcus pyogenes*, and perhaps also, though in lesser degree, against meningococci

More recent variations of this drug are now efficacious against the pneumococci or meningococci, and success has also been obtained in connection with erysipelas, scarlet fever, acute streptococcal tonsillitis, and gonorrhœa

Any number from six to ten 0 5-gramme tabloids may be administered daily by the mouth and continued for about a week after the temperature has fallen to normal If it should not be tolerated by the stomach (the simultaneous internal use of magnesium sulphate should be avoided) its intramuscular injection may be tried The occurrence of sulphæmoglobinæmia may constitute a contra-indication to this line of treatment

Non-hæmolytic varieties of streptococci may produce lesions which tend to be less acute than the foregoing Of these, *Str salivarius* and *Str mitis* are common inhabitants of the mouth, throat, etc , and may acquire a varying and sometimes considerable degree of pathogenicity, being very frequently associated with infections of the teeth and gums, tonsils, nasal sinuses, middle ear, etc , and with lesions elsewhere secondary to these, such as in the gall-bladder, appendix, renal pelvis, etc , and such focal infections are not unfrequently found in cases of rheumatism From their tendency to produce in culture a greenish discoloration of hæmoglobin, a somewhat heterogeneous group of these non-hæmolytic streptococci have, rather loosely, been termed '*Str viridans*'

'*Str fæcalis*,' also non-hæmolytic, probably comprises a group of closely allied species It is a normal inhabitant of the intestine, which occurs very commonly in wounds contaminated with fæcal material, and is an organism usually of only moderate virulence

(3) **The Pneumococcus** (Streptococcus pneumoniæ) (Plate I , Fig 4) is practically a normal inhabitant of the mouth It is the commonest cause of acute lobar pneumonia and the accompanying pleurisy Four main serological types are described, of which Types I and II are found especially in acute lobar pneumonia Infections with these two types, more especially Type I , and also, but to a lesser degree, with Type II , but not the others, are often benefited by the use of the homologous serum and the mortality considerably reduced The pneumococcus is found in many suppurative conditions connected

* *p*-aminobenzenesulphonamide

† 'Tabloid' Sulphonamide-P

‡ See articles by the Staff of the Wellcome Research Laboratories in *The Lancet*, 1936, 1 , 1286, and *ibid* , 1937, 1 , 16, etc

with the lungs, especially empyema, and often as a secondary infection in other pulmonary lesions, thus, in the walls of a tuberculous cavity suppuration is very frequently due to pneumococci alone or in conjunction with other organisms It is a common cause of nasal sinus infection and middle-ear disease, and of their cranial or intracranial complications Pneumococci also cause arthritis, which may or may not result in suppuration, and may follow an attack of pneumonia Peritonitis also may be due to this organism, especially in young children, and may be primary, or secondary to some pulmonary lesion In pneumonia, especially in the more serious cases, as well as in grave pneumococcal infections elsewhere, the pneumococcus frequently enters the blood in varying numbers and may sometimes produce a definite septicæmia, with or without ulcerative endocarditis

(4) **The Bacillus coli** (Bacterium coli) **group** (Plate III , Fig 4) occurs in great numbers in the contents of the healthy intestine It is distinguished from the typhoid-paratyphoid-dysentery group by the serological reactions of these and by its action on various sugars, especially its fermentation of lactose, the latter group being non-lactose fermenters

Under normal conditions the bacilli of the *Bact coli* group, which occur in the intestinal contents, are not very virulent, but when any pathological condition arises in the gut, and the resistance of this is lowered, *e g* strangulation, ulceration, perforation, etc , active invasion of the tissues by it, usually along with other organisms, especially streptococci, **Clostridium welchii** (or bacillus welchii), etc , may follow, and may lead to appendicitis, acute peritonitis, etc , any pus so formed having usually a fæcal odour *Bact coli* and its allies may also give rise to cholecystitis and cholangitis It is one of the commonest causes of pyelitis and pyelocystitis, in which it is frequently associated with streptococci

(5) **The Typhoid-Paratyphoid Group** —*Bacterium typhosum* (bacillus typhosus) and its relatives of the paratyphoid group sometimes cause abscesses, especially in connection with bones or joints, after an attack of the specific fever It is now well known that for many years after such an attack some persons continue to excrete these bacilli in the urine or fæces, in the latter instance the commonest focus of such persisting residual infection being the gall-bladder These typhoid and paratyphoid 'carriers,' as they are termed, may at any time initiate an epidemic of the disease

(6) **Bacillus pyocyaneus** (pseudomonas pyocyanea) is occasionally a cause of suppuration, *e g* in the middle ear, or in gunshot wounds, etc The pus produced by it turns bluish-green when collected on dressings and exposed to the air The discharge is often abundant, and has a characteristic musty smell The infection is not as a rule of grave import, and may usually be controlled by suitable drainage and antiseptics without much difficulty This organism, however, sometimes gives rise to a general infection somewhat resembling typhoid fever, and it may then be found in the blood, fæces, and urine

(7) **The Proteus Group.**—*Proteus vulgaris* (bacillus proteus) and some

of its allies are a not uncommon cause of suppurative cystitis and otitis

(8) **Gonococcus** (Neisseria gonorrhœæ) (see p 133)

Many cases of suppuration are due to a **mixed infection** with two or more of the species of bacteria enumerated above, or with some of the anaerobes described elsewhere In other instances an abscess formed by the action of one of the pyogenic bacteria may be subsequently infected with simple saprophytes which have the power of growing in pus and dead tissues, but do not as a rule invade the living tissues This is especially liable to occur in a large abscess when the drainage is insufficient, or when the dressing is not performed with sufficient care as to asepsis Such an accident should be studiously avoided, for lesions due to a mixed infection heal with difficulty, the tissues appearing more easily to acquire immunity against a single variety of organism than against two or more at the same time The fact that a wound is already infected is no reason for neglecting to treat it with the fullest aseptic precautions, and this should also be borne in mind in connection with operations on the mouth, rectum, etc

I Acute Abscess.

Ætiology.—It may be taken as established that suppuration as met with in surgical practice is almost always due to the action of bacteria, though occasionally it may follow upon the intramuscular or other injection of certain medicaments

Bacteria can reach the area, which becomes inflamed either from outside the body or from within Staphylococci are commonly present in the skin, and often on instruments, sutures, dressings, etc , and it is to infection from such external sources that most cases of post-operative suppuration are due Suppuration and abscess formation is particularly liable to occur in lymph-nodes, from the spread of infection in their drainage areas, *e g* in the axillary nodes from the fingers, etc , or in the cervical nodes from the tonsils, teeth, etc

In some cases, however, bacteria gain access to the tissues by way of the blood, thus a deep lesion (such as a ruptured muscle or ligament) may result in suppuration, although the skin over it is unbroken, and the intervening tissues are apparently healthy Here we must assume the existence of auto-infection (p 4), the bacteria reaching the blood from some pre-existing septic focus elsewhere, such as infected gums, teeth, tonsils, nasal sinuses, intestine, especially the appendix, etc

In other cases abscesses may be due to organisms which have lain latent in the tissues locally, it may be, for long periods The possibility of this, especially as a sequel in wounds of ragged and irregular shape which have been the seat of prolonged suppuration, has already been mentioned (p 5), and it is a factor that has to be carefully considered in deciding upon the best time to perform secondary plastic or other operations, *e g* on bones or nerves, usually it is wise to wait for from three to six months, special attention being given meanwhile to the patient's general health Bruising of the part without breach

form of a fluid wave Some soft solids give a sensation of fluctuation, *e g* lipomas, and soft rapidly-growing sarcomas, whilst, on the contrary, it may be absent when the fluid is under great tension, or surrounded by a thick wall, or widely diffused in such a structure as the glandular tissue of the breast

Sometimes, when the pus is small in quantity, all that can be detected is a feeling of elastic resistance in the centre of the brawny hyperæmic mass, but this, to the practised finger, is quite as conclusive of the presence of fluid as fluctuation When the pus is placed deeply under muscular and fascial planes, very careful examination may be needed in order to determine its presence, the surgeon must not be misled by the sense of fluctuation obtained *across* the fibres of a muscle, but, in the absence of pus, such fluctuation will not be felt on palpation in the longitudinal axes of the muscle-fibres Marked and increasing œdema is frequently conclusive of the presence of deeply-seated pus, *e g* in acute osteomyelitis and suppurating mastitis

2 **Pressure effects** are due mainly to the mechanical influence of the swelling upon surrounding structures The most evident are those due to the irritation of nerves, as a result of which neuralgic pain may be present, or the patient may refer the pain to some distant unaffected region In some cases, where large blood-vessels traverse the suppurating focus, the tissues surrounding them may be destroyed, leaving them exposed in the abscess cavity as bands Thrombosis and subsequent obliteration may result, especially in the veins, or occasionally hæmorrhage follows, due to erosion of the vessel wall (suppurative periarteritis or periphlebitis), preceded perhaps by dilatation of the vessel, owing to loss of its external support

3 **The general effects** of the formation of an acute abscess of sufficient severity are **fever,** sometimes amounting to a **rigor,** and **leucocytosis** A **rigor** consists of a definite series of phenomena, due to stimulation of the thermogenic centres by an accumulation of toxin in the blood It is ushered in by a feeling of intense cold and discomfort, the features are pinched, and the teeth chatter The skin, however, feels dry and hot, and the temperature of the body rapidly rises After this stage has lasted a variable period, from ten minutes to half an hour, the patient gradually begins to feel warmer, the face becomes flushed, the temperature ceases to rise, and perspiration commences Finally, there is a rapid fall of temperature accompanied by profuse sweating, which probably assists in the elimination of the toxin, but leaves the patient more or less exhausted

Pus and its Constituents —Pus is a thick, creamy fluid, having a specific gravity of about 1030, an alkaline reaction, and containing 85 to 90 per cent of water If allowed to settle, it separates into two layers, an upper or fluid part, the liquor puris, which is usually somewhat opalescent, and a deposit of a greyish- to slightly greenish-yellow colour, which is usually more bulky than the fluid portion The liquor puris is derived from the plasma and consists of dilute albuminous fluid very similar to serum, and may sometimes undergo spontaneous coagulation after its removal from the body

The deposit consists in the main of polymorph leucocytes, most of

which, as has been already pointed out, are dead and degenerated, whilst a few may still be living and capable of spontaneous movement In addition, there are nuclei and other fragments of cells from the tissues, shreds of fibrous tissue, granular débris, and bacteria Red blood-corpuscles are often present

Muco-pus is a discharge from an inflamed mucous membrane, it is sticky or glairy from the presence of mucus **Sero-pus** is thin and more liquid from an admixture with serum **Blue** or **bluish-green** pus owes its colour to the presence of Bacillus pyocyaneus (*Pseudomonas pyocyanea*) (p 45)

Occasionally an abscess contains not only pus, but also **gas.** This may be due to the existence of direct communication with a hollow viscus, *e g* the stomach or intestine, and hence is found in some cases of subphrenic abscess In some of the many types of abscess associated with the appendix or other parts of the intestine, gas, when present, though it may be due to the activity of some member of the *Bac coli* group, is probably most frequently produced by Bacillus welchii or Bacillus aerogenes encapsulatus (*Clostridium welchii*) In the limbs gas is also usually the result of infection with gas-producing anaerobic organisms, *e g Bac welchii*, or bacillus of malignant œdema (*Cl welchii* or *Clostridium œdematis maligni*) Occasionally gas develops in an abscess which is localized and has no connection with the bowel, the infection being probably of pyæmic origin In gas-gangrene cases (see p 113), *Cl welchii* attacks and spreads in muscle especially, probably on account of the carbohydrate content of this tissue forming a suitable medium for its growth

Treatment of Acute Abscess —When an inflamed area is threatening to suppurate, the formation of pus can sometimes be **prevented** by elevation and rest of the part, together with the application of evaporating lotions and the administration of a dose of stock staphylococcal or mixed staphylococcal and streptococcal vaccine Bier's treatment by induced hyperæmia may also be useful In the case of an incipient boil, the inflamed area may be strapped firmly with elastoplast

If, as already noted, the pus is not too abundant, it may occasionally be **absorbed** after its formation, more particularly when situated in a cavity of highly absorbing powers, such as the interior chamber of the eye (hypopyon) or the peritoneal cavity

As a rule, however, one relieves pain and encourages suppuration by applying fomentations (medicated when necessary with opium or belladonna) or poultices to the part, and then, as soon as such suppuration has occurred, an incision is made to **evacuate** the abscess cavity The opening must be large enough to prevent reaccumulation it should be placed at a spot suitable for drainage, but as far as possible from sources of secondary contamination, and in such a direction that movements of the part do not close it Where the opening is not dependent, it may be desirable to make a counter-opening by pushing the finger or an instrument through the abscess wall amongst the tissues, making it protrude beneath the skin at some dependent position, and cutting down upon it in this direction,

In dealing with deep abscesses in dangerous regions, Hilton's method may be advantageously employed This consists in dividing merely the skin and superficial structures and then thrusting a pair of sinus or dressing forceps into the abscess cavity On separating the blades forcibly a sufficient opening is made to insert a finger, or a drainage-tube Rigid aseptic precautions must be taken in opening abscesses, for, although bacteria are present, it is essential that no fresh organisms be admitted, thereby giving rise to a mixed infection, the presence of which is most unfavourable to rapid repair When an abscess is evacuated, it is always advisable to have the pus bacteriologically examined, and an emulsion of the causal organisms reserved for the preparation of an autogenous vaccine, which will thus be available, if necessary, for the further treatment of the case, and for the prevention of possible recurrences

Any sloughs present should be removed, and when the abscess has burrowed, or if the cavity is large, it should be gently explored, but adhesions or bands crossing it should not be indiscriminately broken down, as they may contain blood-vessels, and care must be taken not to damage the limiting pyogenic membrane All that is subsequently needed is to arrange for drainage, as by inserting a rubber drainage-tube or a slip of rubber or protective, and to prevent a mixed infection by a carefully applied antiseptic or aseptic dressing, or by packing the cavity with gauze soaked in an iodoform emulsion (10 per cent) There is often a considerable loss of blood during the first twenty-four hours from the capillaries in the abscess wall owing to the sudden relief of tension, but this usually ceases of itself, or yields to moderate pressure When once the abscess has been evacuated and drainage provided, if external contamination (mixed infection) has been avoided, the suppurative process should rapidly subside, the discharge becoming serous, and the wound closing and healing, and this in spite of the fact that bacteria are for a while present, they are evidently unable to develop or do harm as the result of a local immunity An abscess cavity which has contained foul or stinking pus usually heals fairly rapidly if aseptic conditions are maintained, *e g* if no communication with the bowel exists, the discharge becoming free from smell in a few days Infection with *Pseudomonas pyocyanea* is best treated by the application of eusol (5 per cent) fomentations changed every four hours, they should be thick and of sufficient size Deep wounds or sinuses should be irrigated with hot eusol

The persistent discharge of pus from an abscess which has been opened usually points to inadequate drainage, due either to too small an opening or to one badly situated, to the retention of dead tissue, *e g* a sequestrum, or of foreign material, *e g* a piece of rubber tubing In other cases the supervention of a mixed infection or the presence of a tuberculous or syphilitic lesion may be causing the discharge to continue, and occasionally it will happen that the patient's recuperative powers are not equal to dealing with the infection even after good and sufficient drainage The cause must be ascertained and remedied, and attention must be given at the same time to improving the general

condition of the individual In other cases undue pressure should not be maintained on acutely inflamed tissues by tight packs, drains, bandages, etc , as sloughing is very likely to ensue

II Chronic Abscess of Pyogenic Origin

A chronic abscess may be defined as a collection of pus which forms slowly and without the signs of active inflammation, so that it is sometimes termed a 'cold abscess' Although the majority are tuberculous in origin, a few are non-tuberculous and due to the liquefaction of other granulomatous masses, to an infection with pyogenic bacteria of low vitality, or to chronic pyæmia The clinical phenomena are alike in the two types, and will be dealt with later (Chapter VI), but there is one important distinction between them, in that the lining membrane of the pyogenic variety is merely granulation tissue more or less active, whilst in the tuberculous form it contains living tubercle bacilli Hence, whilst a simple incision under aseptic precautions may be all that is required in the former, the latter also needs treatment directed against its tuberculous nature

Sinus and Fistula.—When an abscess, acute or chronic, has been opened, and does not heal completely, either a sinus or a fistula may persist A **Sinus** is a narrow track lined with granulations, penetrating into the tissues, open at one end and closed at the other, the discharge may be purulent or merely serous A **Fistula** is an abnormal communication, congenital or acquired, between two cavities, or between a cavity and an external surface When such conditions result from the non-closure of an abscess of pyogenic origin, the walls consist of an external fibro-cicatricial layer, and an inner lining of granulation tissue Should the abscess have been of tuberculous origin, the lining membrane will also contain tubercles

It is often a matter of difficulty to secure the healing of a sinus or fistula, and the following are the main causes of their non-closure (1) The presence of some irritant persisting in the depths of the wound, such as a piece of clothing, the catgut ligature, silk thread or silver wire used in an operation, or diseased tissues, such as a fragment of dead or carious bone or, in the case of the jaws, a septic fragment of broken tooth (2) the irritation of discharges, such as urine, fæces, or fœtid pus, finding an exit through the abnormal opening (3) insufficient drainage of a deep cavity, so that there is always a certain amount of tension in the wound (4) want of rest to the part, due either to voluntary movements, as in the limbs, or to involuntary muscular action in the immediate neighbourhood, as in fistula-in-ano (5) tuberculous infection of the wall or closed end of the sinus, or an analogous actinomycotic or some similar infection (6) the growth of epithelium along the walls of the sinus or round the margin of the fistula (7) the presence around the sinus of dense sclerosed fibrous tissue which prevents contraction, or (8) of tumour-tissue, either previously present or supervening or (9) constitutional debility

The orifice of a sinus often looks depressed from the amount of infiltration around, but when the surrounding tissues are healthy,

puckering in of the orifice is a good sign In cases where foreign bodies are lodged within, or where diseased bone exists, it is usually surrounded by prominent fungating granulations

Treatment —The removal of the cause should be the first aim in dealing with a discharging sinus or fistula Foreign bodies or dead bone (if loose) must be removed, and diseased bones or tissue suitably treated Efficient drainage is provided by dilating or incising the passage, or by providing a counter-opening in a dependent position The granulation lining may need to be scraped away, and the raw surface disinfected by liquefied carbolic acid or sulphate of zinc solution (40 grains to 1 ounce) The cavity may be packed with gauze soaked in a hypertonic solution, such as glycerin and iodoform emulsion or 5 per cent saline solution Zinc ionization, diathermy, or the ultra-violet ray are sometimes useful Rest to the part is provided by bandaging or by a suitable splint Occasionally it is possible to excise the lesion completely and close the wound

Should a fistula have become lined with epithelium, the edges will require paring, and some form of plastic operation must be undertaken to close the opening

In addition, sinuses often react well to vaccine treatment, and this is especially the case with those left after empyema, when one or more injections of moderate doses of the causal organism will sometimes prove efficacious Tuberculous sinuses, such as may be left after suppuration of lymph-nodes in the neck, etc , are occasionally curable by the use of tuberculin Attention should in all cases be given to the general health

Results of Long-continued Suppuration —In certain cases, even though an abscess is treated antiseptically, and the formation of pus has ceased, the wound may not heal for months, but the discharge is merely serous, and, unless other organs and tissues are involved (a tuberculous fistula-in-ano, for example, may be secondary to tuberculous disease of the lung, intestine or both, from the swallowing of infected [illegible] ium), no constitutional results may be manifested The temperature remains normal and the general health unimpaired, if no other disease is present Should a tuberculous abscess become infected with pyogenic organisms, or a mixed infection occur in a pyococcal abscess, the discharge of pus continues or reappears, and fever to a varying degree develops When an extensive or deep abscess is thus involved, the discharge may become profuse, high fever may supervene, grave visceral changes may follow, and the patient may lose his life through toxæmia and exhaustion Long-continued suppuration is always an evidence of persistent infection, and amongst the conditions which arise therefrom may be mentioned hectic fever and amyloid disease of the viscera

Hectic Fever may be defined as a chronic toxæmia due to the continued absorption of small doses of toxins, and is found in any condition of chronic infection, *e g* after acute, or in chronic suppurative affections of bones or joints, in tuberculous disease of the lungs where secondary mixed infection has occurred, and in chronic syphilitic or cancerous ulceration It is characterized by a diurnal elevation

of temperature during the afternoon or evening, when the face becomes flushed (hectic flush of the cheeks), the eyes are bright and sparkling, the pupils dilated, and the patient feels better and stronger The pulse, however, is small, compressible, and ten or twenty beats quicker than it should be This condition continues till late in the night, by which time the temperature may have risen four or five degrees In the early morning it falls as rapidly as it had formerly risen, and usually drops to normal, or even below it, and this is accompanied by profuse perspiration, which leaves the patient in a much exhausted condition Day by day this continues, the fever and sweating together causing rapid and marked emaciation

Amyloid, Waxy, Albuminoid, or **Lardaceous Disease** of various organs is a condition due to the deleterious effects of toxic compounds circulating in the blood,* whereby the delicate connective tissue of the walls of the arterioles, and subsequently the perithelial coats of the capillaries and the connective tissue of the walls of the veins, as well as, later, of the larger arterioles and small arteries, are converted into or infiltrated with a wax-like substance, from which lardacein, an extremely insoluble protein body, may be obtained It may also come to involve the connective-tissue framework, basement membranes, etc , but never the cytoplasm of the special cells, of certain viscera As this material is in no way akin to starch the name ' amyloid ' is a misnomer, but remains in common use It occurs as a wax-like homogeneous material, becoming a dark mahogany brown on the application of tincture of iodine, and an inky blue when sulphuric acid is subsequently added With methyl-violet the amyloid substance is coloured ruby-red, whilst normal tissues are stained blue The organs mainly affected are the kidneys, spleen, liver, and villi of the intestines The **liver** usually becomes uniformly enlarged to a considerable degree, often reaching from the fifth rib to the umbilicus or lower, it is firm in consistency, like indiarubber, and waxy-looking on section The arterioles of the portal tracts and the capillaries in the intermediate zone of the lobules are those first affected The secreting cells of the liver, kidneys, etc , may undergo compression atrophy and other secondary degenerative changes, but, as just noted, are not themselves invaded The glycogenic and bile-producing functions are interfered with, so that the digestive processes, and especially the power of absorbing fats, are impeded, although the appetite may remain good The **kidneys** become similarly enlarged, the change usually commencing in the arterioles leading to the glomeruli, but the intertubular capillaries and the basement membranes of the tubules are also early affected In this stage the urine is very abundant (from the increased filtration through the degenerated vessel walls), pale, limpid, and containing a few hyaline† casts and fatty cells, later on, when secondary degenerative fatty and catarrhal changes have attacked the tubules, there is less urine, with a higher specific gravity, and a considerable amount of albumen The **spleen** increases in

* Amyloid disease may also be due to syphilitic infection, and it occasionally occurs as a complication or sequel of repeated attacks of acute rheumatism

† These are *never* ' waxy ' in the true technical meaning of the word

size, but not always to so great an extent as the other viscera, the Malpighian bodies being the chief seat of the change The capillaries in the **villi of the intestines** become lardaceous, and allow of an increased transudation of the fluid parts of the blood, resulting in diarrhœa, which may also be in large part due to the secondary catarrhal inflammation of the mucous epithelium which usually supervenes The absorption of nutriment is thereby much lessened, and thus both by increased excretion and diminished absorption of food the strength of the patient is steadily undermined It is most frequently seen in connection with long-continued suppuration in bone, but also occurs with phthisis and syphilis, especially when non-specific infection has been superadded

In cases of chronic suppuration, amyloid degeneration in the viscera, far from being a contra-indication to operation, is rather to be considered as a sign that radical treatment is urgently necessary, unless the general condition of the patient absolutely forbids it If by an operation, *e g* excision or amputation, the local disease can be eradicated, the amyloid change in the viscera, if still only in its earliest stage, may gradually disappear At the same time it must not be forgotten that the kidneys are likely to have been seriously damaged, and that antiseptics, such as carbolic acid, which are absorbed into the blood and eliminated in the urine, may light up an acute nephritis, possibly with fatal results

III **Focal Sepsis**

Much attention has been given of recent years to the widespread influence in the body of the absorption of organisms and their toxins from foci of **persistent bacterial infection,** whether suppurative or not Various forms of disease have been traced to this cause, and it is interesting to note that many of the organisms concerned are normal inhabitants of the mouth or intestine, and lead to trouble only when absorbed into the tissues The **resistance** of different patients varies, and may be seriously diminished by the long-continued action of the organisms upon the blood and blood-forming tissues Such chronic infections with streptococci, even when comparatively mild, not infrequently give rise to a leucopenia, combined with a varying degree of secondary anæmia

Such primary areas of **focal sepsis** may be found in various regions, but amongst the more important of these local lesions may be mentioned (1) **Dental sepsis,** due either to apical infection with associated bone lesions, or to **chronic gingivitis** or **pyorrhœa,** either superficial or deep The most important organisms present in these cases are streptococci of the non-hæmolytic types (see p 43) For the diagnosis of dental infections, and for the detection of buried septic roots, and unerupted teeth which may have become infected, a complete X-ray examination of the teeth and jaws is essential, and in this connection it should be observed that not merely the grosser changes produced by an apical abscess should be looked for as evidence of infection, but also such less marked changes as thickening, beading, or calcifica-

tion of the periodontal membrane, increased translucency of the fangs, especially their apices, the presence of pulp-stones, etc , such changes being never exaggerated, but rather minimized, in radiograms, as is proved by subsequent bacteriological investigation of such teeth When it is found necessary to remove several infected teeth, it may be wise to extract one tooth at a time, or only a few teeth, and not too large a number simultaneously (2) **Naso-pharyngeal sepsis,** generally associated with **chronic nasal sinus** trouble, is usually streptococcal, sometimes pneumococcal in origin, or may be due to a mixed infection (3) **Chronic tonsillitis** is often characterized by the presence of plugs of infective material buried deeply in the crypts and often encapsulated, although the tonsil itself may not necessarily be greatly enlarged, and may even be atrophied and sclerosed (4) Various **intestinal** lesions, such as chronic appendicitis, colitis, cholecystitis, etc , may lead to the absorption of micro-organisms and their products, and such are often themselves secondary to dental, naso-pharyngeal or other lesions, but may persist when these have been removed or cured (5) Chronic streptococcal lesions of the **urinary** and **genital tracts** in both sexes may produce similar results, for example in the cervix or Fallopian tubes in the female, or in the prostate or seminal vesicles in the male It may also be noted that streptococci in very small numbers may from time to time find their way into the circulation from such areas of focal sepsis, and be excreted from the blood by the kidneys, and thus be found in the urine if catheter specimens are taken with extreme care, and a sufficient amount of centrifugalized deposit is inoculated into suitable media In rheumatic cases this is most likely to be successful during an attack or exacerbation of the symptoms, as such streptococci may appear only intermittently in the urine An autogenous vaccine prepared from them is often of great value in treatment

Results of Focal Sepsis —Only a few results of the absorption of bacteria and their toxins from areas of focal infection can be mentioned here (1) The direct passage of bacteria from the mouth or naso-pharynx is likely to have an injurious effect upon the mucous membrane of the stomach or intestinal tract, and thus chronic gastritis, gastric or duodenal ulcers, appendicitis, or colitis are liable to follow, as also the extension of such infection along the biliary or pancreatic ducts, thus bringing about disease of the liver or pancreas, and perhaps leading to the production of gall-stones or of diabetes In this connection it is important to emphasize the necessity for careful treatment of teeth and disinfection of the oral cavity before all operations on the mouth, such as excision of the tongue or tonsils, and also prior to gastro-enterostomy

(2) The air-passages similarly may be infected by direct extension from oral sepsis, tracheitis with an abundant muco-purulent expectoration is often due to this cause, as is also aspiration pneumonia after an anæsthetic

(3) The effect upon the blood of chronic absorption of bacteria and their toxins is to produce a secondary anæmia, mild or severe in type Chronic infection, *e g* of the sockets of devitalized or 'dead' teeth,

with non-hæmolytic streptococci (*Str salivarius*, *Str mitis*, *Str fæcalis*, etc), which is so frequently associated with secondary 'rheumatic' and 'rheumatoid' manifestations, usually produces a varying degree of anæmia, especially a hæmoglobinæmia, accompanied by leucopenia Infection with hæmolytic streptococci, *e g* *Str pyogenes*, may also lead to a pronounced secondary anæmia, and leucocytosis may be present, though in bad cases a leucopenia affecting especially the polymorphs may supervene later

(4) As regards the body generally, there are few organs which cannot be markedly affected, and the possibility of absorption of toxic material from some hidden or obvious source or sources—for these are often multiple—should always be considered In particular, one would draw attention to the grave influence of such infections in the development of all the so-called rheumatic lesions, including synovitis, arthritis of many types, fibrositis, neuritis, perineuritis, endocarditis, etc The development of chronic osteo-arthropathy has long been recognized as dependent on toxic absorption, and modern ideas as to the origin and treatment of many chronic lesions of bones, joints, fasciæ, ligaments, and of the eye, etc, are an extension of the same principle

For treatment of the various lesions, see under special headings

IV **Cellulitis**

Cellulitis is a disease characterized by the existence of a spreading inflammation of the subcutaneous or cellular tissues, due to the activity of, especially, pyogenic organisms, and going on perhaps to suppuration, sloughing, or even to extensive gangrene

Causation.—The one essential is the infection of the cellular tissues with organisms These may have gained entrance through a wound or abrasion, or by spread from some already infected focus Deep infected wounds which are not properly drained are amongst the most favourable for the development of this condition, especially if the general health of the individual is bad, if he is suffering from albuminuria or diabetes, or if his surroundings are of an insanitary nature Where much loose cellular tissue is present, inflammatory phenomena may readily supervene, from the absorption of bacteria from neighbouring contaminated structures, *e g* pelvic cellulitis arising from an infected uterus, or cellulitis of the neck from an ulcerated throat

Bacteriology—The *Streptococcus pyogenes* is the organism most frequently found in cases of cellulitis, particularly when there is much tendency to spread In some of the more localized forms the *Staphylococcus pyogenes* is present

Clinical History—The symptoms necessarily differ according to the site of inoculation and the virulence of the organisms, and hence anything from a localized suppuration to the most acute form of spreading gangrene may result In a case of moderate severity, due, say, to a prick or abrasion which has become infected, there is often a period of quiescence for a day or two, and the site of inoculation shows but slight signs of inflammation, beyond being a little tender.

The patient at first may feel only slightly unwell, but the symptoms, both general and local, tend to become progressively more marked Fever is almost always present to a greater or less degree, and in the more severe types one or more rigors occur, or the temperature may be subnormal, owing to the intensity of the toxæmia The affected part becomes hot, tender, and swollen, if superficial, it looks red and angry, and feels brawny In some cases local hæmorrhages or petechial spots are found in addition to the other inflammatory phenomena The course of the case depends to a very large extent upon the treatment adopted, if freely incised, the process may become limited, and even although suppuration and sloughing occur, repair may be readily effected If, however, the infecting organism is very active, or the patient's power of resistance low, or if the inflamed area is left to itself or merely poulticed, the process may spread rapidly, and extensive destruction follow Intense pain and sleeplessness, accompanied perhaps by delirium, form the most prominent symptoms, and these, together with the toxic fever, rapidly exhaust the patient's strength Though often of slow development, definite and localized suppuration may at length occur, or the swelling may remain hard and brawny for some time in such a region as the neck, with no evidence of softening, so that it may be difficult to determine whether actual localized abscess formation has supervened or not The infiltrated cellular tissues are likely to slough, and in a limb extensive subcutaneous necrosis may occur, although the skin gives way only in places, hence it is often possible to pass a probe between the skin and the deep fascia over a considerable area Sometimes the chief focus of inflammation may be found at a distance from the original site of inoculation, whilst the intervening portion is but little affected, or shows the characteristic features of acute lymphangitis This is due to the organisms being transmitted along the lymphatics, and then arrested at some point further along their course Occasionally the infection spreads along the deeper areolar planes, or even along muscle substance, which may be infiltrated with pus or may actually slough In all these more severe forms the patient runs a considerable risk of developing general septicæmia or pyæmia

Treatment.—Careful attention to the principles of antiseptic and aseptic surgery can prevent the occurrence of cellulitis to a very large extent in casualty and operative work Any wound, whether deep or merely superficial, must, after the immediate application of tincture of iodine or other suitable antiseptic, be protected from further infection Should inflammatory phenomena occur, the application of warmth and moisture in the form of mildly antiseptic fomentations or poultices may be sufficient, whilst attention should be given to free action of the kidneys and bowels and to the general health If, however, a spreading cellulitis supervenes and suppuration is threatening, free incisions, *e g* in the long axis of a limb, should be made into the brawny tissues, so as to give exit to the serous and irritating discharges, but the deep fascia must if possible be avoided, and should not be incised unless the infection has already spread to the cellular tissue beneath it The wounds thus made are lightly packed with gauze

soaked in a hypertonic solution (*e g* 5 per cent salt solution, or 10 per cent glycerine and iodoform emulsion), over which the usual dressings are applied The object of this is to drain the fluids from the parts by capillary action, and hence an effective junction must be maintained between the gauze drain and the surrounding dressing It is often wise to incorporate a piece of sterilized gutta-percha tissue or mackintosh in the outer folds of the dressing, so as to keep the parts moist and encourage a free discharge Packing with gauze soaked in flavine is also useful, or the Carrel-Dakin method of treatment (p 69) may sometimes be employed with advantage Extension of the infection requires further incisions

After the bleeding caused by the incisions has ceased, the affected part should if possible be immersed several times a day in a warm bath for not more than two hours at a time, so as to dilute the toxins and render them innocuous Sterilized normal salt solution at a temperature of 105° to 110° F may be used, or weak solutions of iodine or eusol, but antiseptics are of comparatively little value in checking the disease when once started, the surgeon has to depend mainly on relief of tension, the removal of toxic discharges, and the antiseptic power of the tissues At the same time the utmost care must be taken to prevent any fresh or mixed infection, and immobilization of the part should be insisted upon whenever possible

The **general** treatment is that indicated for septicæmia (p 73), including the use of antistreptococcal serum and perhaps immunotransfusion The administration, preferably by the intramuscular route, of collosol manganese is often useful Plenty of simple nourishing food, with suitable vitamin content, is administered, and such drugs as are required to procure sleep and secure efficient action of the bowels, skin, and kidneys

Special Varieties of Cellulitis.

Cellulitis of the Axilla may be due to a local infection, *e g* incurred, say, during the removal of the axillary hair, but it not infrequently follows an infected wound of the hand, such as occurs at operations or post-mortems, and hence is not uncommon in medical practitioners, students or nurses It may also be caused by extension from an axillary lymphadenitis The tissues of the armpit become hard and brawny, the pain is severe, especially on movement of the shoulder, and the disease is liable to spread towards the chest wall under or between the pectoral muscles, it may also travel upwards, and, from sloughing of the capsule, invade the shoulder-joint, and so give rise to an acute arthritis

Treatment—Early and extensive incisions are required in order to prevent such complications, care being taken to avoid vessels and nerves It is most important in these cases that the arm should be kept away from the side in a fully abducted position, so as to guard against later fixation of the arm to the side by contraction of the cicatrix

Cellulitis of the Scalp usually results from a wound which has penetrated the occipito-frontalis aponeurosis, and reached the subjacent

layer of loose areolar tissue, it may, however, follow a simple laceration of the scalp and remain superficial In the latter case the scalp becomes red, œdematous, and tender, but the inflammation remains more or less localized, in the former, pus forms beneath the aponeurosis, and extends to its limits of attachment, so that abscesses are likely to point in the forehead just above the eyebrows, over the zygoma, or along the superior curved line of the occipital bone The whole scalp may become separated from the bone, and the patient runs a risk of necrosis of the cranial bones and of intracranial complications The scalp itself, however, rarely sloughs owing to its abundant vascular supply

Treatment —This consists in making early and free incisions parallel to the lines of the vessels

Cellulitis of the Orbit is not an uncommon sequel of penetrating wounds in this region, owing to the difficulty of disinfecting and draining them It may also be secondary to suppuration in the cranial venous sinuses The orbital tissues become infiltrated and swollen, the eyelids œdematous, and the eyeball pushed forwards (proptosis) The inflammation may spread directly to the meninges, or through the veins to the cavernous sinus Necrosis of the orbital walls may also occur, whilst the eye itself may suffer, either from an infective panophthalmitis due to lymphatic infection, or from optic neuritis secondary to retro-ocular inflammation and pressure, or, at a later period, from optic-nerve atrophy secondary to cicatricial contraction around the nerve If the cellular tissue of the orbit sloughs, the subsequent movements of the eyeball may be much hampered, or indeed lost, whilst the lids may be drawn back to such an extent as to prevent their complete closure

Treatment —No penetrating wound of the orbit ought to be closed if there is any question of its infection, indeed, it is often wise to increase its size slightly, so as to enable the deeper parts to be cleansed and drained If cellulitis follows, the original wound must be opened up, and possibly fresh incisions made either through the lid or through the fornix conjunctivæ Fomentations are then applied If panophthalmitis supervenes, the eyeball must be incised crucially, this is a safer proceeding than enucleation, which is more liable to be followed by meningitis

Cellulitis of the Neck is usually secondary to lesions of the mouth or throat, and may, for example, be associated with follicular tonsillitis, diphtheria, or scarlet fever, the process probably starting in a deep lymph-node, it occasionally follows operations on the neck, or may be due to suppuration in the mastoid cells If the infection is beneath the deep cervical fascia, the affected side of the neck becomes swollen, red, and brawny, severe pain of a deep tensive character is experienced, and this is increased by movements of the head or jaw The swelling is often peculiarly hard and resistant, and, although œdema may be present, it may be several days before the surgeon can detect any focus of softening suggestive of suppuration During this period the constitutional symptoms are severe, fever may be high, and the pain and consequent sleeplessness may exhaust the

patient, whilst the difficulty of swallowing hinders nutrition Dangerous symptoms arise from pressure on important vessels and nerves, from extension of the inflammation to the mediastinum or to the glottis, causing œdema and consequent dyspnœa, or from the supervention of pyæmia owing to venous thrombosis The process usually ends in sloughing of the cellular tissue and suppuration, the pus burrowing widely if a free exit by incisions through the deep fascia is not provided

Treatment—The causal lesion in the throat must be attended to, any operation wound freely opened up and drained, and the general condition improved by the administration of nourishing fluid food, stimulants, and quinine Antistreptococcal serum may also be injected, but sometimes antidiphtheritic serum has been found equally useful, immuno-transfusion may also help Locally, fomentations are applied at first, but on the onset of suppuration, or before, if the pressure symptoms are severe, or if the affection is obviously extending, free incisions must be made along lines of safety through the deep fascia, so as to relieve tension and give exit to discharges It must be remembered that the tissues are matted together in such a way as to render their recognition difficult, and inasmuch as the pus often lies deeply, the greatest caution has to be taken to avoid injury of important structures

Special interest has been directed to a form of this affection which occurs in the submaxillary region, and is known as **Ludwig's angina.** It is usually secondary to some focus in the mouth, or may occasionally result from the extension of inflammation through the capsule of lymph-nodes, or it may originate in disease of the middle ear, the infection spreading down along the posterior belly of the digastric The swelling in these cases extends forwards beneath the chin, and may involve the floor of the mouth and base of the tongue, pushing that organ forwards, and even making it protrude from the mouth Œdema of the glottis may supervene, or a sublingual abscess form Treatment is similar to that indicated above, and one or more incisions may be required Œdema of the glottis will probably require tracheotomy

Pelvic Cellulitis is an infective inflammation of the loose cellular tissue which ensheathes the pelvic viscera It may result from any penetrating wound, accidental or operative, which encroaches on this region, *e g* extraperitoneal rupture or perforation of the bladder, suprapubic or lateral lithotomy, injudicious catheterization, curetting the uterus, and it is a common sequel of unskilled attempts to induce abortion It may also be due to the spread of bacteria from any of the pelvic viscera, *e g* the bladder, prostate, rectum, uterus, or Fallopian tube It is associated with all the local and general signs of deep inflammation, and often, indeed, with peritonitis, giving rise to a tense, firm, painful swelling, to be felt *per rectum* or *per vaginam* and sometimes to an indurated mass of inflammatory effusion, dull on percussion, above the pubic arch Abscesses may form, bursting either externally above Poupart's ligament or into some of the viscera, or possibly in both directions, producing intractable forms of urinary

or fæcal fistulæ, whilst venous thrombosis and pyæmia from the breaking down and dissemination of the infected blood-clot are likely to develop

Treatment—The surgeon may be called in to such cases in the early pre-suppurative stage, when rest, limitation of diet, small doses of opium, and fomentations to the hypogastrium, with hot rectal or vaginal douches, should be adopted At a later stage, when pus has formed and the abscesses need to be opened, an incision is generally made just above Poupart's ligament and close to the pubic spine, the abdominal muscles are divided to a sufficient extent to enable the surgeon to work downwards between the transversalis fascia and the peritoneum, which, in the female, must be pushed aside in order to reach the broad ligament, where pus is frequently found As soon as the subperitoneal tissue is opened the knife should be discarded, and only blunt instruments or the fingers employed The cavity of the abscess should be efficiently drained, and for this a counter-opening through the vagina may be required

Intestinal obstruction from the contraction of cicatrices may develop as a remote sequel of such cellulitis, and hydronephrosis may arise in the same way from pressure on the ureter

V **Wound Infection.**

When a wound, whether accidental or operative, has become infected with micro-organisms, healthy repair is retarded or may even cease, and is replaced by an inflammatory process usually of a suppurative type In accident cases, wound infection is often unavoidable, due to the dirty state of the skin or the nature of the accident, and, however thorough the subsequent disinfection, it may be impossible to render the parts sterile Still more does this hold good in military surgery In operative work wound infection in a previously non-septic case is usually due to some avoidable mistake or oversight, only occasionally to auto-infection Ineffective sterilization of silk or catgut is perhaps the most frequent cause, since the introduction of rubber gloves has largely safeguarded the patient from infection from the hands of the surgeon and his assistants Devitalization of the tissues as a result of rough handling or prolonged exposure and faulty hæmostasis are, however, important predisposing elements The organisms present are exceedingly variable, as might be expected In post-operative cases staphylococci are usually found, but the worst cases are generally due to streptococci or to a mixed infection In casualty and still more in military work a mixed infection is generally present, often including anaerobes, as well as the above

The **local** trouble may manifest itself merely as an acute or subacute suppurative process within the wound, or as an active cellulitis spreading into the adjacent tissues

In post-operative cases it may commence deeply around a buried stitch, or more superficially In the latter case the lips of the wound look red and puffy, the tissues often swell up between the stitches, which look as if they had become too tight, and on introducing a

probe pus may escape, the patient complains of pain, usually of a throbbing nature, and there is some rise of temperature and in bad cases even a rigor In the milder forms, the changes are limited to the immediate neighbourhood of the wound, but, if neglected, or in an unhealthy subject, or if due to virulent organisms, the phenomena of an acute cellulitis may supervene

When the process starts in the deeper parts of the wound, nothing may be obvious for a few days, except perhaps some fulness and tenderness on pressure, together with some slight rise of temperature Sooner or later an abscess develops and may come to the surface, in which case a sinus is likely to be left until the offending material, *e g* a ligature or buried stitch, has been absorbed or removed The same holds good as regards silver wire, screws, plates, etc , which, when implicated, must be removed before healing can take place

Cases due to accident are often seriously complicated by the carrying in of infected material, such as portions of the patient's clothing, soil from the road, dirt or grease in machinery accidents, etc , and the bacteria derived therefrom, or from the patient's skin, find an abundance of suitable material for their development in the torn and damaged tissues The results of such contamination necessarily vary with the depth to which the lesion has extended, and may consist of sloughing of and suppuration in and amongst the various structures affected Pus tends to track and burrow along opened-up planes of tissue, and the swelling of the more superficial parts aggravates the condition by hindering mechanically the escape of exudate from the deeper parts

The **General Phenomena** connected with wound infection vary chiefly with the nature and virulence of the infecting organisms, whether these produce active toxins, and whether or not the blood itself becomes invaded

1 **Toxæmia**—This results from the absorption of toxic material from some focus of infective inflammation of sufficient extent and virulence A small collection of pus under pressure is capable of giving rise to marked toxic symptoms, whilst in spreading inflammations, such as erysipelas and other forms of cellulitis, the manifestations are often of a grave type The same is true of infective inflammation of the peritoneal cavity, especially when the upper half is involved, since the communication with the lymphatics of the diaphragm is very free Toxæmia is not infrequently associated with a true septicæmia, and clinically it may be almost impossible to distinguish between the two

The **Symptoms** are fever (except in some of the gravest cases, when the temperature may be subnormal, although the pulse may still remain high), accompanying loss of appetite, a dry tongue, a quick pulse rapidly becoming weak, severe headache, and perhaps delirium The patient is at first constipated, but vomiting and diarrhœa may ensue from gastro-intestinal irritation, followed, it may be, by exhaustion, collapse and death, the latter perhaps preceded by coma Dyspnœa from pulmonary congestion and the action of the toxins upon the myocardium, and albuminuria, also occur Effective treatment of the cause, as by opening an abscess or drainage, may lead to

a speedy disappearance of the symptoms, but in spreading inflammation the toxæmia may not subside for some time Should an attack prove fatal, the post-mortem manifestations are practically identical with those of a septicæmia, but the blood is free from infective bacteria

2 **Septicæmia**—Should the organisms not only develop in the tissues, but also find their way into the blood, septicæmia results (p 74), but the stage at which the latter supervenes is in individual cases not easily determined

3 **Pyæmia**—Bacteria may escape into the blood, not only as detached invaders, as in bacteræmia and septicæmia, but occasionally in septic emboli, giving rise to pyæmic abscesses (see p 76), and these abscesses may thus be found in a patient who also shows obvious signs of acute toxæmia

The Local Treatment of an Infected Wound necessarily varies with its situation, the length of time which has elapsed since the infection and with the conditions present

In a Mild Post-operative Infection the relief of tension and the application of warmth and moisture to the part to encourage the local reparative activity of the tissues usually suffice Stitches, both superficial and deep, must be immediately removed, and the wound widely opened up so as to give free exit to the discharge Undue interference, as by scraping, squeezing, syringing, etc , is to be deprecated, as thereby the infection may be disseminated It is futile to apply strong antiseptics, since the organisms have penetrated into the tissues and cannot be destroyed without also involving these structures, moreover, the phagocytic power of the leucocytes is thereby checked Some of the more modern antiseptics, such as the hypochlorites or flavine, are less objectionable and may be useful on occasion, but it is possible that the benefits which follow their judicious employment are due to causes other than their antiseptic qualities

Sloughs may be cut away, but generally are left to separate by natural processes, assisted perhaps by the use of hypertonic substances, such as gauze soaked in salt solution (5 per cent), or glycerine and iodoform (10 per cent emulsion) If there is a considerable cavity in the depth of the wound, it may be desirable to drain it by introducing a strip of sterilized rubber glove or a rubber drainage-tube Otherwise the wound is lightly packed, and warm moist applications, *e g* boracic fomentations, are applied In Ludwig's angina, the pathological process is mainly concentrated in the plane subjacent to the mylohyoid muscle, and the tension cannot be completely relieved without transverse section of the fibres of that muscle The bowels must be freely opened, and attention paid to the general health of the patient In a few days, when granulations have formed, the wound may be irrigated with normal salt solution or swabbed out with peroxide of hydrogen Healing is finally brought about by granulation, but can sometimes be hastened by strapping the edges of the wound together, or by grafting

If such a régime does not suffice to stop the process, the wound must be still further opened, and the spreading infection followed up—in fact, it is treated as a cellulitis Sometimes great benefit is derived

If at the end of two or three days the infective process is active and numerous bacteria are present, then treatment as for cellulitis by one or other of the methods indicated below must be carried out, and healing occurs by granulation, assisted perhaps by grafting or hastened by **Late Secondary Suture.**

The treatment of broken bones is not described here, but if present they must be dealt with in accordance with the plans outlined in Chapter XX

The **Carrel-Dakin Treatment of Wounds** is dependent on the antiseptic properties of the hypochlorites, especially of Dakin's solution, which destroy bacteria, but do no serious damage to the phagocytic activity of the leucocytes or to the reparative power of the tissues It is essential to open up and cleanse all the depths of an infected wound, dead and badly damaged tissues are removed, but it is not always necessary to provide dependent drainage, and indeed the wound which can be most readily treated by this method is one which can be kept full of the solution Multiple rubber tubes with a calibre of 4 mm and of suitable length to command all the depths of the wound, entering into all pockets, are introduced and kept in place by strips of gauze, soaked in Dakin's solution, placed amongst them and between them and the walls of the cavity These tubes are closed at one end, but perforated for a variable distance by minute apertures (Fig 21), in a large wound it is possible that six, eight, or even twelve such tubes may be required Their free ends are gathered up by glass connections (single to four-fold) which link them by larger tubes to one or more reservoirs above the bed, from which a limited quantity of Dakin's solution is allowed to escape every two to four hours so as to irrigate the wound If no reservoir is available, a syringeful of the antiseptic is squirted down the main tube, a clip is subsequently placed on this tube so as to prevent regurgitation, and thereby ensure the escape of the fluid through the tiny perforations into the depths of the wound The tubes pass to the wound between layers of gauze soaked ... the solution and through a sheet of sterilized non-absorbent wool in a gauze cover The Dakin's solution is sometimes irritating to the skin, especially if free alkali is present, and to prevent this the parts around the wound should be protected by layers of gauze infiltrated with sterilized vaseline The amount introduced need not be great, but provision has to be made to prevent the bedding from getting wet, as the solution has a damaging effect on bed-linen When the healing is progressing satisfactorily, and secondary suture is not contemplated, a chloramine ointment is useful It should consist of Chloramine-T, 10 parts, stearate of soda, 86 parts, and water, 4 parts

When properly carried out, this treatment is most valuable, but it requires very careful organization of technique and efficient assistance The bacterial content of the discharge from the wound is tested from time to time, and, as the hypochlorite takes effect, the number of organisms gradually diminishes until in ten to fourteen days, perhaps, only one bacterium may be found in several microscopic fields of the smear The wound is then regarded as clinically sterile, and secondary suture may be adopted The absence of fever and toxæmia

is remarkable, the patient's sufferings are much reduced, the amount of reactionary injury to deeper tissues is minimized, and hence repair is more rapid and accompanied by less mutilating disabilities and disfigurements than under other circumstances The opportunity of undertaking secondary operations on damaged nerves or bones at an early period is of great value

Treatment with B.I.P.P. (Bismuth-Iodoform-Paraffin-Paste) is simple and valuable It consists in opening up and cleansing the wound mechanically by excision of damaged tissues or friction with gauze swabs Complete hæmostasis must be secured, and the wound is then swabbed out with alcohol The surface is rubbed over with swabs, covered with an antiseptic paste consisting of bismuth subnitrate, 1 part, iodoform, 2 parts, and sufficient liquid paraffin to make the paste of the consistency of clotted cream In preparing the paste, each element must be previously sterilized, the iodoform by washing with 1 in 20 carbolic lotion, the bismuth and paraffin by dry heat at a temperature of 120° C for half an hour The bismuth and iodoform are mixed in a sterile mortar, and the paraffin is slowly added and well stirred, so that no lumps or gritty masses occur The B I P P should be gently but thoroughly applied to the surface of the wound, being carefully rubbed in with a sterilized swab, especially into the muscles, so that a thin film covers all the tissues, lumps of the paste must not be left in the depth of the wound, and no undue quantity must be employed for fear of toxic symptoms, a drachm is usually quite sufficient even for a large cavity If the wound shows no tendency to ooze and its condition appears to be otherwise favourable, complete suture without drainage may be adopted In less favourable conditions the wound is left open and packed with sterile gauze, unless any special cause for re-dressing supervenes, the wound is left for five or six days, on removing the gauze the wound looks very dirty, being covered with a mixture of pus and paste, but on washing this away with sterile salt solution the surface should now appear healthy, and granulations be found beginning to form. A similar dressing is reapplied, and may often be left for another period of five or six days, when reparative activity should be fully established

Secondary suture is often possible in these cases, the skin around is thoroughly cleansed, and the margins excised and undercut for a short way The granulations are freely curetted, bleeding is stopped completely, the surface is swabbed out with ether or alcohol, and carefully 'bipped', sutures are introduced, buried ones of catgut to close muscular gaps, and deep ones of silk or silkworm gut to command the main wound, whilst fine catgut stitches bring the margins of the skin into accurate coaptation

Some surgeons, especially in the United States, consider it bad practice to close a wound suspected of being infected and to rely on some incorporated antiseptic such as B I P P to prevent infection If there is the slightest doubt a drain is used, and efforts are directed toward the production of a lymphorrhœa from the wound by the use of hypertonic salt solution

Toxic symptoms have occasionally occurred as the result of the employment of B I P P, chiefly from bismuth poisoning A blue discoloration of the gums occurs, which may also appear on the mucous membrane of the cheeks and tongue Gastro-intestinal disturbances may also sometimes arise in the form of colic and diarrhœa, and a few fatal cases have occurred, ulceration and sloughing of the sigmoid have been found in some of these Care must also be taken that the paraffin is pure, some cases of irritation around the margins of the wound have been traced to imperfectly refined paraffin

Finally, it must be pointed out that the presence of this paste in the wound interferes with X-ray examinations, since bismuth casts a shadow, and that excess of the paste may lead to a persistent sinus or even to a secondary abscess which can heal only when such excess has been discharged

The use of the aniline dye, **Flavine,** in a solution of 1 in 1,000, has been advocated by some who claim that its antiseptic powers are enhanced by the presence of blood-serum (which hinders the action of the hypochlorites), that it has no deleterious effect on phagocytosis or tissue activity, that it is a stable non-toxic compound, and that its effects in a septic wound are most marked when gauze soaked in a solution of the dye is kept in close and persistent contact with the tissues Bacteria are said to be quickly destroyed and wound sterilization rapidly accomplished Most observers, however, do not agree with these claims, but maintain that, whilst the exudation of pus is checked or aborted, the process of repair is also delayed and the growth of epithelium hindered, so that, at the end of a week, although there may be no pus in the wound, yet the surface looks much as it did at the start, after a time a yellowish film or pellicle forms in which the superficial layers of the exposed tissues are incorporated, and the wound takes on the appearance of a callous ulcer If now the flavine is discontinued and other applications, such as normal salt solution or eusol, are substituted, the wound as a rule quickly assumes a healthy aspect

Sir Almroth Wright's Physiological Method of Treating Wounds with a hypertonic or isotonic solution of sodium chloride was introduced during the Great War because of the difficulties encountered in applying the ordinary aseptic and antiseptic measures for dealing with wounds found sufficient in civilian work, the delay often experienced in bringing the wounded under treatment allowing extension of the infection

The chief means of cure when such an infection has once developed reside (1) In the lymph, which when fresh has decided antibacterial properties and also considerable anti-tryptic power, this latter increases rapidly in an infected person, but is lost if the lymph becomes ' stale ' (2) in the leucocytes with their phagocytic powers, bringing to an end bacterial activity, and thereby encouraging reparative changes (3) in the tissues, which, when once the bacteria are seriously weakened, assert their natural tendency to repair

The agent recommended by Wright for counteracting the deleterious processes at work in the wound and for stimulating the reparative

activities is a solution of sodium chloride, either hypertonic or isotonic *

Hypertonic salt solution (5 or 10 per cent) acts beneficially in several directions (1) It encourages lymph drainage of the tissues, and thereby not only removes stale lymph and replaces it by fresh and active lymph, but also restores the vascular supply of the tissues by modifying the 'lymph-bound' condition of the parts (2) It also limits leucocytic emigration and therefore reduces the amount of pus excreted (3) It disintegrates any leucocytes with which it is brought in contact, and sets free a limited amount of trypsin in the wound which can act upon the sloughs and loosen them by erosive digestion, this power is held in check by the anti-tryptic influence of healthy lymph From these facts it is obvious that hypertonic salt solution will be of most value in the treatment of the earlier stages of an infected wound There comes a time when its beneficial influence is lost, and indeed it may be positively harmful, and then the surgeon may wisely employ the **isotonic** or **normal salt solution** (0 85 per cent), which attracts leucocytes and favours phagocytosis

The value of the application of hypertonic solutions to infected wounds cannot be denied, but it is not only sodium chloride solution which thus acts beneficially Other agents, such as glycerine, as in the old-fashioned iodoform emulsion (10 per cent), and perhaps Dakin's solution, act in this way It must be admitted, however, that some surgeons attribute these benefits, not to the osmotic action, but to the continued moisture, which loosens any dried clot or lymph on the surface, and permits a more abundant flow of lymph from the tissues

The method of application of hypertonic solutions varies widely with the character of the wounds In accessible superficial lesions all that is needed is to apply to the surface moderately thick pads of sterilized lint or gauze soaked in the solution, and keep them covered with a layer of jaconet This dressing is renewed frequently In other cases where repeated changing of dressings may do harm, the lint or gauze is kept moist by allowing the solution to drop on to it from a suitable reservoir In deep wounds the solution may be carried into the deeper part by tubes and allowed to escape from the wound on the Carrel system

Wounds treated in this fashion rapidly take on a characteristic appearance They become clean, of a pink colour, and are covered by a thin layer of granulation tissue from which little or no pus is

* The influence upon the tissues of various fluids brought into contact with them differs with their specific gravity and density, and may be illustrated by the effect on red blood-corpuscles of varying strengths of salt solution An isotonic solution (0 85 per cent) has no osmotic pressure on either side, and the red cells remain unharmed A hypertonic solution (5 per cent) exercises considerable osmotic pressure or attraction of fluid towards the solution itself, and fluid is withdrawn from the red cells, which become shrunken and crenated A hypotonic solution, on the other hand, allows the cells to absorb fluid to such an extent that they swell up and burst, and thus the injurious influence of plain water on the tissues is in part explained It is only necessary to irrigate the nasal fossæ firstly with normal salt solution, which is comforting, and then with plain warm water, to appreciate the irritating influence of the latter agent on the tissues

discharged The organisms, too, are greatly reduced in numbers Such wounds heal slowly, if at all, unless the hypertonic is replaced by normal saline solution, and then the surface of the wound becomes greyish and discharges a considerable amount of pus, but granulation quickly occurs and healing goes on satisfactorily

It must not be forgotten that Wright himself admits that dead spaces in the tissues, *i e* spaces in which pus can collect, must be effectively opened up and drained before any good can follow the use of hypertonic salt solution, and it is not improbable that much of the value of his method depends on suitable removal of dead tissues and effective mechanical drainage of the wound, and these have long been recognized as constituting essential elements in the treatment of infected wounds

VI Septicæmia

Septicæmia is the condition of infection of the blood by bacteria and their proliferation therein It differs from pyæmia in the absence of secondary abscesses (although, as explained later, it may be associated with it), and from toxæmia by the fact that the latter is due merely to the absorption into the blood of toxins generated in a diseased focus in which the bacteria themselves remain localized In other cases, again, the process is rather that of an overflow phenomenon, in which the organisms gain access to the blood-stream from some septic focus, but do not proliferate in the blood itself—a condition to which the term **bacteræmia** is now applied In both septicæmia and bacteræmia the organisms circulate in the blood, though in many cases, especially of bacteræmia, in but scanty numbers, and periods may occur in which no bacteria can be detected in the blood, so that too much weight should not be attached to a single negative bacteriological result, which has been obtained from the cultures of only a few c c of blood

Bacteriology—The commonest causal organisms are streptococci (p 43), which are almost always present in puerperal septicæmia and in ulcerative endocarditis Next in frequency is the *Streptococcus pneumoniæ* (or pneumococcus) Staphylococci are also fairly common organisms in this condition, and the prognosis may then be rather less grave

Rarer causes are *Bac coli* and allied organisms, Bacillus pyocyaneus (*pseudomonas pyocyanea*) and the gonococcus (*Neisseria gonorrhœæ*) It may also be noted that the specific organisms of certain of the acute infective fevers, *e g* typhoid and paratyphoid, may be found in the blood, especially in the earlier stage of these infections, whilst the septicæmic forms of anthrax and plague are conditions of the utmost gravity and often prove fatal

Clinical History—Septicæmia occurs most commonly from direct inoculation with virulent streptococci through small lesions, such as post-mortem wounds, or from scratches or punctures with infected pins or instruments, in rarer cases it follows operation wounds and severe lacerated injuries It is the usual accompaniment or sequel of acute spreading gangrene, and may occur in cellulitis and cancrum

oris Frequently the individual attacked is already in a debilitated condition and the inherent germicidal activity of the tissues thus insufficient to cope with the inroads of the infection

The **Local Changes** at the site of inoculation may take the form of an acute lymphangitis, some type of cellulitis or spreading suppuration, or even an acute spreading gangrene In virulent types local symptoms may be absent

The **General Symptoms** are those of fever, often ushered in by a distinct and severe rigor, the temperature reaches 104° or 105° F and usually remains high, with but slight remissions and no intermissions Malaise is present, with loss of appetite, and the tongue is brown and parched The pulse is quick and feeble, the heart-sounds are weak, and the heart itself dilated The skin has often a slight icteric tinge, and petechiæ may be present Diarrhœa usually ensues, and the fæces may be blood-stained, whilst the urine is albuminous and contains blood The patient may, after a period of delirium, become comatose, and die Dyspnœa sometimes precedes such fatal issue, whilst the temperature may be exceedingly high, or occasionally subnormal, the association of a low temperature with a very rapid pulse is always of grave import Leucocytosis is usually present and well marked in the earlier stages, but is absent in the worst cases and towards a fatal issue, even under these circumstances there is a relative increase in the number of polymorphonuclears

When a case takes a more favourable course after the local focus of infection has been effectively dealt with, and perhaps suitable serum and vaccine treatment adopted, the temperature falls gradually, and the patient slowly returns to health

Diagnosis—It is sometimes a matter of considerable difficulty to differentiate cases of septicæmia from those of some of the more virulent forms of the acute exanthemata before the characteristic appearances of the latter are manifested Acute toxæmia is always associated with some focus of infection, but may be so severe as to cause grave anxiety for a time as to whether or not septicæmia is present If, however, it is possible to open up and drain the infected area, the rapid disappearance of the fever indicates that the cause was probably merely a local, and not the more serious general, affection A blood examination by cultural methods (see p 33) may assist in clearing up the diagnosis From pyæmia, septicæmia is differentiated by the absence of repeated rigors and secondary abscesses

The **Prognosis** of acute septicæmia is always very grave, especially when due to hæmolytic streptococci (chiefly *Streptococcus pyogenes*)

The **Treatment** of such cases in which the infecting organism is a **hæmolytic streptococcus,** *i e* belongs to the *Streptococcus pyogenes* group, has been revolutionized by the recent discovery and use of drugs of the sulphonamide group Other forms of chemotherapy, such as mercurochrome, eusol, quinine, etc , are useless and may be harmful, as they interfere with the phagocytic activity of the leucocytes Treatment will further consist in dealing immediately and actively with any local focus of inflammation, either by free incisions and drainage, hot baths, or amputation if such seems desirable

uppurative foci in the liver, spleen, kidneys, brain, and in or around ones and joints, etc If, however, the causal phlebitis is situated in he portal area, the emboli become lodged primarily in the liver, giving ise to acute suppurative inflammation of the portal vein (**pylephlebitis**) Vhen the emboli are many in number, the symptoms are severe, constituting **acute pyæmia**, this is sometimes associated with the presence f micro-organisms in the blood, producing **pyo-septicæmia**, the patient erhaps dying before the secondary abscesses have fully developed n other cases the general symptoms are due rather to the absorption of toxins from the local foci than to the organisms in the lood

Clinical History —The most marked symptom indicating the onset f **Acute Pyæmia** is the occurrence of a severe rigor, which is repeated vith a sort of irregular periodicity, *e g* at intervals of about twenty-our to forty-eight hours, somewhat simulating an attack of ague The rigors do not differ from those occurring in other diseases, but hey are very severe, and usually followed by profuse sweating Between the rigors the temperature may fall to normal, but more ommonly remains above it The skin is hot and soon develops an arthy or dull yellow tint, together with erythematous or petechial atches A sweet, mawkish, hay-like smell of the breath is very haracteristic Grave prostration supervenes, and the patient rapidly vastes The pulse becomes soft and weak, the excretions are diminshed, and a certain amount of nocturnal delirium is noticed, but not ecessarily loss of consciousness The presence of a bruit in the preordial region may suggest the existence of an infective and ulcerative ndocarditis, which is not very uncommon The condition of the ongue varies, but is often red with very prominent papillæ, and ecomes dry and brownish

Towards the end of the first week secondary abscesses appear, they re sometimes unaccompanied by local pain or tenderness and form very rapidly Joints are not infrequently involved, and may fill with us, with little or no pain, unless treated early, rapid disorganization nd dislocation may follow The effusion may be puriform, or thin nd viscid, it is always, however, swarming with organisms In the viscera the abscesses are as a rule small and numerous, if they occur in vital organs, such as the heart or brain, death may result from their ocal development They are characterized, at first, by the almost otal absence of a barrier of granulation tissue, and hence, even when pened early and aseptically, are likely to extend and continue to form us, instead of following the usual course of rapid repair which succeeds the aseptic opening of an ordinary acute abscess Any of the erous sacs, and the meninges, are apt to become involved, and widespread suppuration occur in them

Not uncommonly in these cases painful patches occur here and here in the subcutaneous tissues, accompanied by hyperæmia, which fades away after a few days These are probably due to the presence of small infective emboli, which the patient has sufficient vitality to overcome without suppuration

In **Chronic Pyæmia** the febrile symptoms are much less marked,

the abscesses may be few in number, and not of immediate danger to life unless forming in important structures

The condition of an external wound which has given rise to pyæmia may show the following characteristics It gapes open and presents an indolent, dry, glazed surface, lacking in the production of the layer of healthy granulations which, on account of the germicidal power of its constituent cells, should form a barrier against the diffusion of the organisms, any newly-formed scar-tissue actually produced tending to break down If the disease arises in connection with bone, the latter structure may be seen lying bare at the bottom of the wound, denuded of its periosteum, and the cancelli filled with sloughy, fœtid and disintegrating marrow and pus In cases of bronchiectatic and other varieties of lung abscess, secondary abscesses analogous to those of a pyæmia are of not uncommon occurrence in the brain

Pathological Anatomy —The veins leading from the infected area are usually in a state of phlebitis, the coats are thickened, and the lumen is filled with soft, pale, disintegrating clot, which may extend for a considerable distance, the tissues surrounding the vein are also involved in the suppurative process (periphlebitis) Secondary abscesses are found in various parts of the body, most frequently in the lungs, and the consecutive stages in their formation can be clearly demonstrated, from the embolic colonies of bacteria, usually micrococci, through the stage of hæmorrhagic infarction to the complete abscess The general signs common to all cases of death from toxæmia (p 65) will also be manifest

The **Diagnosis** of pyæmia should not be difficult in the majority of cases, but, when it originates without any obvious external wound from a deep-seated focus, or if the importance of some local lesion has not been appreciated, the initial symptoms may be mistaken for those of acute rheumatism, malaria or pyelitis

The **Prognosis** depends upon the inherent vitality of the patient and the virulence of the disease In acute cases it is extremely grave, probably terminating in a week or ten days, whilst in the chronic type recovery is not only possible, but even probable, if the local abscesses are favourably situated

The **Local Treatment** consists in preventing, if possible, the further dissemination of infected emboli and contamination of the general blood-stream A typical illustration of such treatment, which may be carried out with a prospect of success, is that adopted for infective phlebitis of the transverse (O T lateral) sinus complicating disease of the middle ear, where, after tying the internal jugular in the neck, the sinus is exposed, opened, and all the infected clot removed, partly from above, partly from below Where such treatment is impracticable, all that the surgeon can undertake is, by free incision, to relieve tension in the primary focus and prevent any further or secondary infection by careful attention to asepsis In some cases amputation will be necessary The abscesses must be dealt with, when possible, by early opening and drainage, or by aspiration, such wounds often heal well, and joints which have been distended with pus may

recover with free mobility Aspiration, if practicable, is preferable to incision Occasionally, however, although asepsis has been maintained, the suppuration continues, and even sloughing of the abscess-wall may follow If the general condition can be improved, a barrier of granulation tissue will form in time, and repair be established

The **general** treatment is similar to that for septicæmia (p 74)

CHAPTER V

ULCERATION AND GANGRENE.

Ulceration may be defined as the process which gives rise to a loss of continuity in the skin or mucous membrane, due to a gradual necrosis of the tissues, and which results in the formation of a sore or **ulcer.** The dead tissue, which becomes separated from the living during the process, is termed a **slough**

Necrosis is the term applied to the death and degeneration of a group of cells together with their intercellular tissue When the process is occasionally limited to the cells, without involving the intercellular tissue, it is called **necrobiosis.** This latter condition is best exemplified in the glandular organs, such as the liver, in which the cells may die as a result of some toxin without disturbing the supporting structure But, in general, the term 'necrosis' is applied to all types of cell death irrespective of whether the process is limited to individual cells or takes place *en bloc*

Gangrene is the term applied to tissue necrosis which is accompanied by putrefactive changes It follows, therefore, that gangrene can never be, strictly speaking, an aseptic process, although the term aseptic is sometimes applied to certain types of gangrene in which the putrefactive phenomena are reduced to a minimum The factors which control the development of these putrefactive changes are mainly two in number—namely, the presence of organisms and the quantity of fluid within the affected organ at the time of onset of the gangrene A normal or excess amount of tissue fluid forms a good pabulum for the development of bacteria, hence the dry type of gangrene is usually associated with minimal septic changes and the moist type with the reverse In the case of the liver, necrosis may remain as such without the development of gangrene for an indefinite period, because it is shut off from contact with putrefactive organisms, but in the case of a limb, the outer covering of which is permeated with saprophytic and other types of organisms, necrosis of any extent is soon followed by the onset of gangrene

Causes of Ulceration.

The causes of ulceration may be grouped under four headings—mechanical, bacterial, vascular and trophic, and malignant

Mechanical.

1 Trauma
2 Thermal agencies
3 Chemical irritants
4 Electrical agencies
5 Radio-active emanations
6 Prolonged pressure

Bacterial.

1 Non-specific bacteria
2 Specific bacteria tuberculosis leprosy, syphilis, soft chancre typhoid, amœbic
3 Parasitic affections

Vascular and Trophic.		Malignant.
1 Vascular	Arterial, *e g* endarteritis obliterans, embolism Venous, *e g* varicose veins, thrombosis	1 Rodent ulcer 2 Epithelioma 3 Carcinoma 4 Sarcoma
2 Trophic	Tabes, syringomyelia, diabetes	

We do not propose in this chapter to deal with all types of ulceration, and those due to malignant disease and specific bacteria will be discussed in the chapters dealing with these subjects Simple ulceration may be caused by any form of surface irritant, but any of the factors which predispose to inflammation facilitate its development Faulty nutrition of a part, whether from defective local vascular supply or from long-standing congestion, is particularly liable to further the ulcerative process, thus, in the lower extremity there is a predisposition to its occurrence from, on the one hand, arterial disease which leads to a diminished blood-supply, or, on the other, from the passive congestion due to varicose veins General debility, such as results from various forms of anæmia, Bright's disease, diabetes, etc , will also favour the occurrence of ulceration Moreover, when any part becomes anæsthetic, or is cut off from its trophic centres, the continued presence of an irritant may not be appreciated, and hence destructive inflammation occurs, for example corneal ulcer following sensory root section of the fifth nerve or perforating ulcer of the foot in tabes hot bottles applied to the feet or elsewhere in old people or in persons suffering from nervous lesions, *e g* of the spinal cord or peripheral nerves Prolonged pressure will also cause ulceration and is the cause of bed-sores In malignant disease the projection of the mass of the growth may expose it unduly to irritation, but the chief cause of ulceration is the replacement of the deeper layers of the skin or mucous membrane by the cells of the neoplasm, so that, partly from interference with their blood-supply, and partly by their infiltration and destruction by the tumour, when the superficial epithelium wears or sloughs off, it is not reproduced

Pathology.

The simple type of ulcer tends to pass through three stages from the start to the time when it is healed These three stages are the following (1) The stage of ulceration proper or extension, (2) the stage of transition or preparation for healing , (3) the stage of healing or repair The first stage alone represents the true ulcerative process, although in a larger ulcer the three stages may co-exist

Stage I., Ulceration Proper, or Extension.—The special characteristic of this stage is that destructive changes are progressing with greater or less rapidity, and hence the ulcers may be described as inflamed, spreading, or sloughing

Naked-eye Appearances.—The surface is covered with ashy grey or dirty yellow material, partly slough, partly lymph, partly breaking-down tissue, no granulations are present, the discharge being usually

considerable in amount, thin, serous or slightly sero-purulent, and often irritating and offensive, less frequently purulent The margins are thickened and inflamed, and the surrounding tissues often œdematous and infiltrated the edge sharply cut and well defined, and the base of the ulcer thickened and fixed to the underlying structures In fact, the phenomena are those of an acute spreading superficial inflammation, which terminates in tissue destruction

Stage II. The Transition Period is concerned mainly with the separation and removal of sloughs and the preparation for repair It is a variable stage, which may be short or long, depending on whether the ulcer is running a rapid or slow course, and may persist until after the whole surface is covered with granulations

Naked-eye Appearances.—When the destructive process has ceased, the surface of the ulcer begins to clean, and becomes, as it were, glazed over, sloughs separate or are absorbed The discharge becomes less abundant, and the angry red blush is replaced by a rosy hyperæmia The infiltration of the base diminishes, so that the tissues around are less fixed and more supple The film on the surface becomes more defined, and in the course of time, shorter or longer according to circumstances, little red vascular spots appear, which gradually increase in number and size, and coalesce, until the whole surface is covered by what has now become granulation tissue The processes occurring in this stage are (*a*) the removal of sloughs, (*b*) the covering of the surface with a cellulo-plastic exudate, and (*c*) the vascularization of this, and its conversion into granulation tissue These do not necessarily go on equally all over the surface at the same time, and thus much variety in its appearance may be manifested

Stage III, The Process of Repair, follows on the transitional stage At this time the ulcer is characterized by the following conditions The surface is smooth and even, shelving gradually from the skin, and covered with healthy granulations, these present a florid red appearance, are painless, and bleed, but not too readily, on being touched The discharge is merely serous if the surface is kept at rest and free from all irritants, but, should it become infected, or be dressed with irritating antiseptics, ordinary pus is formed The surrounding skin is soft, flexible, and free from congestion, and the base is similarly free from fixity The margins present a healing edge, which has been described as manifesting three coloured zones within is a red area consisting of granulation tissue, covered by a very delicate layer of epithelial cells, which can be seen only in a good light, next comes a thin dusky purple or blue line, where the granulations are covered by a more definite layer of epithelium, and the circulation is becoming retarded owing to cicatricial development, whilst outside is a white zone due to the heaping up of sodden cuticle upon the healthy or healed part

Clinical Varieties of Ulcers.

The acute ulcer has been described Other varieties of ulcer are chronic and are the indolent or callous ulcer, the varicose ulcer, and the irritable ulcer

The Indolent or Callous Ulcer occurs most frequently on the legs of women about the middle period of life Their chronic character may often be due largely to neglect on the part of the patient, but is also contributed to by the state of general health, and locally by such factors as poor circulation, lack of cleanliness, and the presence of excess scar tissue in the base of the ulcer The surface is usually smooth and glistening, and of a dirty yellow colour, with perhaps a few badly-formed granulations, the edges are hard and sharply cut, and elevated considerably above the surface, whilst the skin around may be heaped up over the edge, and either covered with sodden cuticle or congested The skin around is often deeply pigmented from chronic congestion, the pigmentation starting in the separate papillæ as maculæ, which gradually coalesce The discharge is purulent or serous, and may be so abundant and irritating as to cause eczema of the parts around, and thus give rise to one form of **eczematous ulcer** The base consists of scar-tissue, more or less abundant according to the age of the lesion, and often extremely dense, it is adherent to the underlying tissues, fasciæ, etc , and this constitutes one of the main difficulties in healing, as contraction is thereby prevented If the ulcer is situated over a bone such as the tibia, chronic osteo-periostitis results, and a subperiosteal node is formed, corresponding to the size and situation of the ulcer, forming a mushroom-shaped projection, and possibly going on to necrosis or to diffuse osteo-periostitis A rare-factive osteitis of the bones of the lower part of the leg, due to interference with the blood-supply, may supervene These ulcers are sometimes very painful from pressure on cutaneous nerves, and thrombosis not infrequently occurs in both veins and lymphatics of the limb, leading to chronic œdema of the foot, often of a very solid, brawny type, and even to pseudo-elephantiasis Various deformities of the feet, occurring first as postural contractures, later becoming fixed, are liable to develop in old-standing cases The superventtion of carcinomatous change in these chronic ulcers of the leg is rare

A somewhat similar condition may also follow large burns or extensive wounds on any part of the body, healing proceeds to a certain extent, and then the contraction of the cicatricial tissue already formed interferes with the vitality of the part still unhealed by compressing the vessels which supply the granulations

The so-called **Irritable Ulcer** is usually met with in this stage Its chief peculiarities are the position, generally in the neighbourhood of the ankle, and the pain which accompanies it The surface of a healing or chronic ulcer can usually be touched without the patient complaining, but in this variety the pain is excessive, especially at night If a probe is run lightly over the surface of such a sore, one or more spots may be detected as the chief seats of the pain, the rest being insensitive In all probability, nerve-filaments are there exposed, as the pain has a very marked burning or shooting character

The **Varicose Ulcer** tends to occur in the leg of a patient with varicose veins, especially when the smaller venules are involved The skin becomes passively congested, and its nutrition impaired, any

injury or abrasion, which would readily heal in a sound limb, is likely under such circumstances to give rise to a chronic sore Again, it may be preceded by eczema resulting from the irritation of dirt or the friction of clothes, whilst occasionally it is due to the yielding of the thinned skin which forms the only covering of a much-dilated vein, an accident which may lead to severe hæmorrhage The characters of a varicose ulcer in the main correspond with those of the indolent variety, it is usually situated on the inner and lower portion of the leg, whilst syphilitic sores are more often placed nearer the knee and on the outer side

Trophic Ulcers —These ulcers develop in connection with a disturbance of nutrition of the tissues consecutive to a lesion of the central nervous system The exact mechanism involved is not properly understood, but it seems to be especially connected with affections of those nerve fibres which pass through the dorsal columns of the spinal cord, and, therefore, these ulcers are seen most commonly in tabes and syringomyelia, but also occur in peripheral neuritis In diabetes the perforating ulcer which occurs may be due either to a trophic disturbance resulting from a peripheral neuritis, or from associated vascular degenerative changes As is to be expected, this type of ulcer is very refractive to treatment

Treatment.—In the early stages treatment resolves itself into removing the cause and protecting the surface from further mechanical irritation The inflamed part must be kept at rest and elevated, if there is much congestion The ulcer should be dressed with moist and mild antiseptic applications and, if there is much sepsis, hot fomentations should be employed When the discharge is very offensive it is better to use a charcoal and linseed-meal poultice

In order to facilitate the healing process it is advisable to avoid too frequent dressings when the acute stage has subsided Once the wound is mending, the most satisfactory form of treatment is the application of an adhesive elastic bandage The benefit which follows this method of treatment is derived from two sources—namely, from the continuous pressure exerted, which relieves the congestion of the limb by improving the venous circulation, and the medicated dressing which is incorporated in the adhesive material Once the bandage is applied it need not be disturbed for one or two weeks It should be applied with moderate firmness, in the manner illustrated in the accompanying diagram (Fig 23), and care should be taken to include the foot and ankle An alternative method of treatment consists of the application of either Unna's paste or zinc and ichthyol ointment The former has to be melted before it can be used, but in both cases the applications are made as with the adhesive elastic bandage When the ulcer is complicated by an eczematous eruption soothing applications are required, and for this purpose lead lotion (1 per cent) is the best when the process is very acute, and liq carbonis detergens (5 per cent) may be added to this when the acuteness is subsiding Later the adhesive bandage may be employed and kept on if no further irritation is produced

When the ulceration is chronic and the granulations are indolent

Signs of Local Death.—The onset of gangrene is promoted by the presence of certain alterations which take place in the dead tissues These are five in number

1 Loss of pulsation in the vessels

2 Loss of heat, since no warm blood enters it

3 Loss of sensation in the dead part, although much pain of a referred type may be experienced whilst its death is occurring

4 Loss of function of the gangrenous mass, which, if it is a limb, lies flaccid and motionless

5 Change of colour, the character of which depends on the amount of blood present at the time of death if the part is full of blood, it becomes purple and mottled, if anæmic, a waxy or cream colour results

These five signs may be in measure present when gangrene is threatened, as when the vitality of a limb is seriously depressed, as by ligature of the main vessel or by its embolic obstruction, but if they continue for any length of time, death of the tissues will ensue Sometimes it is difficult to determine whether such a part is actually dead, especially when it is engorged with venous blood and the arterial pulsation has ceased If living, it will usually be found that pressure causes some modification of the colour, and that the discoloration returns when the pressure is removed

Pathology —The character of the changes occurring in the dead tissues depends mainly on the conditions in the tissues at the time of their death and whether or not active putrefaction supervenes

1 **Dry Gangrene** —In this form there is **death** and **drying up** or **mummification,** which can occur only when the tissue involved is, previous to its death, more or less drained of its fluids, and where there is free evaporation The usual cause is chronic arterial obstruction, as brought about by arterio-sclerosis or calcification of the terminal arteries, to which a sudden or gradual complete occlusion of the main trunk is often superadded The dead part becomes hard, dry, and wrinkled, and is of a dark brown, greenish-brown, or almost black colour from the diffusion of the disintegrated hæmoglobin The more fleshy parts, *e g* above the ankle, rarely undergo perfect mummification, and are often considerably inflamed, and sometimes horribly offensive

2 **Moist Gangrene** arises when a part of the body full of fluid dies, and is associated especially with conditions which involve venous obstruction as well as a sudden arterial block, *e g* in traumatic gangrene due to pressure upon, or rupture of, the main artery Obviously, if the part affected includes, say, skin-surface or some portion of the alimentary canal, this form of gangrene is likely to supervene

Where necrosis has occurred in moist tissues, but where the organismal infection is minimal and can still be kept under control, the dead tissues become more or less discoloured, either purple or any shade from black to yellow, green or white The part remains of much the same size and consistency as at the time of death so long as it is kept from further contamination, and is then gradually cast off from the surrounding tissues without any obvious inflammatory disturbance The term 'aseptic moist gangrene' is sometimes applied

to this variety, although, as has already been pointed out, its application is not wholly accurate

When the putrefactive processes are active, the resulting **Putrid Moist Gangrene** is associated with a rapid breaking-up and disintegration of the mass, which becomes black, green, or yellow The cuticle is raised from the cutis vera by blebs containing stinking serum, or even bubbles of gas, and these can be readily pressed along under the epidermis for some distance The tissues of the limb are soft and lacerable, and on grasping them emphysematous crackling is usually noted

The **Later History** of a necrotic or of a gangrenous mass depends upon the nature and degree of the bacterial infection, and also on the bulk of the affected area

(*a*) If the necrotic area is small in size, and either sterile or only mildly infected, it may, under favourable circumstances, be **entirely absorbed** in the same way as is a catgut ligature This is often observed after sloughing of small portions of amputation flaps, if the part is kept dry and as aseptic as possible, it is gradually removed, and when the process is completed a small dark scab will separate, and a cicatrix be found beneath it In a similar way dead bone may be absorbed, if the sequestrum is not too large or too dense, and if it is in close proximity to healthy vascular tissue The dead portion of tissue is first invaded by phagocytic cells which infiltrate and gradually remove it, granulation tissue replaces it, and this in turn is converted into a cicatrix, and, if at the skin-surface, becomes covered with cuticle in the usual way

(*b*) If the mass is of such a size or consists of tissues of such a character as to prevent its total absorption, or if the vital activity of the patient is lowered but at the same time the septic processes are reduced to a minimum, a modification of the same process results in **partial absorption** of the dead material, whilst the remainder is separated by a process of ischæmic* ulceration, and, if on a surface, is cast off as a **slough.** The dead part immediately contiguous to the living is removed and replaced by granulation tissue, and this change continues advancing into the mass until the layer of granulations which has penetrated furthest is at such a distance from its nutritive base as to be unable to derive from it sufficient pabulum, owing to the contraction of the cicatricial tissue which is forming behind, and then a simple ulcerative process from defective nutrition causes a **line of cleavage** to form between the living and dead tissues, and by this means the latter are separated from the body The size of the portion thus cast off is distinctly less than that of the original necrotic mass This process is associated with local reparative, rather than with active inflammatory, reaction, and but little resulting constitutional disturbance, it is slow in progress, but there are none of the risks attaching to the more rapid septic process The denser and harder the tissues, the longer they take in separating, and hence, when a whole limb is involved, it is possible for the soft parts to have separated, and the wound caused thereby to have cicatrized before

* Ischæmia = local cutting off of blood-supply

much impression has been made on the bones Considerable retraction ensues, giving rise to a 'conical stump,' from the apex of which the bone protrudes

(*c*) If the necrotic portion is septic, and especially if it be definitely gangrenous, its **separation** is accomplished by inflammatory processes taking place in, and at the expense of, the surrounding living tissues The extent of the gangrene is primarily indicated by a **line of demarcation,** due to the change in colour occurring in the dead part, the living tissues retaining their normal hue Apart from any actual septic process also at work, the irritation of the chemical products formed in the dead mass causes inflammatory reaction in the surrounding structures, which ends in suppuration, whilst a layer of granulation tissue forms at the limit of the living portion, and thus the **final line or plane of separation** is produced Clinically, one notices in this latter stage a bright red line of hyperæmia at the extremity of the living tissues, which gradually spreads and deepens until about the eighth or tenth day, when, if the cuticle is intact, the living and dead parts are separated by a narrow white or yellow line, which is proved, on pricking the epidermis, to be due to the presence of a layer of pus, as the pus escapes, a shallow groove is seen running between a granulating surface on the side of the living tissues and the gangrenous mass This process, gradually extending through the whole thickness of the limb, is accompanied by the local signs of inflammation, and by fever, the degree of the latter depending on the amount of toxic material absorbed The inflammation, moreover, is not always limited to the line of separation, but may spread upwards along the lymphatics or veins, or in the fascial and muscular planes, until, perhaps, the whole limb is involved in an extensive suppurative process

The **Constitutional Symptoms** in cases of gangrene may be described under two distinct headings

(*a*) Those general conditions which predispose to the occurrence of gangrene, and which are mainly of a debilitating character, such as diabetes and nephritis, and other conditions affecting either the composition of the blood or the vitality of the limbs

(*b*) Those conditions resulting from the presence of the dead tissue and its connection with the body Various forms of toxæmia result, usually causing a variable degree of fever Pain, moreover, is frequently a prominent feature in some forms of gangrene, and the patient is liable to become enhausted from this cause

Little need be said as to the **General Treatment** of gangrene, beyond that the strength of the patient must be maintained by plenty of easily assimilable food, sufficient stimulant, and tonics Pain and sleeplessness must be combated by the administration of a suitable amount of opium or morphia, if the kidneys are healthy Diabetes and nephritis require appropriate dietetic and therapeutic measures

Local Treatment.—In the early stages when gangrene is threatening and not yet definitely established, the surgeon's aim is directed towards **prevention,** and for this chief reliance is placed on improving the circulation and keeping the part warm The limb is slightly raised

so as to assist the venous return and thereby prevent stasis, thus helping to improve the arterial supply When it seems likely that an element of spasm is present, the operation of removal of the sympathetic ganglia (ganglionectomy) or section of the rami communicantes are operations of choice Periarterial sympathectomy has been tried in England and America and found wanting It has been shown by Kuntz and others that the sympathetic supply to arterial trunks enters the sheaths at more than one point during their course By no means do they all enter the sheaths high up It is perhaps for this reason that the benefits, when derived from a periarterial sympathectomy, are not lasting Ganglionectomy is the method of choice and its value is now definitely established, and further reference will be made to it in Chapter XVI A similar result, it is claimed, can be secured by injecting the periarterial sheath with absolute alcohol, which destroys the plexus Apart from these methods, hot-air baths may be serviceable, but if these cannot be provided the limb is wrapped in warm, dry, carefully sterilized cotton-wool, and moderate elastic pressure is maintained Under all circumstances the greatest care is taken to ensure as complete asepsis of the part as possible If measures such as these fail and gangrene supervenes, **amputation** will be required sooner or later, and the rules that govern the time and level of this procedure will be given in the appropriate sections

Varieties of Gangrene

I Gangrene from Arterial Occlusion

1 **Arterial Disease** forms the most important cause of this condition and may be considered from the two main aspects of degeneration and inflammation

(*a*) **Arterial Degeneration** accounts for two important varieties—namely, senile and diabetic gangrene

Senile Gangrene occurs in elderly people and is the commonest variety met with in civil practice It is produced by a narrowing of, and loss of elasticity in, the smaller arteries, particularly of the limbs, due to the deposition of calcium salts in the middle coat, which results in the formation of calcareous plaques by means of which the arteries are converted into a series of rigid tubes At the same time the intima becomes roughened, predisposing to thrombosis, the development of which is also favoured by the low blood-pressure so often present in elderly people The process is a slow one, but may be precipitated by a slight degree of trauma, such as might be associated with an ingrowing toe-nail, a contusion or even exposure to cold The gangrene is usually of the dry type

Symptoms —Evidences of ischæmia may have been present for some time in the form of cramp and pain in the muscles, which become fatigued rapidly, or of sensations of pins and needles or numbness The pulsation in the tibials may be so slight as to be scarcely perceptible, and the whole limb is shrivelled, and feels cold and heavy The skin is often passively congested, and prone to eczema or ulceration When the gangrene commences as a result of some peripheral lesion, an area

of the true skin Burns due to the sudden generation of heated gases, such as the explosion of shells or bombs, or the bursting and ignition of a petrol-tank, are often of this type, and with careful treatment which conserves any undestroyed portion of epithelium excellent results are often obtained, the face, neck, and hands are usually the parts chiefly involved

In the **fourth** degree the whole thickness of the integument is destroyed, as well as part of the subcutaneous tissues In the **fifth** the muscles are also involved, whilst in the **sixth** the whole limb or other affected part is completely charred and disorganized In the last three forms healing can occur only by removal of sloughs and the formation of a cicatrix, which by its contraction may lead to deformity

From a practical standpoint it is easier to divide burns into two classes (1) those which involve partial skin loss (1st and 2nd degree burns) and (2) those which involve total skin loss (3rd degree burns or deeper)

The Clinical Course of Burns may be considered under four stages

(1) **Initial Shock**—This is uncommon, but if it does occur its intensity depends as much on the extent of the burn as on its depth, so that total scarring of a limb may cause less depression of the system than an extensive scorch, especially if the latter involves the abdomen or the head and neck Initial shock results from a severe vasomotor upset initiated by the reception of multiple painful impulses from the injured area It resembles a fainting attack The clinical picture is fairly constant, there is a fall in blood pressure, the temperature is subnormal, and the pulse is feeble but its rate is usually unaltered

As would be expected, death from initial shock due to burns is rare

(2) **Secondary Shock** may be an extension of the initial shock or occur after an interval, and it is the cause of 60 to 70 per cent of all deaths from burns

It has now been definitely proved that secondary shock is a condition of circulatory failure due to loss of circulating blood in the circulation There is an abnormal permeability of the walls of the small blood-vessels due to the injury of the burn and plasma escapes into the tissue spaces and from the surface of the burnt area This excessive permeability may persist up to forty-eight hours and causes a great reduction in the volume of the circulating blood, while hæmoconcentration becomes marked The result of the changes is dangerous to the patient as there is a definite oxygen want in the vital centres of the brain and therefore treatment must be prompt if life is to be saved

Clinically secondary shock is a more marked picture of initial shock, only the blood pressure is lower

As a rule the greater the hæmoconcentration the worse the prognosis Hæmoconcentration is probably the best criterion of the presence of secondary shock

(3) **Acute Toxæmia.**—This is a condition of septic intoxication which tends to occur from forty-eight hours to ten days after the

injury, and is the result of absorption of injured cells and tissues in the region of the burn This process of septic absorption as it progresses floods the circulation with its products, which when they reach the liver cause some necrosis of the liver cells Should some bacterial invasion into the burnt area also take place the degree of toxæmia becomes much more marked The clinical picture consists of a distressed and irritable patient with a high temperature, rapid pulse and complaining of headache and anorexia Vomiting is quite common By the time such symptoms have developed the actual burnt area is obviously septic and exudes sero-pus This state of affairs should not be seen at the present day, for it can be prevented by prompt and adequate treatment Once the toxæmia has gained a foothold it is difficult to eradicate, and if sepsis is well marked septicæmia and pyæmia may supervene Duodenal ulceration is a rare complication of infected burns, and it was not met with in the navy in the first World War, when over a thousand cases of grossly infected burns were treated in the naval hospital and hospital ships

(4) **Healing** of burns should be complete without scarring or deformity

As a rule burns appear to take longer to heal than raw surfaces of similar extent resulting from mechanical violence Sepsis is the commonest cause of scarring with contracture and should be eliminated by efficient treatment

Large whole-thickness skin burns require skin grafting if scarring is to be prevented

Causes of Death from Burns —If an individual is burnt to death, the fatal event is usually occasioned by asphyxia from the smoke and noxious fumes of the fire, or by shock and syncope If death occurs within the next few days it results from secondary shock due to loss of plasma into the tissue fluids and from the surface of the burnt area A fatal issue may also result from infection, the terminal event being bronchopneumonia At a later stage still, general exhaustion with nephritis may be the cause of death The prognosis in children is always more unfavourable than in adults

Treatment.—In the treatment of burns first aid is of primary importance Pain should be alleviated at once by morphia, for an adult $\frac{1}{8}$ gr to $\frac{1}{2}$ gr should be given, depending on the severity of the pain *Morphia will never kill a patient who is suffering from pain* In small children up to six months tinct opii $\mathfrak{m}\frac{1}{4}$ to $\mathfrak{m}\frac{3}{4}$ should be given, while at the age of one year three minims of tincture of opium can be given

Once pain is relieved other methods for preventing or reducing shock should be instituted without delay Warmth is essential and any local treatment should be painless and prevent any loss of plasma from the burnt surface, it should also prevent the development of sepsis and help to promote rapid healing

For minor burns one of the many excellent burn jellies, gentian violet, triple dye, amertan, or dettol burn jelly, can be applied and will give very satisfactory results

3 **Gangrene due to Electrical Agencies.**

This will be considered in the Chapter on War Surgery (LI)

4 **Gangrene due to the Effects of Radiation**

Many types of radiation will lead to necrosis of tissues When these have been employed therapeutically the necrosis is always the result of over-exposure, and hence is not often seen nowadays The most serious variety is that which follows radium treatment because it is penetrating, very often causing necrosis of bone, and taking several months or years to heal In some cases it is followed by the development of carcinoma in the scar Necrosis may also follow treatment by X-rays, ultra-violet and infra-red radiation and artificial sunlight, but is usually less severe and of shorter duration than the type due to effects of radium In the early stages a painful erythema develops, which may be succeeded by blister formation and later by ulceration The latter often spreads deeply and widely, and may lead to the death of the patient from exhaustion or toxæmia The whole process, particularly after radium, is very slow and may be very painful, but once the healing process has commenced recovery may be hastened by the judicious employment of skin grafting But early plastic repair of the defect is not as a rule successful

IV **Infective Gangrene**

Infective Gangrene may be of two types, specific and non-specific The latter variety is commonly due to non-specific organisms, in particular the pyogenic group, and is manifested in such conditions as boils, carbuncles, phagedena, noma and cancrum oris Boils and carbuncles will be described in connection with the chapter on surgical diseases of the skin, and reference will be made to phagedena in the chapter dealing with syphilis Cancrum oris and noma will be dealt with below The specific variety of infective gangrene is due to a particular group of anaerobic organisms and is referred to as acute spreading, acute emphysematous or gas gangrene, and is one of the most rapidly fatal diseases met with in surgery

Gas Gangrene (Acute Spreading or Acute Emphysematous Gangrene) — This disease is one of the most rapidly fatal met with in surgery

The individual attacked is often debilitated, *e g* as a result of the hardships of military service, or from alcoholic excess, or from malnutrition, but even healthy individuals may be attacked if the infective agent is active It is sometimes seen in diabetics, but a non-diabetic toxic glycosuria occasionally develops in the course of the disease itself

The causal lesion is usually severe, such as a compound fracture or dislocation, especially if the soft parts, and particularly the muscles, are much contused or very dirty Defective purification of such tissues, and injudicious attempts to save them by accurate and close stitching, perhaps without drainage, are amongst the most frequent predisposing causes of this complication Less commonly it follows a small and insignificant prick, scratch, or abrasion, through which

a highly virulent organism gains access to the tissues Its most frequent occurrence was in connection with wounds received during the Great War, the majority of which took place on highly fertilized soil

Most cases usually consist of mixed infections, the anaerobic organisms have been found along with those of the pyogenic variety The more important anaerobic organisms are the following

Bacillus welchii (B aerogenes encapsulatus, B perfringens)
Bacillus œdematis maligni (Vibrion septique)
Bacillus œdematiens

To these may be added a fourth, Bacillus sporogenes, which, although neither causal nor gas-producing, is responsible for much of the odour which is so characteristic of the disease The most important of these organisms is the Bacillus welchii, a non-motile bacillus, which sometimes forms spores It attacks carbohydrates more actively than proteins, and therefore acts especially upon the muscles, in which the infection tends to spread rapidly with abundant gas formation Occasionally the bacilli may be carried in the circulation to a distance and produce metastatic gas gangrene, but as a rule they do not enter the blood-stream until just before death On post-mortem examination an abundance of gas may be found in the tissues, *e g* the liver, brain, etc , which may show innumerable small, apparently ' empty,' sponge-like, gas-filled cavities in their substance, occasionally produced before death, but most commonly a phenomenon of decomposition occurring at or after death B œdematis maligni (the Vibrion septique of Pasteur) is a similar organism, but actively motile and strictly anaerobic, producing an abundance of gas from glucose Its inoculation into mice and guinea-pigs is followed by their death within twenty-four hours, preceded by a spreading œdematous condition of the connective-tissue spaces containing multitudes of the bacilli and perhaps gas The gas which is formed early consists of hydrogen and carbon monoxide and is odourless, but it later becomes mixed with sulphuretted hydrogen and becomes highly offensive as a result

Symptoms —The active outbreak of this disease may be delayed for two or three days after the occurrence of the wound, during which time the latter is perhaps a little painful but shows no special signs of activity, the absence of discharge being an unfavourable sign In some cases the period of incubation may be as short as twelve hours The wound, when opened, is found to be unhealthy, the surface covered with sloughs, and a thin serous or slightly sero-purulent blood-stained discharge escaping, in which the organisms may be present in enormous numbers There is usually comparatively little or no local leucocytic reaction, unless there is mixed infection with pyogenic organisms, and the inflammatory process rapidly spreads along the connective-tissue planes, and especially in the substance of the muscles (Plate III), *e g* of a limb, which becomes swollen, painful, and brawny In one case under observation the gangrene spread from the foot to the groin within twelve hours At first the parts show a bright red blush, but they soon become purple, gangrenous, and

crepitant If gas in the deeper tissues is suspected, its presence or otherwise may sometimes be demonstrated by X-ray examination The emphysema spreads widely and rapidly, with at first no other local signs, sloughing will, however, follow if the patient live long enough Evidences of profound toxic disturbance, such as hyperpyrexia and delirium, soon manifest themselves, but not uncommonly fever may be entirely absent, the temperature being subnormal and coma present The presence of a marked pallor and restlessness suggests the possibility of a profuse hæmorrhage, but is due to the severe toxin The outlook is exceedingly grave, death usually ensuing in two or three days, but the clinical course may be modified by the type of gangrene present Clinically it is possible to recognize three main varieties

(i) The localized variety, which is limited more or less to the area of the wound This type is the most favourable, and cure may follow prompt and energetic treatment

(ii) The diffuse variety, in which the organisms spread among the muscles of the affected area, giving rise to much gaseous distension It is the most common type, and in civil practice occurs most frequently in connection with accidents involving a severe crush of a limb

(iii) The fulminating variety, in which the gaseous organisms spread with great rapidity through the muscles and fascial planes to involve the greater portion of the body The prognosis in this variety is practically hopeless, treatment being of little or no avail

Treatment —It is impossible to emphasize too strongly the danger of closing up completely and without drainage lacerated and contused wounds which have been caused on the battlefield, or by accidents on the railways, the street or elsewhere, whereby the damaged tissues have been brought into contact with the ground, and perhaps infected thereby with the dangerous anaerobic organisms which are so constantly present in the soil Prophylactic injections of anti-tetanus and anti-gas-gangrene sera should be given in all cases immediately such infections are suspected, and in this connection it may also be noted that a prophylactic inoculation of anti-gas-gangrene serum may now be regarded as a routine precautionary measure against the toxins of *B welchii* in operations upon suppurative or gangrenous conditions of the bowel wall, *e g* in [illegible] of a volvulus or hernia, infarction, appendicitis, etc , this organism being practically a normal inhabitant of the intestine, in which, under these abnormal conditions, it may proliferate and attack the damaged or dead tissues Absence of hydrochloric acid in the gastric juice, *e g* in pernicious anæmia, has also been found to favour the proliferation of *B welchii* and other organisms of putrefaction, as well as pathogenic streptococci, etc Scrupulous antiseptic cleansing of the wound, accompanied by the removal of dead and damaged tissues, followed by the application of bipp, loose suturing of the parts, and free drainage, are essential if dangerous consequences are to be avoided The appearance of inflammatory phenomena will necessitate free opening of the wound, followed by incisions through infected tissues and immersion of the limb in a warm bath containing eusol or weak iodine solution

If, in spite of this, the disease spreads, a guillotine amputation, *i e* without flaps, well above the visible extent of the disease, or a high ordinary flap amputation, even through the shoulder or hip-joint, is the only hope of saving life

1 **Wound Phagedena and Hospital Gangrene** were common in the pre-antiseptic era, but are now practically unknown They were forms of rapidly spreading ulceration or gangrene, which attacked operation wounds a few days after their infliction, and as a rule resulted in rapid death Since the disappearance of this malady the term has been retained in connection with a certain type of sloughing ulceration of the penis, which is occasionally seen as a complication of venereal disease This latter variety will be described in connection with the section on syphilis

2 **Cancrum Oris and Noma**—**Cancrum oris** is an infective gangrenous stomatitis—now fortunately rare in this country—affecting especially young children living in squalid surroundings in over-populated districts of large cities The patients are always in a low state of health, perhaps convalescing from one of the exanthemata, particularly measles The process starts in an abrasion of the mucous membrane, which, being infected, perhaps from a diseased or dirty tooth, becomes inflamed and gangrenous A foul ashy-grey pultaceous slough forms on the inside of one of the cheeks, and from this a most offensive discharge is poured into the mouth and swallowed, the breath in consequence becoming intensely fœtid The gangrene gradually spreads both superficially and deeply, the cheek becomes swollen, shiny, and tense, and, should the process extend through its whole substance, a black slough appears on its outer aspect (Fig 41) In bad cases the adjacent bones of the face may be affected and become necrosed, and the tongue, palate, and even the fauces, may also be involved (Fig 42)

The general phenomena are those of a severe toxæmia, since not only are the toxic products swallowed, but they are also absorbed by the lymphatics, and may be inhaled, in the latter case giving rise to septic broncho-pneumonia Moreover, the patient runs a considerable risk of developing pyæmia, from implication of the facial or other veins in the necrotic process, whilst septicæmia may also supervene Rigors and high fever may occur early in the case, but death is usually preceded by symptoms of collapse and coma, with a subnorma temperature

The **bacteriology** of this affection is still doubtful Enormous numbers of mixed organisms are present, but of these probably the most important is the *Streptococcus pyogenes*, perhaps in conjunction with a fusi-spirochætal (Vincent's) or other infection

The **Treatment** must be prompt and energetic if the child's life is to be saved The patient should be anæsthetized, and all the pultaceous slough removed by cutting or scraping, until healthy bleeding tissue is reached The denuded surface is then freely rubbed over with pure carbolic or strong nitric acid In using such agents, the throat must be carefully protected, and the excess of acid in the case of the former dissolved by spirit, and in the latter neutralized by

CHAPTER VI.

SPECIFIC INFECTIVE DISEASES.

Erysipelas.

ERYSIPELAS is a contagious infective disease almost always, in the human subject, due to the development of one of the various strains of the hæmolytic *Streptococcus pyogenes* in the smaller lymphatics of the skin and occasionally of mucous membranes, with a decided tendency to spread, and to recovery without loss of tissue, the constitutional symptoms being due to the absorption of toxins developed locally Occasionally the subcutaneous connective tissue is also involved, constituting the variety known as **cellulo-cutaneous erysipelas**

The organisms gain entrance into the body through an abrasion or wound, particularly if dirty As abrasions are common on unprotected areas such as the face, hands, and arms, it follows that erysipelas is seen most frequently in those sites Its development is facilitated by a weak or depressed state of health, and hence it is a very severe and often fatal disease in infants and old people Bad hygienic surroundings and overcrowding are important predisposing factors

The **Symptoms** of the disease usually commence with headache and malaise, followed, in about twenty-four hours, by a slight rigor, well-marked pyrexia, and the development of the rash, spreading either from the margin of the wound, or showing itself in apparently unbroken skin as in the so-called 'idiopathic' variety If there is a wound, it usually presents a yellowish, unhealthy-looking surface, with very little evidence of repair When the infection is an unmixed one, the healing process may continue until the rash appears on the third or fourth day, when the wound breaks open again, exposing a dry and sluggish surface with a thickened margin The erythema is generally of a characteristic vivid rosy-red colour disappearing on pressure, and accompanied by a sensation of stiffness or burning, scarcely amounting to pain, except when dense structures, such as the scalp, are involved, and then the pain may be severe Swelling is not marked, except in loose areolar structures, such as in the eyelids or scrotum, the œdema may then attain considerable proportions In a typical case the erythema continues to advance more or less rapidly, with an abrupt continuous slightly raised margin, and as it spreads to new regions it fades away from those already involved, leaving a slight brownish pigmentation and a fine branny desquamation In some cases it does not spread regularly, but appears to leap over an interval, the infection having travelled by the intervening lymphatics, which are found to be thickened Vesicles and bullæ may form, containing

serum, which speedily becomes turbid, but suppuration is uncommon, except in lax œdematous tissues, *e g* the eyelids Occasionally, from the severity of the inflammation or the low state of vitality of the tissues, the skin may become gangrenous and slough, especially about the umbilicus and genitals of young children Neighbouring lymph-nodes are enlarged and painful, and this may be noted even before the rash has appeared Periphlebitis may also be caused, and may lead to thrombosis and perhaps pyæmic complications Fever is present as long as the rash persists, and shows merely slight diurnal variations It is not uncommon for the temperature to reach 104° F , but any rise above this is of grave significance At first the fever is of a sthenic type, the pulse full, and delirium, if occurring, noisy and active, but later the pulse becomes quick and weak, accompanied by low, muttering delirium and great prostration A polymorphonuclear leucocytosis, moderate in degree (12,000, 15,000 or perhaps 20,000 per cubic millimetre), is usually present in the blood The duration of the attack is very variable, lasting, as a rule, from one to three weeks, but relapses are not uncommon The swelling of the part does not always clear up entirely, owing to persistent blocking of lymphatics, when repeated attacks occur, this swelling may become so great as even to simulate elephantiasis

Cellulo-cutaneous Erysipelas, as already stated, is a clinical variety in which there is marked infection of the subcutaneous tissues, resulting in a diffuse infiltration and œdema of these tissues, and less often in suppuration or even sloughing of the skin and subjacent cellular tissue The infiltration is at first brawny in type but subsequently softens and becomes boggy, the skin finally giving way to allow an exit for pus and sloughs The general symptoms are correspondingly severe, and pyæmia may supervene As features distinguishing it from ordinary erysipelas it may be mentioned that the margin of the redness is less defined and that the lymph-nodes are less enlarged

Erysipelas of the scrotum, sometimes seen in infants following a circumcision, is characterized by the part becoming greatly distended with serum, but without any marked redness Suppuration and sloughing are not unlikely to follow It may thus sometimes simulate the appearance produced by extravasation of urine, but is distinguished from it by the facts that micturition is usually not interfered with and that the swelling is not limited in the same way as in the latter affection

Pathological Anatomy.—On microscopical section of the affected skin, very numerous cocci arranged in chains will be found invading the lymphatics just beyond the spreading margin, whilst in the inflamed area there is a considerable excess of leucocytes, blocking the lymphatics, and evidently engaged in the destruction and removal of the cocci, since phagocytic inclusion of the organisms is frequently observable The lymph-nodes will also be found enlarged and congested Fatal cases otherwise show merely the ordinary post-mortem signs of death from a general toxæmia or septicæmia

Diagnosis.—The points to be noted are the bright red colour of the rash, the irregular sharply defined and raised edge and the frequent

accompaniment of tiny areas of vesication It has to be distinguished from the exanthemata and other varieties of erythema, *e g* sunburn, ultra-violet radiation, or dermatitis venenata

Prognosis depends upon the presence or absence of complication The disease in itself is not of a serious nature, although the toxæmia may be very great in debilitated people The complications are all serious, the common ones being pneumonia, meningitis, and pericarditis

Treatment —Erysipelas is a notifiable disease under the Infectious Diseases Acts, and the patient must be isolated and, if possible, removed from a surgical or obstetric ward If this is impracticable, the patient must be placed as far away from others as possible, especially from surgical cases, and it is wise, under these circumstances, to put off all operations that can be safely postponed

General Treatment —This should be of a tonic and supporting character The food should be good and easy of assimilation and stimulants should be given as required Of internal remedies tinct ferri perchlor (dose, ℥ xx-xxx) is the most effective and sometimes acts as a specific Collosol manganese ($\frac{1}{2}$-2 c c daily for three to four days), quinine (gs iii-v, t d s), and S U P (1 c c daily) are less effective remedies but may be tried The introduction of drugs of the *sulphonamide* group has, however, been of the first importance in this disease, and undoubtedly they form specific remedies They should be given in full dosage Antistreptococcal serum in dosage up to 50 c c daily may also be employed, but is probably of less value than the sulphonamide preparations

Local Treatment —The most effective local preparation is undoubtedly a saturated solution of magnesium sulphate, applied in the form of a cold pack, from which crystals of salt separate out on the skin It is especially useful where there is much pain Alternatively a 20 per cent solution of subitol may be applied, or lotio plumbi containing opium (laudanum, 1 ounce to the pint) Ichthyol, in the form of an aqueous solution (20 to 40 per cent) or ointment (10 per cent), is also a very satisfactory remedy and should be applied continuously

In cellulo-cutaneous erysipelas early and free incisions must be made to relieve tension, and, if possible, anticipate suppuration The tissues, when incised, look gelatinous from the œdema present, and much fluid of a sero-purulent type will escape Antiseptic fomentations or hypertonic applications should be employed after the incisions have been made, until granulations have developed

Diphtheria.

Diphtheria is an infectious disease due to the Bacillus diphtheriæ (the Klebs-Loffler bacillus), which is a non-motile, Gram-positive organism about 3 or 4 μ in length (Plate I , Fig 7), staining irregularly, particularly at the poles, and thus presenting a beaded appearance The infection may be transmitted directly by the discharges, or indirectly as in milk The bacilli may occasionally be found in a virulent condition in the throats and nasal fossæ of apparently healthy

individuals, who act as 'carriers,' and may thus lead to outbreaks of the disease without obvious cause The disease usually involves the mucous membranes, particularly those of the pharynx, larynx, and nasal passages, occasionally it attacks open wounds, the skin, conjunctiva, or the genitals It is characterized by the formation locally of a fibrinous exudate, closely incorporated with degenerating or necrotic superficial layers of the tissues affected—the so-called diphtheritic 'false membrane'—so that attempts to remove it cause slight bleeding Constitutional symptoms are due to the absorption of bacterial exo-toxin The bacilli themselves remain limited to the local lesion, which may be found anywhere in the nose and throat, but which does not give rise to serious disturbance except when the membrane develops in the larynx (membranous croup), in which case grave laryngeal obstruction may occur, when this event takes place, tracheotomy or intubation should be performed at once The general effects produced by the absorption of the toxins are seen mostly in connection with paralysis of the palatal and orbital muscles, and less frequently the diaphragm and muscles of the limbs Cardiac weakness is also not uncommon, and is due partly to degeneration of muscle and partly to action on the vagus The toxin has considerable poisonous effect on the kidneys and albuminuria is common

The characteristics of pharyngeal and laryngeal diphtheria are described under their respective headings

Treatment—The most important point is the immediate administration of antitoxic serum in doses of from 8,000 to 120,000 units* given intramuscularly or intravenously, depending upon the severity and urgency of the case—the latter route being chosen in the more urgent cases, and the dose repeated if no improvement within twelve or twenty-four hours ensues Children require as large doses as adults, or even larger The subcutaneous route may be used to supplement either of the other two, or when the serum is given as a prophylactic measure The value of the treatment depends largely on the promptitude with which it is applied, the mortality from diphtheria being practically nil among patients who receive antitoxin on the first day of the disease, and rising steadily with delay In all cases where there is a reasonable probability that the infection is diphtheritic, serum should, therefore, be administered immediately, and without awaiting the result of the cultural bacteriological examination In addition, local antiseptics are useful, and in laryngeal cases, where dyspnœa occurs from obstruction of the larynx by membrane, tracheotomy or intubation may be necessary Suitable prophylactic immunization, passive with the antitoxic serum, active with concentrated toxoid (Formol-Toxoid, F T), or mixtures of toxoid and antitoxin (Toxoid-Antitoxin Mixture, T A M), may be employed to protect those found to be 'Schick-positive'

* The unit is the amount of antitoxin which will neutralize 100 times the minimum lethal dose of toxin required to kill a guinea-pig of 250 grammes in four days

Tetanus.

Tetanus is a local infective disease, due to Bacillus tetani, associated with a characteristic toxæmia The bacillus occurs in the form of delicate straight rods, which sometimes grow into threads It is a strict anaerobe, and usually develops a characteristic spherical terminal spore, giving it the appearance of a drumstick (Plate III , Fig 3) Such spores appear both in the pus of the wound and in cultures, and are extremely resistant to the action of heat (they usually survive boiling for at least five minutes) and antiseptics The bacilli stain by Gram's method and possess numerous flagella They of themselves do not tend to proliferate actively in the tissues unless the vitality of these is also lowered by the action of the toxin itself, or by the products of other bacteria, or the presence of a foreign body such as a splinter of wood, earth, etc , or by other damage to the tissues, *e g* the fracture of bone When washed completely free from their toxins the spores often fail to produce tetanic symptoms, when injected even into susceptible animals, should, however, a minute trace of toxin be present, it so depresses the vitality of the surrounding tissues that the spores develop into bacilli, which then continue to proliferate and produce more toxin

Ætiology —The causal organism is a facultative saprophyte, and is almost constantly found in garden soil, and street, stable, farm, and road refuse Those, therefore, who are brought in contact with the ground, *e g* gardeners and agricultural labourers, are specially liable to the disease, particularly if the soil has been persistently and heavily manured Horses also are very susceptible to tetanus, and the bacilli are usually present in their fæces, hence stablemen and others engaged in looking after horses are attacked with comparative frequency The disease is more often seen in the tropics than in other climates, probably owing to the heat favouring the development and virulence of the organisms in the soil

The existence of a **wound** can almost always be demonstrated, usually of a dirty, lacerated or punctured character, and suppuration is generally present Any part of the body may be thus affected, but perhaps those regions, such as the sole of the foot or the palm of the hand, which are liable to be brought into contact with contaminated soil are most often involved Street and road accidents and war-wounds are only too likely to be followed by tetanus The depressed vitality of the tissues owing to the bruising and tearing, the irritation caused by the growth of pyogenic organisms, and the absorption by the latter of any oxygen present, co-operate in favouring the development of the tetanus bacilli Hence it is rare for the disease to affect wounds where asepsis has been maintained and rapid repair has been effected, and it is very uncommon, though possible, for it to develop after blows or bruises with no visible breach of surface Gunshot wounds due to blank cartridges, since the injury is largely due to the wad, which may be made of coarse horsehair felt, and is therefore likely to contain spores of the bacillus, are often followed by tetanus,

individuals, who act as 'carriers,' and may thus lead to outbreaks of the disease without obvious cause The disease usually involves the mucous membranes, particularly those of the pharynx, larynx, and nasal passages, occasionally it attacks open wounds, the skin, conjunctiva, or the genitals It is characterized by the formation locally of a fibrinous exudate, closely incorporated with degenerating or necrotic superficial layers of the tissues affected—the so-called diphtheritic 'false membrane'—so that attempts to remove it cause slight bleeding Constitutional symptoms are due to the absorption of bacterial exo-toxin The bacilli themselves remain limited to the local lesion, which may be found anywhere in the nose and throat, but which does not give rise to serious disturbance except when the membrane develops in the larynx (membranous croup), in which case grave laryngeal obstruction may occur, when this event takes place, tracheotomy or intubation should be performed at once The general effects produced by the absorption of the toxins are seen mostly in connection with paralysis of the palatal and orbital muscles, and less frequently the diaphragm and muscles of the limbs Cardiac weakness is also not uncommon, and is due partly to degeneration of muscle and partly to action on the vagus The toxin has considerable poisonous effect on the kidneys and albuminuria is common

The characteristics of pharyngeal and laryngeal diphtheria are described under their respective headings

Treatment.—The most important point is the immediate administration of antitoxic serum in doses of from 8,000 to 120,000 units* given intramuscularly or intravenously, depending upon the severity and urgency of the case—the latter route being chosen in the more urgent cases, and the dose repeated if no improvement within twelve or twenty-four hours ensues Children require as large doses as adults, or even larger The subcutaneous route may be used to supplement either of the other two, or when the serum is given as a prophylactic measure The value of the treatment depends largely on the promptitude with which it is applied, the mortality from diphtheria being practically nil among patients who receive antitoxin on the first day of the disease, and rising steadily with delay In all cases where there is a reasonable probability that the infection is diphtheritic, serum should, therefore, be administered immediately, and without awaiting the result of the cultural bacteriological examination In addition, local antiseptics are useful, and in laryngeal cases, where dyspnœa occurs from obstruction of the larynx by membrane, tracheotomy or intubation may be necessary Suitable prophylactic immunization, passive with the antitoxic serum, active with concentrated toxoid (Formol-Toxoid, F T), or mixtures of toxoid and antitoxin (Toxoid-Antitoxin Mixture, T A M), may be employed to protect those found to be 'Schick-positive'

* The unit is the amount of antitoxin which will neutralize 100 times the minimum lethal dose of toxin required to kill a guinea-pig of 250 grammes in four days

Tetanus

Tetanus is a local infective disease, due to Bacillus tetani, associated with a characteristic toxæmia The bacillus occurs in the form of delicate straight rods, which sometimes grow into threads It is a strict anaerobe, and usually develops a characteristic spherical terminal spore, giving it the appearance of a drumstick (Plate III , Fig 3) Such spores appear both in the pus of the wound and in cultures, and are extremely resistant to the action of heat (they usually survive boiling for at least five minutes) and antiseptics The bacilli stain by Gram's method and possess numerous flagella They of themselves do not tend to proliferate actively in the tissues unless the vitality of these is also lowered by the action of the toxin itself, or by the products of other bacteria, or the presence of a foreign body such as a splinter of wood, earth, etc , or by other damage to the tissues, *e g* the fracture of bone When washed completely free from their toxins the spores often fail to produce tetanic symptoms, when injected even into susceptible animals, should, however, a minute trace of toxin be present, it so depresses the vitality of the surrounding tissues that the spores develop into bacilli, which then continue to proliferate and produce more toxin

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as are also 'Fourth of July wounds' in the United States due to firework burns Commercial gelatin derived from the hoofs, etc , of horses often contains the bacilli, and the injection in the treatment of aneurisms of this substance, when imperfectly sterilized, has been followed by the disease , and similarly the use of surgical catgut infected with spores which have escaped sterilization may cause tetanus Occasionally the bacilli gain entrance into the tissues through trivial, *e g* small punctured, wounds which may heal over superficially, or in connection with lesions such as frost-bite, and they may even persist for a while in a latent condition, developing only after an interval of some weeks or months This is the explanation of those cases of tetanus which used to be termed 'idiopathic,' *i e* where no obvious cause in the shape of a wound could be detected, and it also explains the incidence of tetanus after operations upon areas previously the site of infected wounds Tetanus neonatorum, due to infection of the cut end of the umbilical cord, was common in pre-antiseptic days

Pathology —Tetanus is, perhaps, the most characteristic example of a local infection causing a general toxæmia The bacilli remain in or near the wound, and do not enter the blood or reach distant parts of the body The toxins produced locally act on the central nervous system in a manner very similar to strychnine, thereby increasing reflex excitability of the motor mechanism, so that slight stimuli produce excessive muscular contractions of a tonic character

The method of transit from a local wound to the central motor nerve-cells is peculiar in that the toxin is not absorbed by these cells from the blood or lymph, from which fluids it quickly disappears, but is picked up locally, or from the blood or lymph, by the end-plates of the nerves in the muscles, and thence is carried up along the motor nerves, either by the lymphatics of the nerves or by the protoplasm of the axones themselves Naturally when an infected wound involves muscles, the transference of toxin along the motor nerves of this region is facilitated, and the cells of the spinal cord controlling this area may be affected earlier than others, and so a localized form of tetanus results It has been experimentally found possible to protect certain areas by injecting antitoxin into the motor nerves, thus if a full intravenous dose of toxin is given to an animal, and shortly afterwards antitoxin is injected into both sciatic nerves, tetanus develops in the usual manner in the head, trunk, and fore-limbs, but the hind-legs are not affected Clinically, if no localizing lesion thus leads to the selection of special areas, the muscles of the jaw and neck appear to have a specific predilection for the toxin, and it is probable that the toxin reaches the motor nerve-cells through the nerves leading from these muscles

The post-mortem anatomical changes are not characteristic The muscles are often pale, or show evidences of rupture or extravasation of blood The peripheral nerves extending from the wound may be red and congested for some distance, this may not be due to the action of the toxin (which appears to produce no demonstrable lesions of the nerves themselves) but to coincident pyogenic inflammation The

nerve-centres frequently present areas of softening and perivascular cellular exudation, with some hyperæmia, especially in the pons and medulla Degenerative changes may also be evident in the anterior cornual nerve-cells of the cord

Clinical History—The **incubation period** varies from twenty-four hours to three weeks, and is also considerably influenced by the prophylactic administration of antitetanic serum As a general rule, in temperate climates the average incubation period of acute cases is from one to two weeks, but in the tropics the disease may appear after a few hours (**Tetanus Fulminans**)

During the period of incubation there may be some local tenderness or swelling of the wound and some rigidity or twitchings of the muscles may develop locally The disease is usually ushered in by the appearance of **Trismus,** hence the popular name of **Lockjaw** for the disease

The patient complains of a difficulty in opening the mouth, associated with a cramp-like pain in the muscles of mastication and of the neck This soon becomes so marked that even a paper-knife cannot be inserted between the teeth, causing great difficulty in the administration of food, to it is added a fixed and rigid condition of the muscles of the back of the neck and of the face, the latter producing a curious grin-like appearance (**risus sardonicus**), whilst dysphagia is sometimes caused by spasm of the pharyngeal muscles A considerable degree of fever is often present, but in some cases an apyrexial course is maintained until nearly the end The spasms soon become generalized and extend to the trunk and extremities, accompanied by cramp-like pains, and when fully established they may be excessively painful and violent, and the remissions between them but partial The disease usually involves the respiratory muscles late in the attack The more severe spasms can be excited by any form of stimulus, such as a bright light, the slamming of a door, a draught of cold air, or some voluntary movement, and are always of a tonic, *i e* continuous, character The body is contorted in various directions, and respiration may be much impeded by the fixation of the thorax Occasionally the body is arched backwards (**opisthotonos**) by the contraction of the muscles of the back, the recti abdominis being firm and tense—'as hard as boards', sometimes it is doubled forwards (**emprosthotonos**), and in rare cases laterally (**pleurosthotonos**) The muscles may contract so violently as to be ruptured, whilst bones have been fractured, teeth have been broken, and the tongue has been almost bitten off The intellectual faculties usually remain clear to the end, which is generally brought about by exhaustion from repetition of the convulsions, or more rarely by asphyxia induced by a prolonged fixation of the respiratory muscles Before death the temperature sometimes may rise to 108°, or even, as in one case recorded, to 112° F, and it often continues to rise for a degree or two after death, such hyperpyrexia is due mainly to the continuous muscular contractions The surface of the body is bathed in sweat, and the urine is scanty, and occasionally albuminous Death may occur in twenty-four hours from the onset of the disease, or perhaps not for four or five days

Another uncommon clinical variety is **Head Tetanus** (Cephalotetanus), which sometimes occurs after head injuries It is due to local nuclear involvement following absorption and diffusion of the toxins via the facial or trigeminal nerves, and leads to involvement of the motor nuclei of the third, fifth, sixth, and seventh nerves, but in rare cases the bulbar muscles may be affected Oculomotor palsies are common and are associated with trismus and possibly pharyngeal spasm, causing severe dysphagia and bearing a superficial resemblance to hydrophobia

Three other clinical varieties should be borne in mind **Tetanus Neonatorum** occurs in new-born children from infection of the umbilical cicatrix It is a very fatal disease, death occurring in one to two days **Post-Puerperal** and **Post-Operative Tetanus** are sometimes seen after childbirth and operations The possibility of their appearance should not be forgotten

Chronic Tetanus is a clinical variety which shows a longer incubation period between the infection and the onset of the symptoms, which are less severe in degree, and the prognosis is better The course is often afebrile, and the spasmodic contractions may be limited to the wounded part of the body where the infection has commenced Sometimes the patient lies in bed with the jaw partially fixed, and the muscles of the neck, back, and abdomen rigidly contracted, but often with none of the characteristic convulsions

Diagnosis —In the early stages tetanus must be distinguished from simple 'trismus' arising from dental irritation, from gastric and other forms of tetany, and from inflammatory ankylosis of the temporo-maxillary joint This may be readily accomplished by noting that rigidity of the neck muscles is also present in tetanus Strychnine poisoning leads to a very similar group of symptoms, but is recognized from tetanus by the contractions being more sudden and violent, the relaxation of the muscles between the spasms complete, so that the mouth can readily be opened, whilst the hands are involved in the contractions—a rare occurrence in tetanus—and the muscles of mastication often escape

No difficulty should be experienced in distinguishing tetanus from hydrophobia, owing to the very different nature of the convulsions in the latter, *i e* clonic and not tonic, moreover, they affect the muscles of respiration and deglutition, whilst the history of the case, the early hallucinations, and the absence of tonic muscular contractions, are also characteristic features

After the appearance of the symptoms, the **Prognosis** is unfavourable in any case, but the longer the disease lasts, and the lower the temperature, the more likely is the patient to recover, whilst an acute onset, hyperpyrexia, sleeplessness, delirium, and strabismus are bad signs The length of the incubation period is also a most important factor Generally speaking, cases developing under five days are fatal, in those developing in from five to ten days 90 per cent are fatal, from ten to twenty days the mortality is 75 per cent , while cases developed after three weeks usually recover

Treatment —In localities where tetanus is known to be rife, it is ad-

visable always to administer a **prophylactic** dose of antitetanic serum in cases of wounds or abrasions that might possibly be infected, especially if due to street accidents, etc (see above, under Ætiology), or if suspicious bacilli are found on microscopical examination of a scraping from the deeper parts of the wound For routine prophylactic injection, the minimum dose should be 1,000 International (=500 U S A) units,* repeated several times at seven-day intervals, but, and especially if there is much contamination of the wound, or much delay has occurred, it is preferable to give 3,000 International (=1,500 U S A) units, or even more In cases where it is proposed to attempt to clean out or excise the wound surgically, the serum should be injected intramuscularly some three or four hours previously

The moment any actual symptoms of the disease have appeared, **no delay** in administering antitoxin in full doses should be permitted, and in this connection it is again wise to insist that the disease can often be recognized before trismus has occurred The modern tendency is to administer antitoxin in much larger doses than were previously considered adequate Treatment should commence immediately with an intrathecal injection, preferably into the cisterna magna (the cerebello-medullary cistern) rather than by the lumbar puncture route, of 40,000 International (=20,000 U S A) units or more, and for this the most concentrated and potent antitoxin available should always be employed The amount of cerebro-spinal fluid withdrawn should be a little less than the bulk of the proposed dose, and the patient's head is lowered after the administration At the same time intravenous and intramuscular injections of, say, at least 20,000 International (=10,000 U S A) units each should also be given Should there be no improvement by twelve to eighteen hours, these doses should be repeated, and again every twenty-four hours for three or four days Then, if necessary, 30,000, 25,000, or 20,000 International (=15,000, 12,500, or 10,000 U S A) units may be given daily intramuscularly, if possible in the immediate neighbourhood of the motor nerves of the affected part Until all danger of relapse appears past, smaller doses may be administered subcutaneously every few days

The **treatment of the wound** is of great importance, for, of course, the antitoxin treatment deals only with the toxic bodies absorbed from it, and has no influence upon the local infective processes Much will depend upon the position and extent of the wound or wounds, and, where these are multiple, upon whether the infection with the tetanus bacilli has occurred in one only or in several The surgeon must consider whether thorough excision of the wound is feasible, or whether, when the infection has occurred in a limb, amputation well above its site, as removing completely the source of the toxin, is inevitable, or whether he may safely rely upon the local application of oxidizing antiseptics and satisfactory drainage It is certain that any injudicious manipulation of the wound may do more harm than good by distributing toxin, and therefore one's choice must be between

* The Ministry of Health has adopted a unit which is one-half the strength of the well-known U S A unit Both standards are, therefore, usually stated on the label of most commercial antitetanus sera

an amputation well above and conservative measures The former has certainly proved very successful in suitable cases, and when the causal wound is deep, involving muscles and bones, badly infected and difficult to sterilize, amputation is often the method of choice In the less serious cases after a suitably large preliminary dose of serum the wound should be opened up thoroughly and yet with the greatest possible gentleness, any foreign body searched for and removed, and the wound cleansed with oxidizing antiseptics, and dressed with hypertonic salt solution or treated by Carrel's method The appearance of healthy granulations will probably synchronize with an amelioration of the symptoms

As to **symptomatic treatment,** the chief essential is to keep the patient quiet in a darkened room and free from all sources of irritation which would produce reflex spasm of muscles Sodium amytal, avertin (tri-brom-ethyl alcohol), hyoscyamus, chloral hydrate, bromide of potassium, chloretone, and other sedatives—morphine and atropine in specially severe cases—are of value in reducing reflex excitability and calming the nervous system, and must be given in full doses Food should be nutritious, fluid, and unstimulating, it has been suggested that the patient should be fed twice a day by stomach-tube under an anæsthetic, or by a soft rubber catheter through the nose, but rectal feeding may in suitable cases be tolerated, and, indeed, the patient must be given an abundance of normal saline and of glucose solution by this route or, if necessary, by intravenous and subcutaneous injection

The spasms can be diminished or almost abolished by the intrathecal or subcutaneous injection of a sterilized solution of sulphate of magnesia, which paralyzes the motor cells, 2 to 4 c c of a 25 per cent solution may be given by lumbar puncture, or 10 to 20 c c of a 10 per cent subcutaneously every four hours Inhalations of chloroform are also of great value in controlling the number and intensity of the spasms

Hydrophobia or Rabies

Hydrophobia or rabies is an acute general infective disease, transmitted from animals, especially rabid dogs, wolves, and cats, to other animals or to man It consists in an affection of the central nervous system, and one of its most marked features is the long and variable incubation period It never originates 'idiopathically' either in animals or man, infection usually following a bite, but experimentally it can be transmitted through unbroken mucous membrane, *e g* of the nose It has also been proved that if an affected animal merely licks an abraded surface the disease may be transmitted, even when the animal has not at the time shown any of the more typical signs of rabies

In the **Dog,** rabies manifests itself about three to five weeks after infection, but the period varies considerably, the original wound usually heals perfectly, or there may be some inflammatory thickening The disease first shows by a complete change of character, which is manifested possibly by snappishness and irritability, especially towards

other animals, by restlessness, or by the dog moping in dark corners, with a depraved appetite, eating any kind of rubbish or dirt, and even its own excreta, or standing aimlessly in the hot sun This period lasts for two or three days, and is perhaps the most dangerous, since there is nothing very suggestive about the symptoms It is usually followed by a stage of violence or frenzy, when the animal runs 'amok' and bites anything and everything that comes in its way The final stage is one of paralysis, going on to death, during which the mouth is filled with ropy saliva, which the animal vainly tries to scratch away, the bark loses its ring and becomes hoarse, and as the disease progresses the lower jaw becomes paralysed, finally, after partial or general convulsions, the animal dies five or six days from the onset of the symptoms

In **Man,** the incubation period varies from a fortnight to six or even eight months, six to seven weeks being perhaps the most usual interval, in Egypt the average day for the onset of symptoms is stated to be the nineteenth During the interval the wound may heal, although the scar remains tender and neuralgic **Premonitory Symptoms** include the development of fever, followed by a vague sense of terror, with illusions of the senses and disturbance of mind, insomnia is marked In about three days the more characteristic signs of the **Stage of Excitement** appear The terror persists and becomes more evident, and spasmodic attacks develop in connection with the muscles of respiration and deglutition, which become more marked if water is brought near the patient, or if he attempts to swallow The attack is really a spasm of the muscles of the throat and of the diaphragm, comparable to 'the long shuddering inspiratory clonic spasm that takes place when a child is immersed in cold water,' with fixation of all the accessory muscles of respiration in the neck, so that the chest is raised and fixed The sound produced by this spasm of the diaphragm is of a loud hiccoughing character, and does not much resemble the barking of a dog, to which it has been likened The temperature varies between 100° and 103° F This stage lasts one and a half to three days, after which the terminal **Paralytic Stage** follows The excitement becomes quietened, paralysis and coma develop, and death supervenes in from twelve to eighteen hours Towards the termination of the disease the spasms become more and more terrible, and the patient's mental state is most distressing, he is in a condition of abject terror, always seeking to keep in the light, possibly striving to get out of windows, probably tearing off all his clothes and constantly chattering

The **Post-mortem Changes** are mainly negative The nerve-cells of the medulla, cord, and elsewhere may be found degenerated The salivary glands are always somewhat enlarged The disease may be diagnosed in a suspected dog by the recognition of the Negri bodies in the nerve-cells, *e g* of the hippocampus major, and for descriptions of these and theories as to their nature special books should be consulted They are also found in most human cases of the disease

Preventive Measures should be adopted *immediately* in all cases of bites from dogs which are either rabid or may possibly be in the

incubation stage of the disease The circulation in the limb should be arrested by a string or bandage, bleeding encouraged, and, if free excision of the part is not feasible, the actual cautery or some powerful caustic, *e g* fuming nitric or pure carbolic acid, applied Even if such application is not made in time to prevent the occurrence of the disease, the onset of the symptoms may be thereby delayed and time gained for the prophylactic treatment by the original Pasteur method, or one of its more recent modifications Such treatment is usually administered only at a fully equipped Pasteur Institute, to which the patient is sent without delay, but some years ago the Board of Health of New York City instituted the practice of mailing to physicians material for the Pasteur treatment, full directions accompanying each package It has been found that the results compare quite favourably with the results of treatment given in laboratories All American State laboratories are now able to furnish treatment in this way Treatment with antirabic serum and more recently with various types of vaccine, *e g* carbolized 'fixed virus' or 'etherized' vaccine, has also been carried out, apparently with marked success, in some of the Pasteur Institutes In cases where such prophylactic treatment has not been carried out, and in which active symptoms have appeared, only **palliative treatment** can be adopted Every source of irritation and disturbance must be removed, and the patient kept absolutely quiet Local applications to the pharynx are useless, and for adults the only drug of value is hyoscine combined with morphia In children, chloral and sulphonal are of value Nourishment should be administered for choice by the rectum

Anthrax.

This disease results from infection with *Bacillus anthracis*, which produces in sheep, cattle, and other animals the so-called **splenic fever,** characterized by well-marked fever and enlargement of the spleen In man, if the organism is inoculated through the skin, it produces a local inflammatory lesion, known as **malignant pustule,** or a more diffuse condition termed **anthrax œdema ;** sometimes the latter follows the former If the infecting bacilli are inhaled into the trachea and bronchi, they produce a spreading inflammatory disorder, known as **woolsorter's disease** An intestinal form of infection also occasionally occurs

B anthracis (Plate IV , Figs 1 and 2) is one of the largest of the pathogenic bacteria It is found in the blood of diseased animals in the form of bacilli, single or in chains It is aerobic, non-motile, grows best at about blood heat, and liquefies gelatin Central oval spores are formed within the bacilli, *e g* on the contaminated hair or in the hides, etc , of such animals after death, or on articles contaminated with their blood and also when the organism is cultivated at a suitable temperature and in the presence of oxygen, but spore-formation does not occur in the living tissues The bacilli alone are readily killed by boiling for a few seconds, whilst the decomposition of the carcase in which they are present causes their death in about a week or less. The spores, however, are very resistant, for whilst a

1 per cent solution of carbolic acid kills the bacilli in two minutes, the spores remain alive after a week's immersion Moreover, alcohol and even a 5 per cent solution of carbolic acid have no lethal effect on them, unless acting for a long time If a mouse is inoculated, say, at the root of the tail with a needle, the point of which has been dipped in the blood of an animal which died of splenic fever, it succumbs in less than twenty-four hours, and bacilli are found in nearly every organ of the body The spores, even when dried, may survive for many months and even years

Some animals are immune against the attacks of anthrax, especially the dog and the white rat One of Pasteur's most useful discoveries was that of providing artificial immunity for cattle and sheep, which are highly susceptible to the infection, by inoculating them with an 'attenuated virus,' obtained by growing the bacillus for some time at 42° C , at which temperature it is rendered asporogenous

Incidence—Infection with this organism occurs chiefly amongst farmers and others who tend the living animal, or butchers who deal with the carcase, and also amongst workers who handle hides, wool, or hair The infection has in some cases been traced to the use of shaving brushes made from bristles contaminated with anthrax spores

Malignant Pustule is seen usually on the face or forearm, or in the case of meat- or hide-porters, about the neck or shoulder It commences as an angry red pimple at the site of inoculation, and rapidly spreads, with much infiltration of the base, whilst the centre becomes covered with vesicles, the serum within being blood-stained or dark brown in colour, and containing the typical bacilli This stage develops by the third day but is associated with no pain, only with great itching and irritation The pustule develops, and by the fifth day the centre has darkened into a brownish-black slough (*L. anthrax*, black), around which is a ring of vesicles with an area of brawny congestion and œdema beneath and around it Neighbouring lymph-nodes also become enlarged Generally, there is a certain amount of fever and malaise, which is not pronounced until about the fourth or fifth day The temperature then rises to 102° or 103° F , the pulse becomes rapid and irregular, and gastric irritability, vomiting, and flatulence more marked Should the disease progress unchecked, the surrounding parts are involved in a rapidly spreading œdema, thus from the face it may extend to the neck, chest, and back The respirations become shallow and embarrassed, whilst signs of grave constitutional disturbances, such as delirium or coma, manifest themselves, and the patient may succumb, generally in less than a week, sometimes in thirty to forty hours More commonly the case runs a less unfavourable course, limiting itself to the local manifestations, which gradually clear up, the slough separating and the œdema disappearing

Anthrax Œdema, though usually occurring in association with malignant pustule, may occasionally develop without the formation of that type of lesion It tends to run a rapidly fatal course, and is usually seen about the face, the skin becoming red and brawny, as in ery-

sipelas, and after a time covered with vesicles, whilst finally gangrenous patches appear The lymphatic trunks and nodes are also involved

The condition may be mistaken in the localized form for accidental vaccination or for a staphylococcal infection, but is recognized by the presence of the bacilli in the serum of the vesicles, in cases of doubt cultures and animal inoculations should be made

Woolsorter's Disease is the term applied to the condition in which the infection gains access by the inhalation of the dried spores The primary lesion is usually in the mucous membrane of the lower part of the trachea and of the larger bronchi, from which it rapidly spreads to the lung, mediastinum, and pleura The patient complains of fever and malaise for a few days, bronchopneumonia usually develops, and the disease runs a rapid course, with high fever, great dyspnœa, impairment of the circulation, and finally collapse in a great majority of the cases A much rarer form of the disease is the **alimentary** type, when the organisms are swallowed In the stomach, the unspored anthrax bacilli are usually destroyed by the acid chyme, but should any of them or their spores reach the intestine, the alkaline contents form a suitable breeding-ground, and the walls of the gut are attacked and the disease becomes general Colic, cramps, vomiting, and blood-stained diarrhœa are the most marked features in such a case The intestinal type appears to be not quite so virulent or fatal as the pulmonary, but is decidedly worse than the cutaneous Acute **meningitis** may follow secondarily upon any of the foregoing forms of the disease

Treatment—In the cutaneous affection, excision of the necrotic patch and of all the infiltrated tissues around, and the application of the actual cautery or of pure carbolic acid, were formerly recommended, but those who have had much experience think such treatment of little value, and put their trust in carbolic fomentations or mercurial ointment

Several sera (p 11) have been introduced for the treatment of anthrax, and good results have been obtained, especially in the localized forms of the disease Sclavo's serum (obtained by immunizing asses or goats) has been most used, large doses being given intravenously and intramuscularly, the latter being repeated every twenty-four hours, or oftener if necessary Sobernheim's serum, combined with vaccine treatment, has also given good results The use of either serum may be followed by fever and sweating, and improvement is often very rapid N A B may also be used with advantage along with serum or when such serum is unobtainable

Tularæmia.

Tularæmia is a specific infective disease of certain of the lower animals, more or less endemic in North America, Japan, Russia and Norway It is transmitted to man especially from rabbits and certain other rodents through handling and the bites of insects The causal organism is the Bacterium tularense, first isolated from infected ground-squirrels in Tulare County, California, by McCoy and others in 1911-12,

the name Tularæmia being bestowed upon it by Francis in 1921 The organism is a minute non-motile, Gram-negative bacillus, tending also to occur in short coccoid forms Clinically, after an incubation period of from one to ten days, the disease is ushered in by an initial rigor and is characterized by the presence of fever, malaise and sweating The disease tends to occur in three forms (1) the **ulcero-glandular,** in which there is the development of an ulcer at the point of infection and the regional lymph-nodes become swollen and painful a day or two later In (2) the **oculo-glandular** form there is a conjunctivitis and swelling of the cervical lymph-nodes and parotid glands In (3) the **'typhoid'** type of the disease there is a more marked degree of prostration The disease is, during the first week, of the nature of a bacteræmia, the organism being easily recoverable from the blood, the inoculation of which up to this time into a guinea-pig or a mouse causes a fatal infection After the first week, however, the organism usually disappears from the blood of the human patient, and about this period agglutinins develop and attain their maximum between the fourth and the seventh week, after which they tend to fall, but persist in lesser degree often for many years

From a surgical point of view the prognosis is good, although in about half the glands involved suppuration is liable to ensue and small foci of suppuration also occur along the course of the subcutaneous lymphatics The disease is self-limited and runs a course of from six weeks to six months The mortality ranges from 7 to 10 per cent and is usually due to sepsis One attack of the disease confers immunity

Because of its occurrence amongst rodents and its convection by animal parasites, the condition has to be differentiated from bubonic plague Tularæmia occurs most often amongst butchers, hunters, and those who come into closest contact with the infection-bearing rodents or with the wood-tick (*Dermacentor*) The patient will probably not be seen until the lymph-nodes are enlarged and the ulcer present on finger or hand, with perhaps the red streaks of lymphangitis up the forearm A history of a preceding attack of chill with nausea, vomiting, fever or malaise should arouse suspicion Laboratory infection of those working with the organism of Tularæmia is usually liable to occur, several cases being recorded both in this country and America

With regard to treatment little need be said The indications are to keep the part and the patient at rest, the ulcer clean, and to open abscesses as soon as the presence of pus can be detected Care must be taken to maintain the nutrition of the patient Blood transfusion, using if possible the blood of someone who has had the disease, will materially shorten the course

Gonorrhœa.

Gonorrhœa is an infective process due to the action of a specific micro-organism, the *Neisseria gonorrhœæ* or gonococcus (Plate I, Figs 5 and 6), and characterized, in its commonest form, by a discharge of pus from the urethra The organism is a Gram-negative diplococcus, this fact being of great importance in diagnosis, since

most, though not all, of the diplococci with which it might be confounded retain the stain Each coccus of the pair is usually kidney- or bean-shaped, the two lying with their concave surfaces towards one another It may occur in large numbers in the pus, and in most cases it is found within the polymorphonuclear leucocytes This is very characteristic, as also the fact that, even when only a comparatively small number of the cells may contain the organisms in their cytoplasm, those that do so are usually densely crowded with them (see Plate I , Figs 5 and 6, in which some of the cells contain few or no cocci, but in others the diplococci can be seen clustered in the cytoplasm) The pus also contains desquamated epithelial cells, in or on which many cocci may often be seen, and varying numbers of the latter may also be found free

Diagnosis —For the detailed description of the methods of laboratory diagnosis of gonorrhœa, both microscopical and cultural, text-books of practical bacteriology should be consulted In the **male,** especially in its more acute stages, the diagnosis can often be made at once by the microscopical examination of stained films of the discharge At least three films should be made, to be stained by Gram's, by Leishman's, and possibly by other methods When the discharge is abundant, the making of these preparations is usually a simple matter, but, if it is scanty, especially in certain chronic cases, such smears can best be made from the morning discharge before this has been washed away by the passage of urine, and it may be necessary to 'milk' the penis for this purpose When the infection has passed its acute stage and may have reached the posterior urethra, prostate and seminal vesicles, massage of these *per rectum* should be performed, any discharge appearing at the meatus being collected in a suitable sterile vessel, and also specimens of urine obtained both before and after this procedure If cultures are to be made, for diagnosis or for the preparation of an autogenous vaccine, it is essential that this should be done immediately by the direct inoculation of platinum-loopfuls of the discharge on appropriate special media, *e g* hydrocele-agar or whole blood-agar with a sufficiently moist surface, preferably previously warmed to body temperature For a satisfactory diagnosis **in the female** — sometimes a matter of great difficulty— such cultural methods are often necessary, the material for these and also for microscopical examination being obtained by expressing some of the muco-purulent discharge from the urethra, and also by taking a swab from the cervical canal through a sterile speculum, after the contaminating surface discharge has in both instances *been thoroughly wiped off* with surgical swabs It must be particularly emphasized that, except in the vulvo-vaginitis of young children, it is practically always useless and even misleading to submit for examination for the gonococcus films or swabs of the general leucorrhœal vaginal and vulvar discharge, which contains enormous numbers of mixed organisms, some of them not unfrequently morphologically resembling the gonococcus, which itself may be present in this general discharge only in such minimal numbers as to escape detection The **complement-fixation test** may also be used as an aid to the diagnosis

of gonococcal infections In suspected cases in either sex, where examination by the above methods has failed to reveal the presence of the gonococcus, a positive reaction is usually obtained if the infection has spread beyond the anterior urethra, and this reaction may persist for one or two months, or sometimes considerably longer, after the cocci have disappeared from the discharge In the female, weaker reactions are obtained than in the male In either sex a positive reaction is diagnostic of the presence or recent existence of gonococcal infection, but a negative reaction, especially in the female, does not by any means invariably indicate freedom from infection It must be remembered, however, that the administration of a gonococcal vaccine also produces a positive reaction with this test

(I) **Gonorrhœa in the Male**—The primary lesion is an acute catarrhal inflammation of the anterior portion of the urethra, rapidly becoming suppurative, and likely to spread back to the deeper portions of the urethra, the prostate, bladder, seminal vesicles, or epididymis Important alike in prognosis and treatment is the fact that the gonococcus is found, not merely on the surface and in the mucous membrane of the urethra, but also deeply in the submucous coat and in the mucous glands and glandular lacunæ The infection may remain limited to the genito-urinary system, but secondary infection by way of the bloodstream may take place, especially of joints (gonorrhœal rheumatism), and, in very rare cases, ulcerative endocarditis or even meningitis has supervened

The Symptoms of Acute Gonorrhœal Urethritis commence usually in from two to eight days after infection Most commonly the discharge appears about the third or fourth day, being preceded by itching of the meatus and a scalding pain on passing urine The lips of the meatus are congested and swollen, and the discharge, which is at first thin and mucoid, soon becomes thick, abundant, and yellowish in colour This stage lasts for a variable time, and is sometimes associated with a good deal of dragging pain in the back and loins, together with some constitutional disturbance and fever The bowels are usually constipated, and the appetite impaired Hæmorrhage from the urethra may result from the congestive swelling of the mucous membrane, which, together with the pain on micturition, may also lead to retention of urine

If the condition is neglected, and often even in spite of treatment, the inflammation spreads backwards, giving rise to what is termed a **Posterior Urethritis** This generally becomes evident about the end of the second week, and is characterized by frequent and painful micturition, a sense of pain and heaviness in the perineum, possibly a little blood in the urine, and a general feeling of depression This extension backwards is always serious, since it is liable to be followed by an acute prostatitis, vesiculitis, or an epididymitis These complications will be described elsewhere, but very frequently the extremely common condition of **Chronic Gonorrhœa** or **Gleet** supervenes, in which a more or less abundant discharge continues for some time without any troublesome symptom other than occasional scalding pain on passing urine The gleety discharge is often thin and muco-purulent,

and may be so slight as merely to cause the lips of the meatus to stick together, or may be evident only on squeezing the urethra after a night's rest This may last for a long time, perhaps years, and it must be remembered that even in this stage the disease can still be transmitted to others Gleet is sometimes due to invasion of deep lacunæ, or to an ulcerated or granular condition of some portion of the mucous membrane, the discharge is then yellow, and the urethra is tender on the passage of a sound, the presence of the local focus can be recognized by the urethroscope In most cases gleet arises from chronic prostatitis, a condition not uncommonly associated with chronic infection of the vesiculæ seminales The latter condition may be recognized on rectal examination, whilst, when the prostate is involved, flocculi of mucus in the shape of worm-like threads may be detected in the urine, especially after massage of the gland by the finger introduced into the rectum

When the disease has lasted for a considerable time, or after repeated attacks, a certain amount of peri-urethral infiltration is certain to follow, and a stricture of the urethra may result, this may also be due to the cicatrization of the ulcerated and granular patches in the urethral wall, described above

The exact source of a chronic urethral discharge is by no means easy to ascertain Examination of the urine by the two-glass test, which was formerly relied on, is in reality quite useless, inasmuch as all the discharge accumulated in the urethra is washed out into the first If, however, the urethra is cleansed by passing a portion of the urine into a glass, and then thorough prostatic massage is carried out, the examination of the first urine passed afterwards will be of great significance, if it contains pus and gonococci, then infection of the posterior urethra is present Examination by the urethroscope or endoscope is, however, much more reliable and useful The instrument consists of a metal tube fitted with electric illumination in such a way as to render visible the walls of the urethra, which should be distended with air by a bellows A commencing stricture can be easily recognized, as also ulcerated areas, patches of granulations more or less polypoid, etc , and the use of this instrument also enables suitable local treatment to be undertaken

Every purulent discharge is not necessarily gonorrhœal, since a simple urethritis may follow connection with a woman who is suffering merely from a non-gonococcal form of leucorrhœa In these cases infection may be due to ordinary pyogenic cocci, or possibly to *Bact coli* Although the history may suggest a simple urethritis the diagnosis can be made only by the microscopical examination of the discharge and, as already noted, cultural examination may also be required It must be remembered, however, that gonococci are capable of remaining in a latent or passive state for a very long time in the folds or crypts of a mucous membrane, and hence a person who has once suffered from it may be capable of transmitting the disease, although no obvious evidence of its existence may have been found Moreover, in a gouty patient, a highly acid condition of the urine, especially if it is loaded with uric acid crystals, may light up

into activity a urethritis which has been quiescent for some time, as may also an over-indulgence in alcohol in a patient apparently cured

The practitioner is not unfrequently consulted as to the advisability or otherwise of marriage after an attack of gonorrhœa, the mere cessation of the discharge is not sufficient to warrant such a step The only reliable test is to light up a fresh attack of urethritis by the injection of some suitable chemical irritant, *e g* a solution of nitrate of silver (1 in 100) or pilocarpine hydrochloride (1 in 400), and to examine the discharge bacteriologically for the presence of gonococci Lugol's iodine solution has also been used for this purpose, combined with an intracutaneous injection of vaccine

Prophylaxis—Whilst it is obvious that the only effective means of avoiding infection with a disease so easily contracted as gonorrhœa is the abstinence from exposure, and that for this purpose moral restraints must be relied on, yet whilst human nature remains more or less constant in type, such abstinence is unlikely to be general, and venereal disease will persist, with all its crippling and mutilating results, which are only too liable to spread to innocent victims From the point of view of the State, to protect these, and also the exposed individual, by the adoption of simple precautionary measures, is necessary The fact that the infection immediately after exposure may still be more or less superficial, and only penetrate to the deeper parts after an appreciable interval, is the key to prophylactic treatment, which consists in the effective washing of the parts with soap and water, followed by a 1 in 2,000 solution of potassium permanganate Attention should be directed especially to the thorough cleansing of the frænum and meatus, the lips of which should be opened so as to allow some of the solution to enter The use of calomel ointment to smear over the parts has also been advised, but it is a comparatively weak antiseptic, and the method advised above has been proved to be efficient in the majority of cases

Treatment—Recent work tends to show that at last an effective remedy has been obtained in drugs of the *sulphanilamide* group The most popular remedy at present is 'uleron,' which is given in doses of two tablets three or four times daily for three days After an interval of ten days a second course may be given, and even a third if the case does not appear cured About 65 per cent of the acute and 70 per cent of the chronic cases appear to be cured with this treatment At the same time general measures should be adopted In acute cases it is wise to keep the patient in bed for a few days on a fluid non-stimulating diet which excludes meat, alcohol, tea, and coffee, he is permitted to drink barley-water and milk and soda-water, alkalies and purgatives are administered with tincture of hyoscyamus as a sedative, and all local interference is avoided A hot bath will usually overcome the difficulty in micturition, every effort must be made to avoid the necessity of the introduction of a catheter At the end of a few days, when the symptoms have subsided, the patient may be allowed to take quiet exercise or to go about his ordinary duties, but the scrotum should be supported in a suspensory

Drainage.—It is a controversial point whether irrigation should or should not be carried out in the acute stages It is probably better that it should be reserved for the subacute (after six weeks) and chronic cases, and when started should include the whole lower urinary tract, including the bladder as well as the urethra, with a weak solution of potassium permanganate (commencing with 1 in 8,000, and increasing the strength as the infection becomes more chronic or approaches a cure, when a 1 in 4,000 solution may be used) The apparatus required is a receiver to hold about 2 pints connected by a rubber tube with a glass cannula protected to prevent splashing backwards, although a simple blunt-ended cannula quite well suffices The lotion is placed in the receiver at a temperature of 104° F , and provision is made for the escape of the injected fluid after use into a suitable vessel The patient is first instructed to micturate so as to wash away all discharge lying in the urethra At first the receiver is kept only about two feet above the patient's pelvis, so as not to force open the compressor muscle and carry the fluid into the posterior urethra, the anterior portion is alone washed out two or three times a day, but the force employed is sufficient to dilate the tube and open up the crypts and lacunæ so as to bathe them effectively with the antiseptic lotion After a day or two the patient is encouraged to fill his bladder with the lotion, this is best accomplished by raising the receiver to a height of about three feet above the pelvis and instructing him to breathe easily and to attempt to micturate whilst the fluid is being injected, the compressor will thus become relaxed, and the fluid enter the bladder After a little practice the patient will be able to distend his bladder in this manner, and thus even if a few cocci are carried back they are floating in a large bath of antiseptic lotion in which they are comparatively harmless All the crypts and recesses of the urethra, both superficial and deep, are by this means opened up and brought into contact with an abundance of antiseptic fluid, which is expelled after being retained for twenty or thirty seconds The effect of this treatment is most satisfactory, the discharge rapidly diminishing, but it must be persisted in until all discharge has ceased

After the acute stage has subsided, and if there has been evidence of an acute prostatitis, massage of the prostate and vesicles should be started so as to expel infective material which may lodge in those organs It should be carried out twice weekly for four or six weeks

The treatment of a case of **Gleet**, which has not responded to chemotherapy, is often a matter of difficulty, but as more efficacious methods for dealing with the acute stage are enforced, gleet should become much less prevalent The first principle of treatment consists in finding out the actual nature and site of the lesion, and to this end the urethroscope is used If patches of granular urethritis are present or localized ulcers, topical applications of nitrate of silver in strengths up to 5 per cent should be made In the absence of these lesions the gonococci are probably to be found in the lacunæ of the urethra, the crypts of the prostate or the seminal vesicles These must be emptied methodically by dilatation of the urethra with some such

attack the vaginal mucosa, and for this reason the presence of gonorrhœal infection in the female is often overlooked In children a true gonorrhœal **vulvo-vaginitis** occurs, sometimes in epidemic form, *e g* in girls' schools and other institutions

Symptoms and Complications —The symptoms in acute cases are those of heat and burning about the genitals, combined with a purulent discharge and painful micturition The **urethra** can be seen and felt to be swollen, its orifice is red and congested, and pus can be expressed from it If the **cervix** is involved an endo-cervicitis results The uterus becomes congested and painful, with a blood-stained discharge, severe backache is felt, and perhaps some tenderness on pressure over the lower part of the abdomen In the more chronic cases little may be noted except that the periods are painful, and that there is a certain amount of leucorrhœa, with occasional attacks of discomfort and frequency of micturition

In all cases the inflammation is likely to spread, either to the bladder, or up the uterus to the Fallopian tubes (**salpingitis**), ovaries, the cellular tissue of the broad ligaments, etc , or to the peritoneum—in which case the inflammation may be localized, producing adhesions around the fimbriated extremities of the tubes, and these are often an important cause of sterility Peritonitis is not an uncommon complication, but is more favourable than the type caused by other organisms in that it tends to remain localized to the pelvis

Treatment follows along the same lines as in the male, *viz* by bathing the parts frequently with an abundant supply of weak permanganate of potash (1 in 2,000) The patient lies on her back in the lithotomy position, and the vagina is filled with the lotion from a douche can, the fluid being retained for a time It may be desirable to apply tincture of iodine or a solution of nitrate of silver to the cervix through a speculum, or to the urethra In addition, treatment by diathermy is very valuable, especially in the chronic cases It should be applied to the urethra and cervix by means of special electrodes, the temperature and duration of treatment being gauged by that degree which causes discomfort to the patient when tried firstly in the urethra Vaccines should also be tried

(III) **Gonorrhœa in Either Sex—Complications arising from Direct Transmission of the Infection —Gonorrhœal Proctitis** sometimes results in the female from infection of the anal region, etc , by the discharge which escapes from the vulva, whilst in both sexes it may be due to unnatural practices It is characterized by tenesmus and a thick muco-purulent discharge, and is treated by injecting lotions of acetate of lead and opium, or of boric acid Abscesses, fistulæ, stricture, etc , will require appropriate treatment

Gonorrhœal Rhinitis has also been seen in a few cases It leads to an abundant discharge of pus, and should be treated by warm soothing injections, followed after a time by dilute astringents **Stomatitis,** with the presence of whitish patches surrounded by reddish zones on the buccal mucous membrane, gums, tongue, tonsils, etc , is a rare complication, which may be treated with a potassium permanganate mouth-wash

Gonorrhœal Conjunctivitis.—For this serious complication see Chapter V

Complications resulting from General Absorption.—Gonorrhœal Affections of Joints are not uncommon sequelæ, arising usually in the subacute stage of the disease The knee is affected in about 40 per cent , the wrist in 20 per cent , and the fingers in 10 per cent Much periarticular thickening takes place, and this leads to a marked limitation or false ankylosis of the joints In some cases suppuration occurs, and leads to a knee ankylosis

Gonorrhœal Fibrositis.—Any muscular, tendinous, ligamentous, or aponeurotic tissues may become inflamed and painful during the course of an attack of gonorrhœa In the case of involvement of the ligaments supporting the arch of the foot, the patient must not be allowed to walk, otherwise the arch may give way and a permanent flat-foot result

Gonorrhœal Scleritis, or inflammation of the deep subconjunctival fibrous tissue, is a rare affection, arising quite independently of gonorrhœal conjunctivitis It is characterized by marked subconjunctival redness, the globe of the eye becoming distinctly tender Local applications of atropine are required and, if need be, leeches to the temples For descriptions of **Iridocyclitis,** rare as an early, but fairly common as a late, complication, and usually associated with gonorrhœal arthritis, and for other rarer gonococcal infections of the eye, textbooks on ophthalmology should be consulted

Gonorrhœal Endocarditis, etc —Occasionally the cardiac valves become infected and inflamed, and an ulcerative endocarditis due to gonococci has been observed More rarely a septicæmic infection may occur

Gonorrhœal pyæmia, a condition of great rarity, is characterized by a formation of secondary abscesses in various parts of the body, containing the gonococcus Gonorrhœal meningitis is another extremely rare complication of the disease

Soft Chancre or Chancroid (*Ulcus Molle*)

Soft Chancre is a local infective venereal lesion, which is rarely seen elsewhere than on the genital organs It is due to a specific bacillus, which was first described by Ducrey, and which occurs in the form of short chains consisting of slender rods, which are Gram-negative and do not form spores The organism can be cultivated, though with difficulty, and in the lesion ordinary pyogenic organisms are often also found Infection is followed by a typical series of events A red papule appears in a few hours, and in two or three days a vesicle, surrounded by a zone of angry hyperæmia, is seen The serum within the vesicle soon becomes turbid, and by the fourth or fifth day a fully-developed pustule is present, as soon as the cuticle is lost, an ulcer forms with cleanly-cut edges and a sharp, distinct outline, gradually increasing in size up to perhaps half an inch or a little more Around the ulcer there is an outer red areola, within which is an inner yellowish-grey zone, whilst the floor of the ulcer

itself shows ' little red cup-like points visible under a lens ' (P Fernet). Such a sore may occur upon any part of the penis, but more especially the prepuce and glans, or the corona glandis, and in the case of the female about the vulva It sometimes develops within the meatus, producing a considerable discharge which may simulate that of gonorrhœa The lesion is usually very painful and tender The exudate is highly infective, and if inoculated elsewhere on the patient produces a typical sore, showing that the condition is purely local, and that no constitutional immunity results from its presence Frequently several soft sores are present at the same time, and the discharge from one chancre is very likely to produce a similar affection (' satellite ' chancre) on any cutaneous or mucous surface brought into contact with it, *e g* it may spread from prepuce to glans, or *vice versa*, or from one lip of the vulva to the other It is a curious but well-authenticated fact that soft chancres are rarely seen on any part of the body other than the genital organs The discharge from a true syphilitic chancre may produce a localized pustule on auto-inoculation, but no typical primary hard sore

Complications of the typical soft chancre may occur Thus, if a long foreskin is present, the discharge may be retained beneath it, and extensive ulceration follow, which may even result in the glans protruding through the upper part of the prepuce, which drops beneath it If the frænum is involved, hæmorrhage may supervene from ulceration into a branch of the artery in it When there is much inflammation, the base of the sore becomes indurated and infiltrated, somewhat resembling the Hunterian syphilitic hard chancre Not unfrequently a co-existing syphilitic infection may complicate the diagnosis, and it is usually advisable to examine such cases bacteriologically and serologically with this possibility in view The sore then runs a longer course, does not heal, even if kept clean, and after a time the patient, if untreated, develops the characteristic signs of syphilis

The neighbouring **Lymph-nodes** practically always become enlarged and tender, and the process is very liable to terminate in suppuration, constituting a bubo Two forms of this affection are described (*a*) The simple bubo results from the absorption of ordinary pyogenic organisms from the abraded surface The pus in this case, if inoculated elsewhere, may produce a pustule, but not a true soft chancre The process is usually limited to the lymph-nodes themselves (*b*) The virulent bubo is due to the absorption, not only of pyogenic organisms, but also of the specific bacilli, so that the pus, if inoculated, produces a typical soft sore In these latter cases suppuration occurs not only in, but even more abundantly around, the lymph-nodes (periadenitis), so that the skin becomes considerably undermined, and the wound produced by opening the abscess may take on the form of a large soft chancre in the groin, in the centre of which is seen the lymph-node only slightly enlarged The process is often slow, and a good deal of cutaneous redness is present with but little pus

Diagnosis of soft chancre and of the buboes secondary to it is sometimes a matter of considerable difficulty, especially its differentiation from lymphogranuloma inguinale For this purpose, in addition to the

isolation and identification of the specific bacillus, two methods may be employed (1) The re-inoculation intradermally of the patient himself with living infective material from his own lesion, reproducing the typical soft sore from which Ducrey's bacillus is recovered, and (2) the intradermal injection of a vaccine ('Dmelcos') giving a positive cuti-reaction

Treatment with stock vaccine of Ducrey's bacillus ('Dmelcos') administered intravenously, and which may also be applied as a local dressing, should be preceded by such local measures as cleansing the sore, and especially its undermined edges, *e g* by playing a strong jet of hydrogen peroxide upon it, followed by eusol, repeated if necessary after brushing off any loosened discharge The surface may then be swabbed with tincture of iodine (mitis) and dressed with sterile gauze If a purulent discharge is still present, the spraying with peroxide and eusol is repeated If it then remains clean, it may be sprayed with sterilized, freshly made, or collosol tannic acid, allowed to dry and remain exposed to the air If the formation of a bubo threatens, the crusts are soaked off and eusol applied Where much balanitis exists, it may be necessary to slit up the prepuce, but circumcision should not be undertaken until the sores have healed In some, but not in all, cases a 3 per cent solution of N A B (see p 159) has been found efficacious

Buboes are treated in the early stages by keeping the patient at rest and applying fomentations, when resolution sometimes occurs If suppuration ensues, the abscess should be incised vertically, so as to allow free exit to the pus even when the patient is sitting, the cavity being subsequently dressed by packing it with gauze impregnated with eusol or lotio nigra

Climatic Bubo, Lymphogranuloma Inguinale, etc

This is a disease which has been described by many names, of which **lymphogranuloma** is the most usual It is due to a filter-passing virus and is transmitted venereally The disease does not appear to be indigenous to Great Britain, but is found usually in seamen who have contracted it abroad, *e g* in the West Indies, China, some parts of Africa, also in the United States The antigen used for the intradermal test devised by Frei is obtained by aspirating blood-free pus from the affected inguinal lymph-nodes of a known case of the disease in whom tubercle, syphilis, gonorrhœa, ulcus molle, etc , have been excluded, the fluid so obtained being diluted with saline and sterilized at 60° C In the male, the primary le ion usually occurs about the coronary sulcus as a transitory herpetiform ulcer or as a nodule, appearing a few days after coitus, and followed in from about one, two, or three weeks or longer by swelling of the inner or median group of inguinal nodes on one or both sides The glandular swelling may be slight or marked, with or without suppuration, and sometimes accompanied by prolonged fever, which may even simulate enteric or endocarditis The nodes show endothelial proliferation, usually with some giant-cell formation not unlike those of tubercle and syphilis De-

generative changes, cellular infiltration, and micro-abscess formatioi usually follow, the process having been described as a 'glandula granulomatosis of progressive type,' and in a few cases an elephantiasi of the genitals supervenes from blocking of the lymphatics A hyper plastic fibrosis of the perirectal tissues, in some cases progressing t stricture of the rectum, may supervene, especially in the female, owin to the spread of the infective process from the vulva and vagina b way of the lymphatics For a note on the differential diagnosis o lymphogranuloma inguinale from soft sore and from syphilis se pp 143 and 144, and in this connection it must be remembered tha mixed infections of these venereal diseases are by no means rare The treatment which is most frequently used is intravenous medicatioi with antimony and pot tartrate, but it is not curative For recta stricture a colostomy provides great relief and improves the loca condition Recent publications tend to show that sulphanilamid medication is likely to prove a very effective remedy in the treatmen of the disease

Syphilis.

Syphilis is a specific disease due to the spirochæte discovered b Schaudinn and Hoffmann in 1905, now termed *Treponema pallidur* (formerly *Spirochæta pallida* and sometimes *Spironema pallidum* (Plate V, Figs 1 and 2) It can be cultivated, as discovered b Noguchi, in a mixture of agar and ascitic fluid containing a bit o sterile fresh animal tissue, *e g* rabbit's kidney, under strict anaerobi conditions Morphologically, it is a very delicate spiral filament having some eight to twelve usually very regular short deep curves its ends are sharply pointed and tapering Its length varies, bu on an average is about equal to the diameter of a red blood corpuscle or a little more, and each whorl occupies about 1 μ Th common *Tr refringens*, which is frequently found in the mouth tonsils, etc, is larger, broader, has blunter ends, and a smalle number of less regular whorls

The specific organism can be detected in the great majority of al cases of syphilis, and it may be present in enormous numbers in th lungs, liver, spleen, and other viscera of still-born syphilitic fœtuses In acquired syphilis it may be demonstrated in the earliest stages o the sore which precedes the typical primary chancre, or in scraping from it, in the secondary stage it occurs in the skin-lesions, or i the fluid of blisters raised near them, in the lymph-nodes and in th spleen, and has been demonstrated in the blood, though rarely, i the tertiary stage it has been found in small numbers in gummat and other specific lesions, but in the majority of cases at this stag it can be demonstrated only with great difficulty and after prolonge search, especially is this the case in the so-called parasyphilitic affec tions of the nervous system, now usually described as neurosyphilis such as general paralysis or locomotor ataxia

Syphilis occurs in man, but may be artificially inoculated into th higher apes, which develop a disease comparable in most of its feature with human syphilis, and experiments on these animals have yielde

results of much clinical value The disease has been transmitted by material obtained from the human subject in all stages, *e g* the blood, the semen, discharges from the primary sore, from secondary lesions, and even from gummata After such experimental inoculation, the incubation period is from three to four weeks, and then an indurated nodule appears which undergoes ulceration, and is accompanied by enlargement of lymph-nodes Mild secondary symptoms usually follow, but in apes tertiary manifestations have not been observed Inunction of calomel ointment locally can prevent infection, even up to twenty hours after inoculation, but excision of the inoculated area has proved useless except when undertaken within eight hours after infection The rabbit has also been much used for the experimental transmission of the organism, the inoculation being made into the eye or testis

The most important methods for the **Laboratory Diagnosis** of syphilis are the demonstration of the spirochæte and the Wassermann reaction Among other valuable though less important methods the Meinicke clarification reaction and the Kahn flocculation test are the most useful, whilst the examination of the cerebro-spinal fluid is often of great importance, especially in the later, but sometimes also in the less advanced, stages of the disease *Tr pallidum* can usually be found without difficulty in the serum which oozes from the surface, and especially from the margins of the chancre after the surface has been thoroughly cleansed with saline, firmly rubbed with alcohol and again with saline, or, after the preliminary cleansing, it may be scarified—bleeding being avoided, or if it occurs, the blood being wiped off until serum alone exudes This is then transferred directly with a platinum loop to a ringed slide for examination by dark-ground illumination and other films made in various special ways, or it is collected in a capillary tube for transmission to the laboratory Puncture of neighbouring enlarged lymph-nodes may also be employed, a little sterile saline being first placed in the syringe in order to wash out the small amount of gland-juice collected in the needle Long before the sore has taken on a typical appearance the spirochætes may be thus demonstrated and the diagnosis made No antiseptic should be applied to the sore before examination Three methods of demonstration may be employed (1) The material may be examined fresh under dark-ground illumination This is considered by many to be the best method, the organisms being easily seen and their characteristic movements observed (2) Appearances somewhat similar can be secured by mixing the exudate with very fine fluid Indian ink, spreading it out into a film, and allowing it to dry on a slide Here also the organisms appear colourless on a dark ground, but, of course, there is no movement This is a simple and quick method, or the material may be mixed wet with 2 per cent Congo red, dried, blued by exposure to the fumes of strong hydrochloric acid—with no washing at any stage—the spirochætes being silhouetted colourless against the blue background (3) There are numerous staining methods, most being modifications of Romanowski's Processes depending on the reduction of silver salts are also used, both for films and sections

In the **Wassermann reaction**—a complement-fixation test—we possess a test which, when positive, is of the greatest value In syphilis, this reaction is not established immediately, but may first show itself in two, three, or four weeks after the appearance of the primary sore In some cases it may be delayed till the fifth or sixth week, or even later It is, therefore, essential to examine a suspected sore itself for *Tr pallidum*, before local antiseptic treatment has been commenced A positive diagnosis may thus be made at once in many cases, and if there are reasonable clinical grounds for believing the case to be syphilitic, and especially if it is possible thus to demonstrate the presence of the spirochæte, it is bad practice to await the establishment of a positive Wassermann before commencing treatment—the results of **immediate** treatment being infinitely better than if delayed until the Wassermann reaction has developed Moreover, in this early stage, a single negative Wassermann reaction is of little value by itself, and the test may have to be repeated several times

In untreated cases in the secondary stage, the Wassermann reaction is practically uniformly positive, and the result of the test may, in the vast majority of cases, be taken as an accurate indication of the presence or absence of syphilitic infection

In the tertiary and late stages, a negative Wassermann reaction is never absolutely conclusive In many cases, a positive reaction may still persist, but in a certain proportion, including older standing congenital cases, it may become feeble or absent In a not inconsiderable proportion of old-standing nervous cases, the **cerebro-spinal fluid** may give a positive result, although the reaction in the blood may be slight or have completely disappeared

For purposes of diagnosis, a positive reaction may, in some cases, be induced by a small ' provocative dose ' of salvarsan, etc It must be clearly remembered, however, that a positive reaction merely proves the presence of a syphilitic infection in the body, it does not prove that a given lesion is syphilitic

The **Clinical History** of syphilis varies widely in different cases according to the virulence of the infection and the degree of resistance of the tissues, but the division into three stages, as suggested by Ricord, though artificial, and though these stages often overlap, is convenient for purposes both of description and treatment The **primary** stage includes a varying period of incubation, and the appearance of a sore, usually known as a ' hard chancre ' This is followed in the course of a few weeks by signs of **general** infection, referred mainly to the skin, mucous membranes, and lymph-nodes, comprising the **secondary** stage After a variable time, perhaps extending to many years, during which definite symptoms may not be in evidence, **tertiary** manifestations (gummata, etc) may show themselves in any part of the body

Mode of Infection.—Acquired syphilis is almost always due to infection of the genital organs by the spirochæte transmitted by sexual connection Cases, however, also occur in which the disease is acquired otherwise, *e g* by direct or indirect contact with syphilitic

lesions, and then the primary lesion is often located on some other part of the body (**extragenital chancres**). Thus, the lip may be infected as a result of drinking out of the same glass or smoking the same pipe as a syphilitic patient, or by kissing It has been conveyed from person to person by imperfectly sterilized dentists', hair-dressers', and manicurists' instruments, and to doctors, dentists, and nurses in the course of their work The spirochæte is a delicate organism, and quickly loses its virulence outside the body This probably explains the rarity of indirect infection The disease is not equally infectious in all its stages, in the primary stage the discharge derived from the chancre will alone convey the contagion, in the secondary period the spirochæte is present in the blood, and consequently in all pathological exudates, as also in the semen It is uncommon, but by no means impossible, for infection to be conveyed by patients in the tertiary stage

The stage of **Incubation** lasts for a variable period, extending from two to six weeks, as a rule, evidences of induration of the sore can be detected about the third week Removal or destruction of the local lesion has not the slightest influence upon the progress of the case unless it is undertaken immediately after infection, or unless the patient is being treated by salvarsan or one of its substitutes Many spirochætes are enclosed within the chancre, and as these are inaccessible to the drug, it is advisable to remove them by operation. During the incubation period the local sore may heal over superficially, if it is purely syphilitic, and nothing further may be noticed until the typical induration manifests itself Not infrequently, however, pyogenic infection is superadded, or, but much more rarely, lymphogranulomatous infection, or a soft chancre may also be present, in the two latter cases the lesions do not heal satisfactorily, and the base of the ulcer becomes indurated after a time A moderate enlargement of the spleen has recently been described as occurring in a large proportion of cases some fifteen days before the appearance of the hard chancre, rapidly subsiding under appropriate antisyphilitic treatment

I **The Primary Stage** of syphilis is characterized by the development of a sore, associated with enlargement of the neighbouring lymph-nodes The sore is most frequently situated on the prepuce, rather more frequently on the inner than on the outer aspect, it is common in the sulcus between the glans and prepuce, or may occur on the glans itself or on the frænum, but no part of the male genital organs is exempt In the female it is most frequently to be found on the inner aspects of the labia majora or nymphæ, but it often causes so little inconvenience as to be overlooked

The primary sore does not invariably present the same appearance, although it is typically characterized by a certain amount of infiltration and induration The following are the chief forms in which the chancre manifests itself (*a*) The **desquamating papule** is a slightly elevated spot, which is irritable, of a dusky colour, and free from ulceration It is usually small, hard, and its surface covered with epithelial scales If exposed to friction or to the irritation of re-

debilitated patients Another form of eruption is the *squamous syphilide*, characterized by patches of hyperæmia and infiltration, combined with superficial desquamation It is usually bilateral, and, unlike simple psoriasis, affects the flexor rather than the extensor surfaces In the later stages, distinct nodules are produced in the skin, which may undergo ulceration (*' lupoid ' syphilide*)

As to the situation of the rash, the roseola is usually limited to the trunk, whilst the other forms are often scattered widely over the trunk and extremities, involving, however, as noted above in the case of the squamous syphilide, the flexor more than the extensor surfaces of the limbs A somewhat characteristic phenomenon is the appearance of a papular rash on the forehead, sometimes known as the ' corona veneris '

The **Mucous Membranes** may be affected in much the same way as the skin The fauces become red and congested, the hyperæmic area being abruptly limited and semicircular in outline, symmetrical ulceration usually follows, starting near the anterior pillars of the fauces, and spreading to the tonsils and along the soft palate to the uvula These ulcers are shallow, have sharply-cut edges, and often present a characteristic greyish appearance, constituting what is known as a *' snail-track ' ulcer* The secondary sore throat rarely results in extensive loss of substance, and hence pharyngeal stenosis is not produced Concurrently with these manifestations in the fauces bare patches from loss of epithelium may be seen on the dorsum of the tongue, or several small superficial ulcers may develop on the inside of the cheeks or lips, or along the borders of the tongue, from the irritation of the teeth

Mucous patches and condylomata are somewhat similar lesions, though more pronounced, arising in the secondary stage in connection with mucous membranes and those parts of the skin which are soft and moist **Mucous patches** consist of slightly-raised areas of enlarged and infiltrated papillæ, white in appearance, and often progressing to ulceration, Examined microscopically, the papillæ are found to be definitely enlarged, and the epithelium heaped up over them They are most commonly observed at the corners of the mouth, on the inner aspect of the cheeks, the side of the tongue, or the margins of the anus, in the last-named situation they are usually symmetrical, one side being infected from the other They are also not uncommon between the toes, and the ulcers caused thereby become exceedingly offensive **Condylomata** are similarly the result of more marked overgrowth of the papillæ, differing from mucous patches merely in degree They consist of wart-like masses, which may attain a great size, constituting a cauliflower-like growth They are seen most commonly about the anus or vulva, in the former situation being often mistaken by the patient for piles, they give rise to an abundant, highly infective discharge A similar condition sometimes occurs on the dorsum of the tongue, known as ' Hutchinson's wart '

The **Lymph-nodes** are usually enlarged throughout the body during this period of the disease, being felt as round, hard swellings beneath the skin The extent of the lymphatic complications is possibly a measure of the degree of virulence of the affection Chronic enlarge-

ment, particularly of the nuchal and supratrochlear lymph-nodes, in the absence of any obvious local cause, is always suggestive of the possible existence of syphilis

Syphilitic Alopecia.—The hair becomes dull and lustreless, and either comes out in patches from the scalp, eyebrows, etc , or there is a general 'thinning' The follicles, however, are not destroyed, and the hair may subsequently regrow

Syphilitic Iritis is characterized by pain in the eye, generally referred to the supra-orbital nerve, together with some interference with vision, and possibly a little lachrymation and photophobia On examination a bright-red circular zone is seen immediately around the cornea, resulting from hyperæmia of the ciliary vessels The iris is lustreless, and its definition somewhat blurred Its colour is changed, a blue iris becoming greenish-yellow from the presence of lymph The pupil is diminished in size, and perhaps irregular, its movements are always considerably hampered, and sometimes entirely prevented, by the formation of adhesions either to the back of the cornea (anterior synechiæ) or to the lens-capsule (posterior synechiæ) Occasionally small yellowish nodules are seen on its surface, consisting of plastic lymph

The **Duration** and character of the secondary stage vary considerably As already emphasized, the sooner effective treatment is commenced, the less severe the secondary phenomena Hence the disease is often of an aggravated type when following undiagnosed extragenital chancres, as also in women, by whom the primary lesion often passes unnoticed When treatment is commenced within four or five weeks of infection, the secondary stage may be slight, and all traces of its existence may pass off in two months or less, if treatment is delayed until the cutaneous eruption has appeared, this stage is likely to last longer If the patient's general health has already been undermined, *e g* by alcoholism, etc , the syphilitic infection will follow a more aggravated course Patients suffering from the debility caused by malaria or other tropical affections are particularly bad subjects, and the disease may then run a virulent course **Relapses** during the first twelve months are usually due to intermissions in or inadequacy of the treatment The rash which appears under these circumstances is often of a more characteristic type, the papules being grouped into rounded or confluent figures

In the **Later Secondary Period** lesions appear which are not strictly gummatous, although they develop some time after the more acute manifestations of this stage of the disease have disappeared These later secondary manifestations include flying pains (*osteoscopic*) in the bones, iritis, and various nervous lesions, whilst **periosteal nodes** may form on the tibiæ and other bones, or a symmetrical chronic effusion develop within the synovial membranes of joints Some of the secondary manifestations, especially those of the bones and joints, may persist through this period, whilst even if they have disappeared the patient is liable to suffer from 'reminders' in the shape of various cutaneous affections A bilateral epididymitis also is not uncommon, and is remarkable in that it is painful The blood-vessels are not infrequently affected in this and later stages of the disease (*end-*

eighteen months All cases should be kept carefully under observation for at least two or three years, and this must include the testing of the blood and c s f for the Wassermann reaction, at first every month, and subsequently every three and then six months A small provocative dose of N A B should be given at the end of the first year after the cessation of treatment, and the serum reactions of blood and cerebro-spinal fluid tested, say a week later The slightest sign of relapse, either clinically or by the Wassermann test, indicates the prescription of a further similar course of treatment In tertiary syphilis salvarsan is useful in helping in the cure of active manifestations of the ulcerative type, but mercury and iodide of potassium still maintain their position, and must be employed Over the deep lesions, especially of the neurosyphilitic parenchymatous type, salvarsan has but little influence

Occasionally unfortunate results have followed the use of these powerful drugs, and a certain small percentage of mortality is liable to occur Headache, fever and a rigor sometimes develop on the same day as the injection, passing off quickly, they are sometimes accompanied by vomiting and diarrhœa Jaundice may be noted at a later date, usually not very intense, but occasionally severe and even fatal, being then due to acute or subacute hepatic necrosis (' yellow atrophy ' of the liver) Various forms of skin lesion may also occur, from a simple herpes to a severe dermatitis exfoliativa, which may be fatal The percentage of these accidents is, however, decreasing steadily, and with increased experience and improving technique may be expected to fall still lower They are due in part to the toxic character of the drugs, and possibly in part to the rapid destruction of spirochætes in the blood and tissues and the setting free of a large amount of endotoxin The administration by the mouth of 1 to 2 ounces of glucose half an hour to two hours previous to the intravenous injection of the arsenical drug helps to protect the liver against its toxic action The bowels should be thoroughly emptied, and only a light meal partaken of several hours previously The urine should be examined regularly, especially for the presence of albumen and casts

Bismuth is now extensively used, and is of especial benefit in cases which have proved resistant to arsenic and mercury When administered alone, it causes fairly rapid disappearance of the lesions, but has a much slower effect on the Wassermann reaction Some preparations are used in conjunction with arsenic salts, whilst others are used alone, consisting of precipitated metallic bismuth in isotonic salt solution The injections are given every three or four days until a total of twelve to twenty doses has been administered, or until the Wassermann reaction is negative The injections are intramuscular, the exact detail of dosage varying with each preparation The complications to which it may give rise are stomatitis and albuminuria Bismuth has not displaced either arsenic or mercury in the treatment of syphilis, but its administration may be additional to or alternate with either or both of these It is also particularly useful in certain cases where mercury is not tolerated or is not effective

The administration of **mercury** also plays an important part in the treatment of syphilis, but it must never be relied on alone unless salvarsan or one of its substitutes cannot be obtained, as even if a prolonged and thorough course of mercury is administered, the results are not satisfactory Many different methods have been suggested in order that the patient may derive the greatest amount of benefit from the drug with the minimum of inconvenience (*a*) It is often given **by the mouth,** and preferably in the form of pills, composed of grey powder (grs 1 to iii , *t i d*), or of the green iodide (gr ½ to 1 , *t i d*) The grey powder may be combined with a little extract of opium or pulv ipecac co if it causes diarrhœa, but this addition is not always needed (*b*) **Inunction** of the mercurial ointment is also frequently adopted with success, inasmuch as it is less likely to cause digestive derangements If the ordinary officinal ointment is employed, a portion as large as a hazel-nut is rubbed into the groin or axilla nightly, the part being washed the following morning, and not used again for this purpose for three or four days, if the ointment is made up with lanoline, a somewhat smaller amount is required This is one of the best ways of bringing a patient rapidly under the influence of the drug The course lasts six weeks, being repeated after six months The **intramuscular** injection of mercurial preparations is now extensively employed, and increasing experience has proved it to be safe and efficacious in careful hands, and with due regard to asepsis Insoluble preparations of mercury are mainly used, and especially in the form of metallic mercury suspended in a cream, *e g* Injectio Hydrargyri Intramuscularis ' 10 per cent ' according to Lambkin's original formula, or his Mercurial Cream made up with Palmitin, Creosote, and Camphoric Acid The dose is injected deeply into the gluteal region, and the absorption, if slow, is regular, so that it is little likely to cause toxic symptoms An injection should be carried out every five to seven days until some twenty to thirty have been given

During the course of mercury, the patient's general health and habits must be carefully regulated, alcohol is forbidden, exercise limited, and strict instructions are given as to keeping the teeth and gums clean An astringent mouth-wash containing alum or chlorate of potash should be ordered, and it may be necessary to remove or fill diseased teeth, but the dentist must, of course, be informed of the nature of the case To minimize the risk of throat and mouth trouble, it is wise to stop smoking for at least six months The dosage of mercury required varies in different individuals, being increased in robust people, and diminished in those who are weak or unhealthy It should be pushed until mild effects are produced in the shape of slight tenderness of the gums, but ' salivation ' of the patient is undesirable Full doses are usually required for four or five months, followed by a milder course, which should extend at least till the end of the first year It is advisable, however, to insist on a three months' course of mercury twice a year for two and a half or three years

Symptoms of **mercurialism** are induced in some people by very small quantities of the drug, and hence treatment should always com-

mence with small doses The gums become soft and spongy, and bleed readily on pressure, salivation follows, or even acute glossitis, whilst the breath becomes offensive The teeth are loosened and may be shed, and the alveoli may undergo necrosis Digestive derangements, such as colic and diarrhœa, are also observed Treatment consists in suspending the drug for a time, and giving a sharp saline purge, whilst the spongy state of the gums is remedied by the use of alum or chlorate of potash mouth-wash already advised

Iodide of potassium is essential in the treatment of the tertiary and intermediate stages It appears probable that its chief action is the removal of gummatous tissue, probably by forming a soluble iodine albuminate, and that it has little influence upon the infection itself, in order to prevent recurrence, salvarsan or mercury is still required The initial dose of iodide should not exceed 5 grains, and is gradually increased, until in some cases 1 drachm four times a day has been reached Plenty of water should always be taken immediately afterwards to assist in its dilution and facilitate its absorption A feeling of depression and sinking at the epigastrium is sometimes produced, but may be alleviated by the addition to the mixture of sal volatile (spiritus ammoniæ aromaticus ℥xv) Symptoms of coryza often follow, and an acneiform eruption over the shoulders and face, which may disappear on increasing the dose Occasionally a vesicular, or even bullous, rash is caused by this drug When large doses are given, bicarbonate of soda or potash must be combined with it, in order to prevent its decomposition by the gastric juice If mercury is required, it is better to give it in the form of grey powder than to add liquor hydrargyri perchloridi to the iodide in a mixture Other drugs, such as sarsaparilla, arsenic, and iron, are often combined with iodide of potassium in the later stages of the disease, and may be useful

The **Local Treatment** of syphilitic sores consists mainly in the application of various preparations of mercury The **primary chancre** may be treated by excision, cauterization, or the use of calomel ointment (30 per cent), with the object of removing or destroying the spirochætes present in the fibrous interspaces **Mucous tubercles** in the neighbourhood of the anus or vulva, or between the toes, are best dealt with by keeping them dry and clean, and dusting them over with powdered calomel and starch, or by the application of calomel ointment, a piece of lint being inserted between opposing surfaces to prevent them from rubbing one against the other **Secondary ulceration of the throat** does not usually require local treatment, as it soon disappears under the influence of mercury A mercurial gargle may, however, be employed, or in bad cases the affected parts should be painted with glycerinum hydrargyri perchloridi (1 in 2,000) **Superficial gummatous ulcers** are treated by removing the scabs, and applying some form of mercurial ointment A determined attempt should be made to keep **deep gummatous ulcers** in an aseptic condition, since secondary septic infection of such sores, especially if they are connected with bone, makes a marked difference in their progress In neglected cases they may become exceedingly foul, and in chronic cases a hectic

temperature and amyloid or waxy degeneration of the viscera may supervene When gummata come to the surface and point, they should be opened with the same precautions as are adopted in the case of an abscess, and either dressed antiseptically or their cavity packed with sterile lint or gauze soaked in sterilized lotio nigra

Inherited Syphilis

Where the parents are syphilitic, pregnancy does not usually continue to full time, the mother miscarrying perhaps at the end of six or seven months In these cases the child may be well formed, and may even live independently for a short while, but not unfrequently it is still-born, and in many cases macerated, in these circumstances the tissues are often teeming with spirochætes Miscarriages may recur for several pregnancies, and then a living child be produced If the infection occurs early in the pregnancy, the mother usually goes to full time, but her offspring is born with all the signs of congenital syphilis If the disease occurs late in pregnancy, the fœtus may escape transplacental infection but become inoculated through a small abrasion acquired during the process of labour In other instances, however, a living child may be born at full term at the end of the first pregnancy in spite of the syphilitic infection of the parents This child may show evidences of the disease at birth, but more frequently appears to be healthy, specific manifestations not showing themselves for some weeks The infectivity of the mother, and the degree of virulence of the disease in successive children, decrease with time, and it is possible that, after five or six years of untreated syphilis, a mother may bear a healthy and untainted child, although infection has been known to be transmitted much later

As noted later (p 167), the Wassermann reaction, however, may be negative in the infant's blood at birth, but may become positive some four or five weeks later In this connection it is interesting to note that, although infective lesions may be present in the maternal passages, primary chancres are not seen in infants, who are presumably protected either by previous infection or by the presence of the vernix caseosa

In some cases the mother has shown no obvious evidence of syphilis, and yet is able to suckle her child without harm, even though there are ulcerating lesions on the child's gums and lips, whereas a healthy wet-nurse develops a chancre of the nipple This is known as Colles's Law, and was first stated by him in 1837 Investigation of the Wassermann reaction in these mothers has given a positive result in 90 per cent , it is therefore practically certain that the apparent maternal immunity is in reality due to a previous mild and unrecognized infection

The length of time during which a syphilitic patient of either sex retains the power of transmitting the disease to the fœtus is an exceedingly difficult point to determine, and one which is constantly coming before the practitioner, who is asked to decide at what period marriage is safe The rule of practice generally followed is that no one suffering

effects of influenza, a neglected cold, or persistent overwork may be followed by the development of the disease

Still more is this likely to happen if the patient lives in unhealthy or bad hygienic surroundings Hot and ill-ventilated workrooms, dark, dirty and overcrowded dwelling-houses, etc , are themselves harmful by lowering vitality, but they often become hotbeds of infection if consumptive patients are admitted and contaminate the air by coughing and expectorating This probably explains the terrible frequency with which tuberculosis occurs in many places where one would expect the inhabitants to be particularly healthy, *e g* some of the holiday resorts of Scotland, Wales, and Ireland, the houses are small, dark, often dirty, and so devoid of ventilation that, if one member of the household contracts tuberculosis, it often spreads rapidly to others Naturally, tuberculosis is most common amongst the poor, but it is also still only too frequent in the well-to-do

A pre-existing local nidus in the body suitable for the development of the micro-organism is usually present, although tuberculous infection very occasionally follows wounds and punctures in previously healthy parts Thus, chronically inflamed lymph-nodes form a suitable breeding-ground for the bacillus, as also bones and joints in a state of congestion resulting from slight and often overlooked injuries

The ultimate exciting cause of tuberculosis is the entrance and development within the tissues of the tubercle bacillus of Koch (Plate V , Figs 3 and 5) It usually occurs in the form of slender rods, straight or slightly curved, about 4 or 5 μ in length and 0 2 or 0 3 μ in width, but sometimes forming filaments The tubercle bacillus is a typical 'acid-fast' or, more correctly, 'acid-proof,' organism, and when stained by the Ziehl-Neelsen method appears in the form of slender red rods, which are often stained only in part, so that they seem to consist of short red alternating with unstained segments *In vitro*, on suitable culture-media, they develop very slowly, two or three weeks elapsing before growth is visible, and require a temperature approaching that of the body and an abundant supply of oxygen The colonies consist of yellowish-buff, white, or grey scales, which have a dryish look

A distinction is now definitely established between the human and the bovine types of the tubercle bacillus, and the varieties of the disease produced by each Both can develop in human beings, but the bovine type is mainly responsible for intestinal and surgical forms of the disease, *e g* those attacking lymph-nodes, bones, and joints, whilst the human variety leads usually to pulmonary phthisis and to acute general tuberculosis Cultural distinctions are readily established The results of inoculation experiments in rabbits also differ, in that the human type of tubercle bacillus produces but little effect and rarely kills, whereas the bovine type is actively fatal Avian and piscine types of tubercle bacilli, attacking birds and fishes respectively, are of much less direct importance and but rarely affect man

The organism gains access to the body in any of the following ways

(*a*) **By inhalation** The sputum of consumptives may contain vast

numbers of tubercle bacilli, and, as drying does not immediately kill them, living bacilli frequently occur in dust and in the air It is also important to realize the fact that in coughing and even in talking the tuberculous sputum is expelled in a state of very fine division, and the infective particles remain suspended in the air for long periods Tuberculosis acquired by inhalation manifests itself usually in the form of pulmonary disease, but may appear as an affection of the cervical, mediastinal, and bronchial lymph-nodes, from which the infection may be disseminated to other organs, including the lungs

(*b*) **By ingestion,** *e g* of infected milk from cows with tubercuious disease of the udders This is by no means rare, and, in some parts of the country, very common in children, the bacilli entering especially through the tonsils or other lymphadenoid tissues of the pharynx and invading the cervical glands, or passing through the stomach unharmed and infecting the intestine and mesenteric lymph-nodes Examination of tuberculous material from the cervical glands in 72 cases in Edinburgh resulted in the discovery that in 65, *i e* 90 per cent , the bovine bacillus was present

(*c*) **By inoculation** This is very unusual, and occurs chiefly in pathologists, post-mortem room porters, butchers, etc , in the form of a wart-like tuberculide, known as verruca necrogenica, or post-mortem wart A few cases of tuberculous infection from an accidental cut inflicted by a broken sputum-cup have been recorded

The laboratory diagnosis of tuberculosis is conducted on one or more of the following lines

1 By the microscopical identification of the tubercle bacillus after staining by the Ziehl-Neelsen method

2. By growing the bacillus upon special media, the material for cultivation being, if necessary, as in the case of sputum, treated with alkali for the destruction of other contaminating organisms

3 By the inoculation of susceptible animals, especially guinea-pigs At least two animals should be inoculated from each case The suspected material — whether exudate or tissue — is usually inserted beneath the skin of the groin, and one animal may be killed in, say, three weeks, when, if the test is positive, the lymph-nodes and probably the internal organs will be found tuberculous A definitely negative result cannot, however, be assumed unless the other inoculated animal survives for at least six weeks, and is then, when killed and examined, found to be free from tuberculosis

4 A characteristic of most tuberculous exudates is the presence of small lymphocytes or lymphocyte-like cells as the prevailing type

5 In some cases a portion of the lesion may be excised and submitted to microscopical examination, which should also include a search for bacilli, since other infections may give rise to lesions histologically resembling those of tuberculosis

6 Tuberculin (as originally prepared by Koch) is obtained by evaporating down a six-weeks-old glycerine-broth culture of the organism, killing it by heat, and filtering The filtrate has been used as a diagnostic agent, but the method is not free from danger and is

Treatment.—When Koch first discovered the tubercle bacillus, a great impetus was given to operative treatment, and some authorities went so far as to maintain that every particle of the diseased tissue must be extirpated with as much care as in the case of cancer The pendulum has now swung slowly back, and we are relying more and more on the natural powers of repair inherent in the patient, and are endeavouring rather to maintain and increase these in every way by suitable general and local treatment

1 **General Treatment** of the sanatorium type under suitable climatic conditions is indicated in all cases of tuberculous disease Failing sanatorium treatment, much good may be effected by exposure to sunshine and air wherever available Heliotherapy applied to the body generally, or locally to the affected part, is most valuable, or in the absence of sunshine exposure to ultra-violet rays, careful dosage being required until immunity from harmful effects has been secured Indications of improvement are shown, not only by relief from local pain, but also by a more regular and normal temperature, increasing weight, improvement in the hæmoglobin content and sedimentation rate of the red corpuscles Care must be taken to protect the patients from cold in winter, and they must be given an abundant and nutritious diet with suitable vitamin-content Whilst the disease is still active, the amount of exercise must be strictly limited The administration of haliverol, as well as various other vitamin-containing preparations and other tonics, is useful Many forms of tuberculin have been introduced since the failure of Koch's original variety as a therapeutic agent Opinions vary as to the value of this method of treatment, but in surgical cases where efficient sanatorium treatment is possible, its use is not indicated except when improvement does not otherwise occur Under such circumstances, in a child, 0 00001 milligramme may be given hypodermically, increased gradually up to 0 001 milligramme, whilst an adult may start with a dose of 0 0001 or 0 0002 milligramme The injections should not be repeated under ten or fourteen days, and should never be attempted when a mixed infection is present

Preventive Vaccination with B C G. (Bacillus Calmette-Guérin) Vaccine.—Calmette, after a long series of trials, succeeded in growing a strain of bovine tubercle bacilli, which, by repeated cultivation upon a bile-containing medium, gradually became non-virulent, as tested by the inoculation of guinea-pigs With these living but attenuated bacilli he, in 1921, ventured, apparently with success, to administer it orally to a human infant whose mother had died of tuberculosis and who was to be brought up by a tuberculous grandmother Since this initial experiment, many thousands of infants, as well as considerable numbers of older persons, such as medical students and hospital nurses, who by their work are exposed and liable to infection, having been treated orally or by injection with B C G , appear to show that a definitely increased degree of immunity is conferred which, though not preventing infection, renders the disease distinctly less virulent, with a considerable reduction of both the morbidity and mortality figures

Local Treatment (Non-operative).—Absolute rest of the affected part as far as is possible is the first principle of treatment In the case of joints, complete immobilization may be effected by plaster of Paris splints and the effect of the weight of the body minimized by recumbency or other means when the disease affects the spine or lower extremities When complete immobilization is not possible, partial rest is still of great value, thus the method of collapsing the lung by means of an artificial pneumothorax is of the greatest service in treating phthisis Every precaution should be taken to prevent the occurrence of a mixed infection A patient with glandular infection in the neck should be carefully treated for any peripheral septic lesions, *e g* of the lips, teeth and gums, the ear, nose, scalp, etc , enlarged tonsils and adenoids should also be removed, inasmuch as bacteria are often lodged in them

3 **Operative Treatment** is required when the measures indicated above have failed to check the disease, or when accidental complications, *e g* abscesses, develop in the course of the case, or when the disease is so extensive or progressive as to make it inadvisable to trust to natural processes of repair alone Obviously, **extirpation** of the tuberculous focus, if practicable, is the ideal treatment in all cases, and for some conditions no other treatment need be considered In superficial lymph-nodes in the neck excision is the best treatment whenever progress to recovery is delayed or absent In many other conditions, as in bone and joint disease, total extirpation is practicable by excision or amputation, but such a proposal involves the consideration of many other questions, such as the operative risk, the possibility of a general diffusion of tuberculous material by the necessary manipulations, the possible infection of the wound or surrounding healthy tissues by tubercle, and the degree of post-operative disability that may result The cure by a local excision is not always certain, and the after-treatment is often very prolonged On the other hand, Nature's cure may be equally uncertain, possibly less satisfactory, and the chances of dissemination and diffusion are not absent The final decision as to the advisability of undertaking a radical operation of this type must be made by a careful consideration of (1) the stage of the disease, whether early or late, (2) its position and extent locally, (3) the presence or otherwise of tuberculous disease elsewhere in the body, (4) its character, whether active and progressive, or chronic, (5) the probable resisting power of the patient to the spread of the disease and to the occurrence of amyloid degeneration of important organs and tissues, and of secondary infection, and (6) the hygienic conditions, etc , under which treatment has to be carried out

Partial operations are sometimes required, consisting in cutting or scraping away as much of the diseased tissues as is practicable, swabbing out the cavity thus produced with some powerful germicide, such as liquefied carbolic acid, and dressing the part with gauze soaked in some antiseptic substance, such as an emulsion of iodoform, the wound being left to heal by granulation Diseased bones, lymph-nodes, and sinuses have sometimes to be dealt with in this way, and

satisfactory cures may in time result Open-air treatment must be instituted at the same time, or commenced as soon after as possible

When the patient suffers from more than one focus of disease, *e g* pulmonary phthisis at the same time as disease of some joint, or of the testis, it is often found that no progress is being made towards recovery, in spite of what appears to be suitable treatment It may then be advisable to remove, if possible, one of the foci, when steady, and perhaps rapid, repair may show itself in the other

The manifestations and treatment of tuberculosis as it affects **special tissues and organs** are dealt with elsewhere under the appropriate headings

The Treatment of Chronic Tuberculous Abscess must necessarily vary considerably according to the position and condition of the part A superficial chronic abscess may be comparatively easy to treat, but the utmost caution is required, in order to avoid pyogenic contamination, when dealing with one placed deeply, and connected with such an affection as tuberculous disease of the spine

1 In a few cases of superficial chronic abscess, especially when connected with lymph-nodes, it may be possible to *dissect out the whole cavity en masse*, and if this be feasible, it is the most satisfactory plan to adopt

2 When the skin is thin and undermined, and the abscess nearly pointing, it is hopeless to avoid leaving an open wound, and hence the condition must be treated by the *open method* The cavity is freely incised, diseased tissue scraped away, unhealthy skin removed, and the cavity treated with bismuth paste and completely closed The incision should not be placed at the most dependent point of the abscess, because a sinus is likely to form should the abscess reappear In some cases it will not be possible to close the cavity The wound should then be packed with iodoform gauze and allowed to granulate upwards Healing is often slow, but *a tuberculous abscess ought never to be allowed to reach a condition in which it is necessary to leave an open wound* of this type

3 When a chronic abscess is situated deeply and covered with healthy tissues, treatment consists in evacuating the cavity in such a manner as to prevent the formation of a sinus, if possible

This is best accomplished by means of *Aspiration*, the needle of the aspirator being introduced from the side when practicable The most thorough aseptic precautions are, of course, maintained, and the vacuum should not be too complete, so as to avoid too rapid a withdrawal of the fluid, which might result in hæmorrhage Slight external pressure will assist in emptying the abscess If the fluid re-collects, the process may be repeated

Sometimes the content of the abscess is so solid that it cannot flow through the needle, and then the latter should be withdrawn and replaced by a trocar and cannula of sufficient size to allow the cavity to be irrigated with warm saline solution (105° to 110° F) The abscess wall is gently kneaded so as to detach curdy material and necrotic pyogenic membrane This is continued until the escaping fluid is nearly clear or only slightly opalescent, and then the cannula

is withdrawn and a deep stitch introduced to close up the track In this way it is often possible to cure a chronic abscess by one aspiration The treatment is most likely to be efficacious when all active bone or joint disease has disappeared, and residual abscesses are the most favourable of all Formerly this treatment was associated with the introduction of some drachms of a sterilized emulsion of iodoform in glycerine (10 per cent), but it is doubtful whether this addition was really effective

It is often a matter of considerable difficulty to secure the healing of a **tuberculous sinus,** owing partly to the presence of, say, diseased bone within it, partly to defective drainage, and also in part to the existence of tuberculous tissue in its wall, the added presence of a pyogenic infection will still further delay healing If possible the whole tract should be excised, or, failing this, thorough curettage, so as to remove as much of the tuberculous material as is possible Not infrequently sinuses of this type burrow widely, and it is sometimes difficult to ascertain their extent with a probe only In such cases it may be helpful to inject the sinus with ' B I P P ,' or with a paste consisting of bismuth subnitrate 1 part and white vaseline 2 parts, and to examine the extent of the lesion by radiography Where there is much discharge, effective drainage must be provided, but efficient general treatment will usually secure healing in time, without recourse to operative measures directed to removal of the diseased bone, if present, which may come away in small spicules It must also be borne in mind that, unless suitable and efficient treatment is adopted, amyloid or waxy disease may supervene in such cases

Glanders

Glanders is primarily a disease of the horse, ass, or mule, which is transmitted to man by direct inoculation, and hence is usually seen in stable attendants and those brought in contact with such animals The disease is due to *Bacillus mallei* In Great Britain the disease, both in man and animals, is now practically extinct, though laboratory infection has occasionally occurred

In **Horses** and other animals glanders manifests itself by a formation of larger or smaller rounded swellings in the mucous membrane of the nose, which break down and ulcerate, giving rise to a thin, sero-purulent discharge, and perhaps to destruction of the bones and cartilages The lymph-nodes, especially those under the jaw, early become enlarged, known to farriers as ' farcy buds,' which by their ulceration may leave ragged, foul, suppurating sores The lymphatic trunks to and from the lymph-nodes are involved (' corded veins ' or ' farcy pipes '), whilst the lungs and internal viscera may also be infected and undergo destructive changes The disease is often chronic, lasting perhaps for years , any undue strain put upon the animal may lead to an acute exacerbation, which may be fatal in six to twelve days

In **Man,** glanders generally starts about the hands and face, but occasionally in the nasal mucous membrane In **acute** cases the incubation period lasts from three to five days, and is succeeded by

the occurrence of malaise and febrile disturbance, followed by severe pains in the bones and joints The site of inoculation becomes red and swollen, whilst the lymphatics leading from this to the nearest lymph-nodes are enlarged and inflamed An eruption of papules, which somewhat resembles that of small-pox or an iodide rash, occurs around the primary lesion, on the face, and in other parts of the body, but each papule, as also the primary lesion, breaks down and goes on to the formation of an ecthymatous-looking ulcer It is not an uncommon feature of these sores, when situated over a bony surface, to involve the periosteum and lay bare the subjacent bone Similar changes occur in the viscera, muscles, and joints, and these being associated with high fever of an asthenic type may suggest the existence of pyæmia In such cases death may ensue in seven to ten days

In **chronic** glanders similar symptoms are met with, but the course is slower, there is little or no fever, the disease is less extensive, and intermissions are not uncommon It may affect the nasal mucosa, leading to chronic ulceration, but more commonly it appears in the shape of chronic abscesses which often extend deeply, even down to the bones, and are very difficult to treat

It is important to make the **Diagnosis** as early as possible, in order to undertake energetic local treatment The local lesions are distinguished from small-pox by the presence of the characteristic bacilli in the discharge, by the fact that they involve the subcutaneous tissues more extensively, and by the absence of umbilication Chronic cases, showing nodules and ulceration, resemble syphilis and tuberculosis, but any history of exposure to infection from animals suffering from the disease is most important, as also the result of cultures made from the discharge Inoculation of the peritoneal cavity of a male guinea-pig with some of the discharge leads to acute orchitis in two or three days, the testicles being enlarged and the skin over them reddened, the affection usually runs on to suppuration Mallein, a sterilized and filtered broth culture of the organisms, may, like tuberculin, be used for diagnostic purposes in animals, the injection of a minute dose causing a sharp febrile reaction if glanders is present Its use in man is not without danger

Treatment in acute cases can be successful only when undertaken early, and before general infection has ensued The local foci should be thoroughly extirpated, either by the knife, or by scraping and applying some active cauterizing agent The same treatment must be adopted in chronic cases, and may then need frequent repetition The use of immune serum and vaccine is also recommended by some authorities

Leprosy.

Leprosy (*syn* Lepra or Elephantiasis Græcorum) is a general infective disease due to *Bacillus lepræ*, characterized by the formation of granulomatous masses which arise primarily in connection with the skin, mucous membrane, and nerves Unlike the tuberculous granuloma, these nodules are vascular, contain no giant-cells, and are comparatively small in size in relation to the number of bacilli present

The bacillus of leprosy resembles that of tuberculosis, and, like it,

is Gram-positive and acid-proof, staining readily by Ziehl-Neelsen's method, though more easily decolorized than are tubercle bacilli Leprosy bacilli are usually smaller, straighter, and more uniform than those of tubercle, and when seen in sections of leprous material they are often present in far larger numbers than are the tubercle bacilli in tuberculous tissues, they are situated mostly within the large granulation-tissue cells (' lepra-cells ') and often show a characteristic grouping as if packed together like bundles of cigarettes (Plate V , Fig 6) Numerous attempts have been made to cultivate them, and successes have been claimed Attempts to inoculate animals have failed, and this test constitutes the best and most definite method of differentiating between the two diseases The Wassermann is sometimes positive

Leprosy, though formerly common in this country, is now observed only in imported cases In Iceland, Norway, Russia, and the East, it is still frequently met with, although the method of segregation of lepers enforced in Norway has greatly diminished the number in that country Leprosy is occasional in the United States It is common in the Hawaiian and Philippine Islands and also in the West Indies It is apparently very slightly contagious to adults, the medical attendants and nurses in leper hospitals rarely contracting the disease, inoculation experiments on criminals have led to negative results The children of leper parents are not diseased at birth, but are very liable to contract it at an early age, this fact emphasizes the urgent necessity for separating the children from their diseased parents at the earliest possible date

Symptoms.—Two chief clinical varieties of leprosy exist, *viz* the nodular, and the maculo-anæsthetic, but the two are often associated

Nodular or **Cutaneous Leprosy** is the form seen most commonly in Europe Nothing may be noticed for months or years after exposure to the contagion, and then, after a period of malaise, associated with dyspepsia, diarrhœa, and drowsiness, a distinct febrile attack is noted, lasting for days or weeks, it may be ushered in by a rigor, and the temperature is usually of a remittent type This is followed by, or associated with, the appearance of shiny, red, hyperæmic spots, which are from the first infiltrated, slightly raised, and hyperæsthetic, they are situated usually on the forehead or cheeks, on the outer side of the thighs, or on the front of the forearms They are due to the development of nodules of granulation tissue They may fade away and disappear entirely, and then again become evident, or fresh patches may be developed, and always with febrile symptoms After a variable period numbers of little pink nodules form over the site of one or more of the erythematous patches, and these gradually increase in size and coalesce, until possibly they become as large as a walnut or hen's egg, and are then of a brownish-yellow colour Almost any part of the surface of the body may be invaded in this manner, but the face is especially prone to be involved, and the resulting disfigurement is very marked, a curious ' leonine ' appearance being imparted to the features (Fig 57) The mucous membrane of the mouth, pharynx, nose, and larynx are also often affected and prone to ulceration

the streptothrices, which are anaerobic organisms Abscess cavities, when present, should be drained, iodides should be prescribed up to 240 grains daily, or more They probably act by promoting absorption of fibrous tissue, thereby improving the blood-supply to the lesions A more effective way of securing oxygeneration of the infected tissues is to pack the wound with freshly-made zinc peroxide paste In the presence of water the peroxide is gradually broken down into the more stable oxide, with the evolution of nascent oxygen Vaccine treatment holds out some prospect of help, the vaccine consisting of a stock, or preferably an autogenous growth of *Actinomyces bovis*, together with such other organisms as may be present in the secondary infections For thoracic and abdominal cases X-ray therapy is often useful, and in those cases in which the lesions are accessible, teleradium or the insertion of radium may be effective

CHAPTER VII

TUMOURS AND CYSTS.

A TUMOUR may be defined as 'a mass, of new formation, that tends to grow or persist, without fulfilling any physiological function, and with no typical termination' The fact that it has no typical termination distinguishes it from inflammatory overgrowths, which tend to form fibro-cicatricial tissue or some modification of it, inflammatory lesions, moreover, may disappear completely, and often diminish in size temporarily Pure hypertrophies are excluded by this definition, since they depend upon some increased physiological function, and are composed of an increased development of normal tissues, as, for instance, the blacksmith's biceps

The recognition of the primarily local origin of a cancer is the fundamental fact upon which has been built up the operative treatment of the disease, the success of which depends to a very large extent upon its early diagnosis At present there is no certain means of diagnosis, except the clinical, and the microscopical examination of a portion of the growth removed for the purpose

The prevention of cancer has attracted a great and growing amount of attention during recent years in view of the alleged increasing death-rate from this cause This alleged increase may, however, be due in large part to the greater accuracy of modern diagnosis Mortality statistics are at best still very unreliable An all-important element in the direction of prevention is the avoidance of sources of irritation, whether local or general

There are several well-known instances of cancer following continual irritation The 'chimney-sweep's' cancer of the scrotum, the malignant papillomata of the bladder in dye workers, cancer of the lower lip due to clay-pipe smoking, and cancer of the skin of the lower abdominal wall and thighs of natives of Kashmir, due to the habit of hugging heated earthenware pots, are all examples of this influence At the same time early attention to all slight local affections in the body is essential, *e g* patches of leucoplakia on the tongue or elsewhere, ulcers from rough teeth or dental plates, a torn cervix uteri, or a small lump in the breast Regenerated tissue also appears prone to become the seat of malignant disease To this end may be mentioned the frequency of the epitheliomatous change in scars and the supervention of carcinoma in the regenerating lobules of hepatic cirrhosis

Finally there is the possible influence of the action of certain chemical substances allied or belonging to the sterol groups, which normally act as 'evocators' of the development of tissues and organs, but which may, under normal conditions, lead in the body of the embryo itself to the development of secondary or induced reduplications of structure

or of tumour growths which have hitherto been regarded as originating from another individual or twin

Tumours may, from the clinical standpoint, be divided into two great classes, *viz* the **benign** and the **malignant,** with, however, all intermediate varieties

Benign or **Simple Tumours** are characterized by their more or less definite limitation, being frequently encapsuled, and by their method of growth The surrounding tissues are merely pushed aside and compressed by the increasing growth of the tumour, pain and atrophy are sometimes caused by this pressure The capsule is formed by an ensheathing layer of fibro-cellular tissue, the outcome of the chronic irritation engendered by the growth, hence enucleation may be easy, and recurrence uncommon They are sometimes multiple, and may be congenital, but there is no tendency to the production of secondary growths They cause no cachexia and do not threaten life unless developing in or upon some part whereby the vital functions are impaired

Malignant Tumours, unless removed by operation or in some cases successfully treated by radio-therapy (pp 303 and 308), are almost invariably fatal The following are the chief characteristics of malignancy (1) The primary growth is usually *single,* rarely multiple (2) It *progresses continuously,* but with varying rapidity in different cases (3) The local development is characterized by *an infiltration* of the surrounding tissues, which are gradually destroyed and replaced by the tumour A capsule is rarely formed, or, if at all, only in the early stages, and thus the limits of the growth are not clearly defined Moreover, many varieties spread locally along the lymphatics draining the area involved, and hence, although the growth may appear to have been completely excised, 'recurrences' are very common, owing to the non-removal of these invisible extensions of the disease into apparently normal tissues If a malignant tumour with all its ramifications is completely removed, it does not recur (4) When a malignant tumour invades the skin or a mucous membrane, it usually leads to *ulceration* and is very liable to secondary infection with micro-organisms, and then not uncommonly a foul fungating mass results (5) *Metastases* due to embolic dissemination of the cells of the growth are often found in neighbouring lymph-nodes or distant viscera (6) *Cachexia* usually develops in the later stages, due partly to the pain, partly to the pressure of the growth on important structures, and in part to the absorption of toxic products from the tumour The patient becomes thin and emaciated, the face drawn and with an expression of pain, the appetite is impaired and the skin often sallow and earthy-looking Pyrexia may be absent unless ulceration of the growth occurs, as is commonly the case when the stomach or intestine is affected, some rapidly-growing sarcomas of bone are also associated with fever (7) Finally, *death* results after a longer or shorter period

The **degree of malignancy** varies with different types of tumour and also with the nature and site of their origin In some the local phenomena predominate, whilst in others the phenomena following upon

their dissemination are the more important Thus, rodent ulcer is slow in its progress, and produces no visceral metastases, if it destroys life it does so merely by extension of the primary growth to vital parts A malignant melanoma, on the other hand, may produce only a small primary growth, but the most extensively diffused metastases may form in the viscera The sarcomas are usually disseminated by the blood-stream, and hence secondary growths are not so common in lymph-nodes, whilst the carcinomas spread especially by means of the lymphatics

In some cases gravity also aids the spread of cancer cells Cells from a carcinoma of the stomach may reach the peritoneal surface and gravitate across the abdominal cavity to the pelvis, giving rise to enlargement of both ovaries (Krukenberg tumour) from secondary deposits

As a general rule malignant tumours differ structurally from the innocent forms in deviating more widely from the normal histology of the tissue in which they develop, thus, a simple fibro-adenoma of the breast approaches more closely to the structure of the normal mammary gland than does an adeno-carcinoma of the same region This deviation from the normal is called **anaplasia,** and in general the greater the degree of anaplasia the greater the malignancy

Classification of Tumours.—Of the various classifications which have been suggested, that of Adami is the simplest and most convenient The introduction by him of many new terms has militated against its general adoption, but, omitting these as perhaps unnecessarily complicated for a textbook of surgery, we shall utilize it here in a simplified form Two main groups of tumours are first distinguished

A **Blastomas** or **Body-Tissue Tumours** have been defined as tumours 'composed of the product of aberrant growth of the cells and tissues of the individual in whom they are developed'

This group of **Body-Tissue Tumours** is then further subdivided From each of the three primitive embryonic layers, epi-, meso-, and hypo-blast, are derived two types of tissues *pulp-tissues*, in which the specific cells lie in, and are separated by, a definite stroma, and *rind-tissues, i e covering-* and *lining-tissues*, in which the individual cells are not separated by a stroma and in which the blood-vessels do not penetrate th groups of specific cells From each of these series of pulp- and rind-tissues respectively tumours both simple and malignant may grow The pulp-tumours derived from all three embryonic layers exhibit so many analogies, both clinical and pathological, that they may be considered together, and a similar classification of the rind-tumours may be made Each of these series of pulp- and rind-tumours may further be divided into those which are *simple* and those which are *malignant* (with the proviso that, both clinically and histologically, all intermediate stages between definitely 'simple' and definitely 'malignant' tumours occur

B **Teratomas,** or tumours 'composed of the products of one individual within the tissues of another individual of the same species'

1 **Epithelial Odontomes.**

(*a*) **Follicular Odontome or Dentigerous Cyst.**—This is a unilocular cyst lined with stratified epithelium It probably originates in paradental rests, or the remains of Nasmyth's membrane It is most frequent in the lower jaw, and is always associated with an unerupted permanent tooth, usually a molar or canine It is common to find such a cyst in rickety children Possibly the cause is an infection from a deciduous tooth, which leads to the formation of a dental cyst The cyst so formed meets and surrounds the developing unerupted tooth A large swelling occurs in the jaw, painless at first, but causing some chronic pain as expansion of the bone takes place Skiagrams reveal the missing tooth lying within the cyst, or in some cases embedded in the cyst wall

(*b*) **The Compound Follicular Cyst** is a follicular (dentigerous) cyst which arises in connection with more than one tooth and is more common in the upper jaw The treatment consists in opening the cyst and removing the infected tooth or teeth The cavity should be washed out with tincture of iodine and treated as a dental cyst (*vide infra*)

(*c*) **Multilocular Cyst (Fibrocystic Disease of the Jaw, Adamantinoma, Cylindroma of Jaw)** —This tumour arises from the paradental epithelial rests (débris of Malassez), which lie along the developmental course of the tooth It is very similar in structure to the adamantinoma found in the pituitary region, and when typical it is possible to recognize an outer layer of cells resembling the basal cells of the epithelium, and an inner mass of 'star-cells,' which undergo vacuolation and, later, mucoid degeneration The stroma contains fibroblasts and, sometimes, giant-cells, and may show hæmorrhagic areas

The tumour is more common in the lower jaw, and is of slow growth, gradually distending it but producing no marked change in the appearance of the mucous membrane As the tumour grows it tends to become extruded from the outer plate of the alveolar border If the tumour is allowed to grow to a large size, a thin layer of bone may cover the cystic spaces of the growth and eggshell crackling may be elicited

This type of tumour may also occur in the pituitary region, where it is thought to originate in the epithelium of Rathke's pouch An adamantinoma has also been found in the tibia, although its presence there is incapable of explanation

Dental Cyst —This is a very common form, and is commoner in the maxilla than the mandible, and seems to prefer the region of the first molar tooth A dental cyst may occur in either sex, and may arise in connection with either deciduous or permanent teeth

The actual cause of these cysts is an infection from organisms in the pulp canals of pulpless teeth In some cases trauma may be the exciting cause where a small apical hæmatoma forms which becomes infected

A dental cyst may arise through the irritation of epithelial cells in alveolar dental periosteum (the remnants of the epithelial sheath of Hertwig) The actual pathology is of interest in so much as the cyst begins as a granuloma in which the epithelium proliferates and

a so-called 'epithelial root tumour' develops A capsule is formed lined by epithelium which may be squamous, stratified, or columnar in type As the cyst grows it causes pressure on the bone surrounding it, the result being a bulging of thinned bone, which may become so attenuated that eggshell crackling may be felt on examination X-ray examination invariably reveals a sharp outline to the cyst, except in those cases where an abscess has formed As a rule there is a zone of rarefying osteitis surrounding the cyst wall

The treatment of a dental cyst demands the extraction of the tooth which has been responsible for the cyst

For a small dental cyst the cavity should be curetted and swabbed out with tincture of iodine to destroy the epithelial lining The cavity should be irrigated daily with an antiseptic until healing has taken place

In the case of a large dental cyst where an extensive cavity remains and healing would take a long time, a flap of muco-periosteum is raised and stitched to the bottom of the cyst Such an operation could be undertaken only where there is no oral sepsis

2 **Mesodermal Odontomes** consist of the fibrous and cementous odontomes The **Fibrous Odontome** is very rare in man and resembles a hard fibroma It may be due to hypertrophy of the tooth sac, or to fibrosis around a dentigerous cyst, and only occurs in association with an unerupted tooth The **Cementome** may be due to excessive development of cementum or to calcification of a fibrous odontome The tooth is embedded in a hard calcified mass Suppuration may occur, resulting in the detachment of the tumour from the jaw Excision may, however, be required

3 **Composite Odontomes** are rare tumours consisting of a hard lobulated mass composed of enamel, dentine, and cement On account of their hardness they are fairly easily removed

The term 'complex' refers to the ordinary variety which is complex in composition The 'compound' composite variety implies the involvement of more than one tooth The 'geminated' variety results from malformations of two or three teeth The 'gestant' composite odontome implies a denticle within a tooth, and the dilated composite variety denotes a dilatation within the tooth, but external to the pulp cavity The **Radicular Odontome** (enamel nodule) consists of an irregular mass arising in connection with the roots of an apparently normally erupted tooth It is generally composed of dentine covered with thick enamel

Osteoclastoma or Giant-Cell Tumour.—This tumour was formerly described as a myeloma It is not derived from the hæmatopoietic marrow-cells, but from osteoclastic and allied cells It should, therefore, *not* be classified as a 'myeloma' In its nature, though in not a few cases the growth may extend rapidly by infiltration of the bone-marrow, *i e* is then definitely though locally **malignant**—and sometimes actively so It is characterized by the presence of large numbers of multinucleated giant-cells (myeloplaxes), embedded in a groundwork of round or spindle-cells, the intercellular substance being usually of a gelatinous consistence (Fig 72) The myeloid giant-

malignant and infiltrating widely, seldom give rise to metastases Various secondary changes such as degeneration, necrosis, and hæmorrhage are common, especially in the more malignant forms An important point in connection with this series of tumour is that some of them, although histologically of ' primitive ' cell-type, *e g* the medullo-blastoma, are comparatively amenable to radio-therapy

Neuroma —True Neuroma, Neuroblastoma, or **Ganglioneuroma** is rare, comparatively few undoubted cases being on record It consists of a mass of newly-formed ganglion-cells and nerve-fibres, which may be myelinated or not It affects especially children or young people, and usually involves the sympathetic system or the suprarenal medulla The tumours may attain considerable dimensions, are often multiple, and may be soft or firm They are insensitive and innocent, and may be freely removed if necessary

Neurofibromas (False Neuromas or **Perineural Fibroblastomas)**, developing in connection with the sheaths of nerves, are in reality fibromatous tumours, but may for convenience be described here under three headings

1 **Localized Neurofibroma** —This may project from one side of the nerve, but more frequently the nerve-fibres are spread out over it It may be moved more freely at right angles to the axis of the nerve than in the direction of its course When developing from a small subcutaneous twig, it has been termed a ' painful subcutaneous nodule,' and gives rise to intense radiating neuralgic pain, especially when compressed or irritated, or when exposed to cold The single false neuroma may also grow from one of the larger mixed nerves (' trunk neuroma '), and is usually less painful

One important site of such neurofibroma is the eighth or acoustic nerve, at the cerebello-pontine angle, but when bilateral, they form part of the more generalized condition of neurofibromatosis described below Apart from the latter, single and occasionally several neurofibromatous tumours may arise from spinal nerve-roots These may lie wholly within the spinal canal and may, as they grow, gradually produce compression of the cord, or they may develop in the nerve as it lies in the intervertebral foramen As the tumour develops, the portions on either side of the narrow passage (which itself may also undergo some degree of expansion) grow larger and produce the so-called ' dumb-bell tumour '

A growth on a purely motor nerve, though sensitive, is not associated with radiation of pain These tumours may sometimes undergo mucoid degeneration, and, as in such tumours elsewhere, all stages between simple and malignant forms, *i e* sarcomas, may be found It is uncommon for tumours of this type to cause complete paralysis or anæsthesia, unless they are of a malignant nature They are not rare in the brachial plexus, in which case Raynaud's disease may be simulated They occur most frequently in healthy adults, and in women a little more commonly than in men

Treatment —The tumour, if painful, should be removed, care being taken, if possible, not to interfere with the continuity of the nerve-fibrillæ, the dissection of the sheath being made in the long axis If

this cannot be accomplished, the nerve must be divided, the growth removed, and if possible the ends then sutured together In removing a painful subcutaneous nodule upon an unimportant sensory twig, it is unnecessary to endeavour to save the nerve

The malignant 'pseudo-neuroma,' as already stated, is sarcomatous in character, and develops at first in the sheath of the nerve, spreading longitudinally, but subsequently involves the tissues around Clinically, it presents at first the phenomena of a simple growth, but its course is more rapid and painful, and if involving a motor nerve, paralysis is induced The main nerve-trunks are usually affected, and it may be possible to treat the case by excision or, failing this, by amputation

2 **Generalized Neurofibromatosis (von Recklinghausen's Disease).**—This consists of nodular thickenings of the nerve-sheaths, causing multiple spindle-shaped or spherical tumours, or a generalized enlargement The growths may be encapsuled and limited, or not, they may be few in number, or hundreds may be present, and they are usually whitish and firm in texture Any part of the peripheral nervous system may be affected, including the *sympathetics*, but the disease is most common in connection with the *cranial nerves* and the *large plexuses of the trunk*, sometimes, when *both* acoustic nerves are involved, *i e* bilateral cerebello-pontine angle tumours are present, the case will usually be found to be an example of this disease The actual symptoms are sometimes very slight, but the tumours may be sensitive to pressure, and some of them, more exposed than the others, may be extremely tender Motor phenomena are rare, and paralysis is due usually to involvement of the nerve-roots in the spinal canal, or to the supervention of sarcoma, which is a not uncommon termination Multiple meningiomatous tumours (p 224) and occasionally gliomas are sometimes associated with generalized neuro-fibromatosis, as well as gliosis around the central canal of the spinal cord, sometimes accompanied by the development of syringomyelic cavities and other rarer lesions The disease may start at any time during life, and, although progressing slowly, sooner or later terminates fatally No known treatment is of any avail, but should any particular tumour become large and tender, it may be removed

In this affection one not unfrequently observes the development of numerous fibrous growths of the skin, similar to what we have already described as *molluscum fibrosum* On microscopical examination of specimens stained by Weigert's method, the presence of nerve-fibrils may be demonstrated in these growths, showing that they are really neuro-fibromatous in origin So excessive does this overgrowth occasionally become that a form of *pseudo-elephantiasis* is produced, *e g* the irregular hyperplasia of the scalp-tissues, known as a pachydermatocele The association of molluscous tumours with neurofibromatous changes in the nerves and cutaneous pigmentation was described by von Recklinghausen in 1882 (Fig 73)

A **Plexiform Neurofibroma** is a special modification of this process, occurring congenitally or in young people, and usually involving the trigeminal or superficial cervical nerves It may be associated with

success is early and accurate diagnosis, followed by adequate operation, but it is only from **early diagnosis** that we can hope for the best results

Recent advances in radiology have led to the increasing employment of X-ray and radium therapy as an adjuvant to surgical procedure Their value and limitations and their methods of employment, both before and after operation, are discussed on pp 303, 310

Many workers are still investigating the **chemotherapy** of cancer Colloidal metals, especially lead, radio-active bismuth, a double colloid of sulphur and selenium ('SSe'), radio-active selenium ('RAS'), followed by deep X-ray treatment in cautiously graded doses, and other substances, have been tried, but, except in the hands of their originators, the results with these methods are so far not sufficiently encouraging for much reliance yet to be placed upon them

Interesting experiments are also being carried out to investigate the possible influence upon new growth, [illegible] or accelerating as the case may be, of the hormones of the ductless glands, *e g* the sex-hormone prolan A excreted in the urine, but the value or otherwise of the results has still to be determined

Many substances have been vaunted as 'cancer-cures,' but careful trial under trained observers has hitherto resulted in disappointment In some few instances the growth of the tumour has been hindered by tying the nutrient vessels, *e g* the external carotid and its branches in malignant tumours of the head, and pain has been relieved by division of sensory nerves, nerve-roots, or even certain of the sensory tracts of the spinal cord itself In ulcerating cases, the adoption of careful aseptic methods and the use of a suitable vaccine may reduce the inflammatory reaction, and cause temporary improvement In the final stages, morphia can alone be depended upon to give to the patient some relief from pain

B **Teratomas.**

By the term **teratoma** is signified a mixed tumour which includes in its substance derivatives of all three germinal layers (epiblast, mesoblast, and hypoblast) The term **dermoid** is retained for tumours of the nature which contain only tissues derived from the epiblast Sometimes the tissues are arranged in a more or less orderly fashion, and represent comparatively well-defined types of adult tissue On the other hand, the tissues may be incompletely differentiated and wanting in orderly arrangement, in which event malignant change may sometimes supervene The origin of these tumours is not definitely known Hitherto the general impression has been that they may be due to the inclusion within the body of the products of another individual of the same species, such inclusion developing along its own lines and being autonomous Recent research, however, appears to throw some doubt on this view, and it seems possible that the development of such abnormalities may be 'induced' in the body of the individual itself during embryonic or fœtal development

The commonest example of this type of growth is the **'dermoid' of the ovary,** which may be unilocular and grow to a large size Its lining-wall is largely ectodermic in nature, and from it an abundant development of cutaneous appendages, such as hair, nails, teeth, nipples, mammæ, etc , is sometimes observed Most commonly the cyst is filled with greasy sebaceous material and with an abundance of hair, which is said to be influenced in the same way as that on the scalp, becoming grey or being shed at the same time Sometimes the tumour is more complex, containing structures such as bone, muscle, gland-tissue, etc , which are formed from all three layers of the embryo, in some rare instances large portions of an embryo, such as imperfectly developed viscera or a limb, are recognizable Similar dermoids or teratomas are found in the **testis** and along the track of its descent in the retro-peritoneal tissues, and they often become malignant, and in that case metastasize early They may also occur in the thorax and sacral region In some cases of teratomas the Aschheim-Zondek reaction, usually employed as a test for pregnancy, may be positive for the presence of prolan B

Teratoid Tumours are a somewhat analogous group due to intermingling of tissues early in development, *e g* rhabdomyoma of the kidney Tumours may also arise from developmental errors in connection with embryonic clefts, *e g* in the neck, or along the middle line of the body, or from fœtal remnants which should normally become atrophied and obliterated These tumours are frequently cystic in character, and may conveniently be dealt with shortly in the following section on cysts

CYSTS.

Cysts are more or less rounded cavities, usually possessing a distinct lining membrane, and with fluid or semi-fluid contents For practical purposes they may be classified as follows

I **Cysts of embryonic or fœtal origin,** or arising in connection with embryonic or fœtal remains
II **Cysts arising from the distension of pre-existing spaces (distension cysts).**
III **Cysts of extraneous origin.**
IV **Cysts** (or, more accurately, **false cysts** or **pseudocysts**) **of degeneration.**

I Cysts of Embryonic or Fœtal Origin, or arising in Connection with Embryonic or Fœtal Remains.

1 **Dermoids** are characterized by the existence in abnormal situations of cavities lined with squamous epithelium, from which may be developed such cutaneous appendages as hairs and sebaceous glands, whilst the cavity is usually occupied by sebaceous contents The structure of the lining wall is very similar in nature to skin or mucous membrane, consisting of stratified epithelium, from which a considerable growth of sebaceous glands and hair-follicles often takes place

however, are attached only at one end, and their free ends (ph, V T) may become dilated, and form small cysts, situated close to the hydatid of Morgagni (sh), which structure represents the remains of the **Mullerian body** and **duct** It is possible that an encysted hydrocele of the epididymis sometimes arises from one of these unobliterated tubules The main duct of the Wolffian body forms the lower portions of the epididymis (Ep) and vas deferens (V d)

In the **female** (Fig 93) the remains of the **Wolffian body** may sometimes persist as a series of closed tubes (paroophoron, P) in the broad ligament not far from the ovary **Cysts of the Paroophoron** may arise in connection with this structure, and are characterized by their inner walls being liable to become the seat of proliferating papillomas The Wolffian tubules can almost always be recognized in the broad ligament, constituting the epoophoron (Ep), parovarium, or organ of Rosenmuller **Parovarian Cysts** formed from the distension of this structure are usually unilocular, and filled with a clear limpid serous fluid, they have no definite pedicle, growing within and separating up the layers of the broad ligament Some of the terminal tubes may be converted into small cysts which project from the fimbriated end of the Fallopian tube, and are known as the cysts of **Kobelt's tubules** The main Wolffian duct generally atrophies, but occasionally persists between the layers of the broad ligament close to the uterus, and may open in the vagina near the urethral orifice, being then known as **Gaertner's duct** (d G) Cysts may occasionally arise in connection with this structure, projecting into the lateral fornix of the vagina

4 The **processus vaginalis,** or **funicular process,** is the term applied to the protrusion of peritoneum which precedes the testis to form the tunica vaginalis, and which in the female accompanies the round ligament as the **canal of Nuck** Normally it becomes obliterated, but sometimes portions remain patent, and become distended with a clear straw-coloured serous fluid, constituting in the male an **encysted hydrocele of the cord,** and in the female a **hydrocele of the round ligament**

5 Cysts arise occasionally in connection with some irregular development of the lymphatic spaces, thus, in the neck the so-called **cystic hygroma** is in reality a congenital **cavernous lymphangiectasis,** to be distinguished from **hydrocele of the neck,** a simple dilatation in a branchial cleft, lined by epithelium surrounded by fibrous and lymphoid tissue

II Cysts due to the Distension of Pre-existing Spaces.

1 **Exudation- or Distension-Cysts** arise from the dilatation of various closed spaces or cavities such as glandular acini, bursæ, etc Such spaces may thus be lined with epithelium or endothelium As illustrations of **epithelial cysts** may be mentioned those which arise in connection with the thyroid gland, and also conditions due to the distension of the central canal of the spinal cord (syringo-myelocele), and those forms of ovarian cysts which arise from distension of Graafian follicles

In some tumours, analogous cysts may be formed by the distension of neoplastic gland-spaces, *e g* especially in the cerebral and other metastases following primary bronchial carcinoma

Exudation-cysts, the walls of which are lined by **endothelial** cells, are

of more frequent occurrence Enlargements of bursæ, hydroceles of the tunica vaginalis testis or of the funicular peritoneal process, and some forms of 'ganglia' in connection with the sheaths of tendons, are of this nature

Serous cysts may arise from the distension of lymph spaces, producing uni- or multi-locular cavities, lined with endothelium, and containing a limpid straw-coloured fluid They are seen most commonly in the neck, axilla, or breast, and in the latter may be surrounded by dense fibrous tissue They may be regarded as **cavernous lymphangiectases** (see above) Another variety may arise from diverticula of serous sacs such as the pericardium

Adventitious bursæ arise as a result of repeated irritation, and are dealt with in Chapter XVIII

2 When a collection of blood forms in a pre-existing cavity, a so-called **Cyst of Extravasation** is produced This is found in the cavity of the peritoneum, especially in the pelvis or in the tunica vaginalis (hæmatocele), and also occasionally on the surface of the brain, constituting one form of arachnoid cyst

3 **Retention-Cysts** arise from obstruction to the escape of some natural secretion from a gland-duct or tubule The cavity thus formed is lined with epithelium, whilst, owing to the irritation produced by the tension, a fibro-cicatricial wall of varying thickness is developed outside The commonest variety is the *sebaceous cyst*, which occurs on the scalp and which is full of sebaceous material The *mucous cysts* occurring in the buccal mucous membrane are of a similar nature and are also not uncommon There is sometimes a considerable formation of intracystic growths, especially in the breast, whilst the contents generally consist of the inspissated secretion, perhaps mixed with blood Retention-cysts may develop in connection with any glandular tissue The majority are described under the appropriate headings, *viz* mammary cysts, renal cysts, pancreatic cysts, etc

III Cysts of Extraneous Origin.

These may occur apart from any embryonic condition or pre-existing cavity The following varieties may be described

1 An **Implantation-Cyst** is one which arises from the accidental intrusion into the subcutaneous or submucous tissues of epithelial cells which retain their vitality, and are enabled to develop a cyst very similar in nature to a dermoid, in fact, it may be looked upon as an acquired or traumatic dermoid Such an occurrence is brought about usually as the result of an injury, especially from punctured wounds, thus, cysts of this nature may be produced in the fingers or palm of the hand, or in the sole of the foot, or elsewhere as a consequence of the penetration of some sharp instrument, whilst they are also occasionally seen in the cornea or the anterior chamber of the eye, following accidental injury or an iridectomy Such cysts remain 'simple' in character, and clinical signs and treatment are similar to those of a dermoid cyst (see p 227)

2 **Parasitic Cysts** are produced by the growth within the tissues of certain animal parasites, especially worms, in certain stages of their

inoculating between the layers of the skin hydatid cyst-fluid obtained from a known case of the disease, either human or animal A positive reaction consists in the appearance within a few minutes of an urticarial weal—a raised whitish, button-like area of œdema at the site of inoculation, surrounded by a zone of erythema, a delayed reaction in some cases following later, usually in about twenty-four hours, gradually subsiding in two or three days Generally speaking, in this test a negative finding is more valuable as pointing to the probable absence of hydatid disease, than is a positive reaction as an indication of its presence

These tests should be repeated at least once if negative

(4) **Eosinophilia** of a moderate degree is present in the earlier stages of the disease or where there has been leakage or absorption of some of the cyst contents

For the diagnosis and treatment of hydatid cyst of the **liver,** see Chapter XXXVII In other regions, if the mass cannot be removed by dissection, reliance must be placed on drainage, *e g* by the method known as 'marsupialization' (*i e* the formation of a pouch, the opening being isolated to prevent the infection of the surrounding raw tissues), where its situation renders this practicable, or aspiration, perhaps followed by the replacement of the contents by 1 per cent formalin, left in for at least five minutes and then withdrawn

IV Pseudocysts or False Cysts

1 **Pseudocysts** may form **around foreign bodies,** which thus become encapsuled They are lined with granulation tissue or with endothelium, surrounded by fibro-cicatricial tissue

2 **Blood-Cysts** are of various origins Some arise from extravasation of blood, and are then filled with coagulated blood, or a thin serous fluid with a varying amount of laminated fibrin In some cases a so-called blood-cyst is really a soft sarcoma into which hæmorrhage has occurred, but a few instances are on record in which a thin-walled cavity existed, occupied by blood, and readily refilling after it had been tapped, and with no evidence of any growth Such conditions have been most frequently observed in the neck

3 **Pseudocysts due to Degeneration** arise in connection with tumours, especially those in which the blood-supply is not very abundant Thus, mucoid degeneration is not uncommon in fibromas, fibromyomas, chondromas, and in some forms of cancer Occasionally such pseudocysts are formed in the sarcomas from this cause, but more frequently as a result of hæmorrhage Degenerative pseudocysts are of frequent occurrence in some of the more slow-growing varieties of glioma, notably in astrocytomas Closely analogous to this form are certain cystic tumours of the central nervous system, especially the cerebellum, a nodule of angiomatous or sometimes gliomatous tumour, or a mixture of these, being found in the cyst-wall The removal or destruction of this mural nodule is essential to the surgical cure of such cysts In **Lindau's disease** or **syndrome** a cerebellar cyst of this nature may be associated with tumours in other organs, such as cavernous angiomas of the eye or liver, and sometimes

CHAPTER VIII

WOUNDS.

A WOUND has been defined as the forcible solution of continuity of any of the tissues of the body, but the term is more commonly limited to injuries of the soft parts, involving the skin or mucous membranes Lesions in which the skin does not participate are spoken of as contusions

A **Contusion** results from external violence causing hæmorrhage into and laceration of the subcutaneous tissues, and may possibly be associated with injuries to deeper structures The signs are usually very obvious, *viz* **pain, bruising,** or discoloration of the part, and **swelling** The amount of bruising varies with the part injured and the severity of the lesion, thus, in the eyelids, scrotum, and vulva, where the tissues are lax, the ecchymosis will be very extensive and of a black colour, on the scalp there is but little swelling unless bleeding occurs beneath the aponeurosis of the occipito-frontalis Again, the condition of the patient's general health influences the amount of blood effused, a strong man in good training does not bruise nearly as much as those of a languid temperament and relaxed tissues Blebs and bullæ may form over the injured spot, especially in connection with fractures The changes that occur in a bruise are well known, the colour passing from a blackish-purple through various shades of brown and green to a yellow, which gradually fades and disappears, this is due to the disintegration of the red corpuscles, and staining of the tissues by the hæmoglobin thus set free, or by the products formed during its removal When hæmorrhage occurs deeply, it is often some days before the bruise 'comes out,' and this may occur at some distant spot, *e g* in the eyelids after a blow on the scalp, whilst it may travel along the muscular and fascial planes under the influence of gravity

In a bruise or ecchymosis, the tissues are, as a rule, merely infiltrated with blood, but occasionally they are torn asunder, and then the extravasation is more localized, and may constitute a fluid swelling or **Hæmatoma.** It somewhat resembles an abscess to the touch, but differs from it in having supervened immediately after an injury, and in having appeared without any heat or other sign of inflammation, moreover, though at first fluid and soft, it soon becomes harder, whereas an abscess is preceded by a stage of brawny infiltration, and the softening occurs later The subsequent history of a hæmatoma varies somewhat according to circumstances (*a*) Fibrin may be deposited peripherally, leaving for a time a fluid centre, which gradually disappears, and the whole is finally absorbed This is well exemplified in a subpericranial cephalhæmatoma, where the contrast

between the peripheral fibrinous deposit and the fluid centre, through which the skull can be felt, is sometimes so accentuated as to give the sensation of a depressed fracture (*b*) The fluid portion of the blood may be absorbed almost entirely, and the solid fibrinous residuum may become organized into a firm fibroid tumour which persists indefinitely, the mass is more or less laminated, and not unfrequently pigmented, and in some cases calcification occurs (*c*) The fibrin may be entirely absorbed, and a slightly pigmented fibrous capsule formed containing serous fluid, and constituting a definite cyst, this is best seen in connection with the cerebral tunics (*arachnoid cyst*) (*d*) Suppuration may ensue owing to auto-infection from within the body, or from an invasion of organisms through abraded skin

The **Treatment** of a bruise usually consists in keeping the part at rest, and applying cold or evaporating lotions The effusion of blood may be hindered, if the case is seen early, by firm bandaging of the part over a compress of cotton-wool In the later stages absorption of the blood may be hastened by massage In the severer cases, where blebs or bullæ have formed or there is a likelihood of the skin sloughing, it must be carefully washed and rendered aseptic, and, if need be, wrapped in an aseptic dressing When a tense and painful hæmatoma exists, as under the fascia lata of the thigh, recovery can be hastened and pain relieved by an aseptic puncture, followed by careful compression In general bruising of the body from a fall or extensive injury, pain can often be relieved by applying fomentations or by a hot bath There is usually a certain amount of fever and constitutional disturbance for a few days, and these are dealt with by purgatives and a suitable limitation of diet In case of suppuration the hæmatoma should be incised and drained

Open Wounds —An open wound may be defined as a solution of continuity of any superficial part of the body, including skin or mucous membrane Various kinds of wounds are described, such as the incised, lacerated, contused, punctured, poisoned, and gunshot, but, of course, the most important distinction to draw is between the infected and the non-infected

I **Incised Wounds** —An incised wound is one made by any sharp cutting instrument, but occasionally one not produced in this manner may be characterized by similar appearances, *e g* the skin of the knee or elbow may be cleanly split open from falling on it with the limb flexed, and occasionally a policeman's truncheon will lay open the scalp almost as evenly as if a knife had been employed

The special features of an incised wound are as follows

1 The hæmorrhage is free, from the fact that the vessels are cleanly divided The amount necessarily depends on the size of the vessels involved, and the vascularity of the part, its continuance, upon the density of the structures allowing or not of contraction and retraction of the severed ends

2 Retraction of the lips of the wound also occurs, the amount depending upon the elasticity and character of the part involved and the degree of tension to which it is exposed

3 Bruising of the margins of the incision is absent, so that under ordinary circumstances rapid healing (by first intention) should obtain The surfaces, to begin with, are lined by a microscopic layer of damaged tissue, some of which may be actually dead, but if suitable precautions are taken, this is absorbed, and in no way interferes with satisfactory union

The chief dangers of an incised wound are (1) Hæmorrhage, (2) injury to subcutaneous structures, such as nerves, tendons, muscles, etc , and (3) the risks involved from infection

Treatment of Incised Wounds.—Seven essentials must be attended to if healing by first intention is to be obtained, *viz*

(1) **The Arrest of all Bleeding.**—General oozing may be stayed by exposure to the air or the pressure of an aseptic swab Divided arteries and veins will need a ligature, but if situated close to the skin, they may sometimes be secured by passing under the bleeding spot the needle used for the suture

(11) **Sterilization of the Wound and its Surroundings** —In casualty work asepsis cannot be always assured, as the wound, though cleanly cut, is made through dirty skin, and portions of clothing, dirt, and splinters of wood or glass may be carried in Under these circumstances the wound and its surroundings must be thoroughly purified

(111) **The coaptation of the opposed surfaces** by means of **sutures** may now be undertaken The substances employed for this purpose are fine silver wire, silk, horsehair, silkworm gut, and catgut In casualty work, and for parts of the body where but little scar is subsequently desirable, as in the face, horsehair and silkworm gut, being non-absorbent, are the best, but in ordinary operative work, which will be more certainly aseptic, fine catgut or silk may be used There are three chief varieties of sutures, *viz* the buried, the deep, and the superficial

Buried sutures may be safely inserted in order to hold the deeper parts of a wound together, if both they and the wound are aseptic, and there they may remain indefinitely, if, however, they are unabsorbent, *e g* silk or silkworm gut, irritation or tension may lead to suppuration with a view to the elimination of the stitch even after lengthy intervals Catgut of varying thickness is therefore the best material to employ, chromicized to a suitable degree according to the length of time it is desired to maintain its action Where permanent retention of the suture with a view to strengthening the part is desirable, and yet an element of tension is present, as in some wounds of the abdominal wall, it may be wise to employ living sutures formed of strips of fascia lata taken from the patient, these, it has been proved, are not absorbed, but remain incorporated in the part, thereby adding to its strength

Deep stitches, or *sutures of relaxation*, are required in cases where there is difficulty in bringing the edges of the wound together, in order to transfer the tension from the healing margin to tissues further away, the edges being thereby relaxed

Superficial stitches, or *sutures of coaptation*, must be so inserted as to bring the edges of the wound into contact without undue pressure,

usually removed on the eighth day, but in the face it is often advisable to take them out earlier

Many conditions may arise to *prevent* the healing of an incised wound by first intention, and they may be epitomized as essentially the reverse of the seven conditions mentioned above, *viz* (i) Non-arrest of the bleeding, causing separation of the lips or deeper portions of the wound, (ii) the presence of infected foreign bodies or failure of the antiseptic precautions, (iii) non-apposition of the edges, (iv) imperfect drainage, leading to tension on the stitches, (v) late infection of the wound, (vi) lack of rest to the part, and (vii) constitutional conditions, such as deficient general vitality from disease or other causes

II **Lacerated or Contused Wounds**—These injuries are caused by blunt instruments, by machinery, missiles, the wheels of a vehicle, etc They are characterized by the following signs

1 The hæmorrhage is as a rule but slight, since the vessels are torn across irregularly, and not cut cleanly, the middle and inner coats, which give way first, are curled up within the contorted outer coat, forming a barrier sufficient to prevent loss of blood The vessels, being elastic, may be pulled out of their sheaths, and are sometimes seen pulsating upon the surface

2 The amount of damage inflicted varies with the character of the injury, but is often so severe as to involve the death, at once or subsequently, of considerable portions of tissue The skin is irregularly torn, and may be extensively stripped from underlying parts, muscles and tendons may be laid bare, or torn from their attachments, nerves may be lacerated, bones crushed and comminuted, joints laid open, and all these damaged tissues may be hopelessly infected by the dust of the roadway or the dirt and grease of machinery When a limb is torn completely off, the tendons are often left long, and the muscular bellies project from their fascial sheaths as flabby congested masses, since the skin gives way at a higher point than the subjacent structures

The **Progress** of the case depends largely upon the question whether or not the wound can be rendered aseptic

In an **Aseptic** lacerated wound it may be possible to bring the edges together, and, even though they are a little bruised, healing by a slightly delayed first intention is possible When the wound remains open, the dead tissue is absorbed or separated, and an aseptic granulating surface results There may be some simple traumatic fever for a day or two

If the wound is **Infected,** however, inflammatory phenomena supervene, as a result of which bruised and dead tissues have to be absorbed or cast off by a process of suppuration, which finally leaves a granulating surface Three stages may be described in the course of such a case, *viz*

(*a*) The stage of injury, resulting in shock, which may be very severe if it includes extensive muscular injury or the crushing of large nerve trunks

(*b*) The stage of inflammation and sloughing, which lasts a week, ten days, or more, according to circumstances, and during this

period various forms of infective trouble may develop, including secondary hæmorrhage, toxæmia, pyæmia, tetanus, and traumatic gangrene

(*c*) The stage of repair by granulation, or prolonged suppuration, with exhaustion and hectic fever in the worst cases

The results of the healing of injuries such as these may be quite satisfactory, or considerable trouble may be experienced at a later date from the implication of nerves in the cicatrix, or their paralysis, from the adhesions or cicatricial contraction of muscles and tendons, impairing the free mobility of the part, or from the deformity caused by the contraction of the scar

The **Treatment** of contused and lacerated wounds varies with their character, and no absolute rule of practice can be laid down to suit all cases

(*a*) **Immediate Treatment.**—All wounds of this nature are to be looked on as infected, and must be treated by excision of the dead or damaged tissues, efficient purification, and *immediate suture only if the surgeon is satisfied that complete asepsis has been secured* Failing this, the wound is left open and packed with some suitable material, *e g* gauze soaked in a solution of flavine (1 in 1,000), and if infection is avoided delayed primary suture is undertaken

(*b*) **Subsequent Treatment** depends on whether or not the measures adopted to obtain asepsis have been successful If the wound remains free from infection, nothing special is required If infection occurs, cellulitis and sloughing follow, and necessitate opening the wound freely, and following up any burrowing suppuration by free incisions Fomentations, baths, etc , as for cellulitis (p 60), will be required as long as the inflammatory process lasts, or the wound must be packed with gauze soaked in hypertonic saline solution When the suppuration has ceased and the sloughs have separated, healing by granulation follows It must be remembered that secondary hæmorrhage may occur when the dead tissues are detached During this period inflammatory fever continues, and the patient's general health must be closely watched

The question of **Amputation** will necessarily arise in dealing with the graver forms of lacerated wounds, although many limbs are now saved which would inevitably in former days have been sacrificed Hard-and-fast rules cannot be laid down as to when to amputate and when not to do so, each case must be treated on its own merits The following **general** points must first be carefully considered (*a*) The *age* and *vitality* of the patient An old person has less recuperative power than a young one, and hence a damaged limb may often be left in a youth which one would certainly remove in an elderly person The vitality of the individual is perhaps even more important than the age, for some men at sixty are in a much more healthy and resistant state than others at forty The habits, as to temperance, etc , must also be taken into consideration, and the existence of general diseases, such as diabetes or albuminuria, might induce one to resort to radical rather than conservative measures (*b*) The vitality of the *extremity* injured A leg has to be sacrificed more frequently than an arm,

since the vitality and reparative power of the latter are so much greater (*c*) The presence or not of *infection* is of the greatest significance, since, if infection can be prevented, the chances of preserving the limb are greatly improved

The **local** conditions which suggest or determine the performance of an amputation may be conveniently divided into two groups, *viz* where amputation is essential, or where it is doubtful

A **Amputation** is certainly **called for**—

1 To trim up the stump of a limb torn off by machinery, or cut off by a railway train, or blown off in an explosion

2 When the whole limb or one complete segment of it has been totally disorganized, or crushed to pulp, though still retaining its connection with the body

3 In cases where gangrene is imminent or has supervened, especially if it is of the spreading type

4 When severe infective symptoms develop in a case where an attempt is being made to save a limb, the retention of which was from the first doubtful, or when exhaustion supervenes from prolonged suppuration

5 In severe compound lacerations of the foot *in old people*, involving the bones and laying open the common synovial cavity Infection is likely to result in disease of the bones and joints, whilst the distance of the foot from the centre of the circulation increases the likelihood of gangrene

B **Amputation** is **doubtful** in the following conditions

1 Compound comminuted fractures in parts other than the foot do not *per se* require amputation unless very extensive By careful attention to antisepsis, free drainage, and the removal of detached fragments of bone and foreign bodies, which should usually be accomplished under an anæsthetic, limbs which would have formerly been condemned to amputation can not only be preserved, but also restored to a considerable degree of functional usefulness The final decision will largely depend on the age, condition, and previous habits of the individual

2 When the soft parts have borne the brunt of the injury, and have been extensively stripped from the bones, *e g* when the muscles of the forearm have been torn up in a machine accident, amputation is by no means an essential, provided that they can be restored to their original position, that there is a reasonable probability of their vitality being maintained, and that the utility of the limb will not be hopelessly impaired, as a result of lesions to the nerves, after the wound has healed The surgeon has here to balance carefully the risk run if an attempt is made to save the limb with the value that the limb if saved will be to the patient

3 Laceration of the main artery of a limb need not in itself determine amputation, but if in addition to this the bones, veins, or nerves are hopelessly injured, and especially in the lower extremities of old people, amputation should be undertaken without delay

Reference must here be made to Trueta's experience in the Spanish Civil War Trueta found that by applying the method of Winnett

Orr to extensive wounds of the soft tissues, whether associated with compound fracture or not, healing was expedited, septicæmia lessened, and mortality greatly diminished The principles of treatment are excision of all dead and hopelessly damaged tissue and excision of wound edges reduction of fracture if present, and the wound is plugged with sterile gauze and the entire limb encased in a skin-tight plaster-of-Paris splint This method gives complete fixation and immobilization, thus by the principle of rest it gives the maximum opportunity for repair This immobilization helps to localize the disease by eliminating muscular movement Although the wound itself is full of organisms which have multiplied after the most extensive and careful debridgement, yet by encasing the limb in plaster they appear greatly inhibited as regards toxicity It has been suggested that the calcium in the plaster plays some part in this, as immobilizing the limb in plaster, with a window cut out over the wound, gives less satisfactory results Courage and clinical judgment are necessary in this form of treatment, as there is usually a pyrexial period of varying time and severity, the temperature may rise to 104°, but should be normal in four days Once the plaster has been applied only the gravest reasons should cause it to be removed In the majority of cases the pus that forms locally drains along the gauze in the wound, and soaks into the plaster As a result the smell becomes very bad, and the first plaster usually needs changing in the third week This must be done with great care, the limb being kept immobile during the process and another plaster immediately applied A third plaster may be necessary The earlier the treatment is carried out the better the results Every effort should be made to do this within six hours

III **Punctured Wounds and Stabs**—These may be brought about by any form of penetrating instrument, from a pin or needle to a sword, bayonet, or pickaxe The external opening may be in itself insignificant, the chief danger arising from the damage to deep structures—blood-vessels or nerves being divided, and serous cavities or viscera opened, or even the skull penetrated The subsequent symptoms depend almost entirely upon the question of infection, there is always considerable difficulty in draining effectively the depths of a long and narrow wound, and therefore collections of pus readily form and may burrow in all directions amongst the deeper planes of tissue opened up by the wound

Wounds resulting from the modern **sword-bayonet,** though very serious from their size and depth, are not so difficult to heal as those inflicted by the old triangular blade They should be effectively purified, well drained, and the skin opening not allowed to close until all discharge has ceased, if necessary, a counter-opening is made at a dependent spot Serious hæmorrhage or paralysis calls for immediate opening up of the wound, so as to expose and deal with injured vessels or nerves

Needles are frequently broken off short in the body, especially in the hands, feet, knees, or nates If seen soon after the injury, it is advisable to undertake their immediate removal, a proceeding sometimes very simple, but occasionally necessitating a deep and difficult

dissection Should the needle not be removed, it may travel about the body along the muscular and fascial planes, and there is no knowing where it may lodge or come to the surface, or how long it may remain in the body, it has been known to constitute the nucleus of a renal calculus

One of the most troublesome and painful forms of penetrating wound is that caused by a **fish-hook,** since the barbed end catches in the tissues, and it is impossible to withdraw it without increasing the size of the wound considerably The simplest plan of treatment is to push on the hook and make it protrude through the skin elsewhere to such an extent as to enable the barb to be cut away, when the remainder of the hook will be set free

For the detection of penetrating foreign bodies of a metallic nature, or of splinters of glass or stone, radiography is indispensable It is always necessary to take the radiograph from two directions, and if the antero-posterior one is taken stereoscopically, so much the better

IV **Poisoned Wounds** —The great majority of poisoned wounds are due to some definite micro-organism, and have been discussed elsewhere A few only remain to be dealt with here

Stings of Insects, such as bees and wasps, are exceedingly painful, but not dangerous, unless some local complication, such as erysipelas supervenes, or the stings are very numerous, as when a swarm of angry bees settles on a person, or the part involved is such as to lead to serious swelling, as in the pharynx or tongue, œdema of the glottis possibly arising under such circumstances All that is usually needed is the application of a weak alkaline lotion, whilst a common and efficient domestic remedy is a freshly sliced onion or a blue-bag applied to the part

Some varieties of flies and spiders are also extremely virulent, and the former play an active part in the transmission of many types of disease Thus various forms of infective cellulitis or lymphangitis may be caused by the bite of a fly that has been feeding on putrid carrion, whilst the epidemic diarrhœa of children in summer is largely due to the infection of their food by flies

The **black widow spider** (*Latrodectus mactans*) is the only proved variety of poison spider found in the United States It is found throughout the south and the south-west, from the Atlantic to the Pacific The *Latrodectus mactans* is not more than 1 to 1 5 cm in length, shiny black in colour, and usually has red or orange markings on the ventral surface of the abdomen, the female having often an hour-glass-shaped bright red spot This spider is found in brush, under stones and roots of dead trees, in country toilets and in dark places generally The bite may be received at any time, even during sleep, and on any part of the body, and it may or may not leave a visible wound Usually, however, shortly following the injury, the spot is marked as a fine red point on the skin Within fifteen to thirty minutes after having been bitten, the victim complains of pain, usually in the region of the nearest lymph glands and, within an hour or so, of pain in the chest or abdomen The temperature rises, the leucocyte count goes up, the abdomen becomes rigid, and the patient may have a chill There may be nausea, vomiting, cyanosis, speech disturbance,

urine retention, coma, shock, and sometimes jaundice has been seen There is often collapse, cold clammy sweat, and the patient is seriously ill The pulse is at first accelerated, but usually soon becomes slow The blood-pressure in the beginning is raised, as is also the cerebro-spinal fluid pressure This, too, presently (after twenty-four hours) returns to normal The condition has been mistaken for appendicitis, cases even having been operated upon The diagnosis of meningitis has also been made The fact that all other muscles as well as those of the abdomen are rigid or spastic should serve to make one think of the possibility of spider bite

The **Treatment** is symptomatic There is no need for incisions, etc The poison is already disseminated before the doctor sees the patient Hot baths are useful, and 10 per cent magnesium sulphate intravenously has been used Hot fomentations to the abdomen are grateful, and it may be necessary to administer morphine several times to relieve the ' cramps ' in the abdomen Convalescent serum has been given and is said to work well

Snake-bites are exceedingly rare in this country, the common adder (*Pelias berus*) being the only venomous one likely to be met with, and even with this the poison is not sufficiently virulent to do much harm unless the individual attacked is a child or a person in a very bad state of health The poison is conveyed to the wound from the glands and poison sac situated on either side of the upper jaw through fine canals in the specialized teeth, which open at their apices, these teeth are so delicate in some snakes that it may be difficult to find the wounds produced by them, but as a rule a double puncture is seen The effects of an adder's bite are not, as a rule, noticed immediately, but come on in the course of an hour or so, extreme prostration supervenes, with a weak pulse, cold clammy perspiration, dilatation of the pupils, and perhaps delirium in bad cases, merging into coma

The **Treatment** consists in preventing the absorption of the virus by tying a ligature firmly above the wound, which should then be laid open so as to allow of free bleeding, and the surface excised or cauterized The collapse resulting from absorption of the poison is best remedied by the administration of stimulants or the hypodermic injection of strychnine

Bites from the rattlesnake and the copper-head (pit vipers) are encountered throughout the United States and in some parts of Canada. In the southern and middle States the moccasin (cotton-mouth, also a pit viper) is encountered Near the Gulf Coast is found a small and less deadly snake, the coral snake

Bites by any of these in children are very dangerous, and the bites of the rattlesnake, copper-head, or moccasin are dangerous to adults as well The larger the snake, the more venom injected For the treatment of these, use of antivenene has almost entirely replaced all other treatment A polyvalent antivenene is for sale at all drug stores during the snake season An institute for its manufacture is maintained at Pittsburgh, Pa

The **Anatomical Tubercle,** or **Butcher's Wart** (*Verruca necrogenica*), consists in a papillomatous development, usually on the knuckles or

protection and stimulating applications, together with general tonic treatment, are required

5 **Painful Scars** arise from either the implication of a nerve terminal in the cicatrix, or the pressure of a contracting scar upon the bulbous end of a divided nerve, as in amputation stumps The pain is often very persistent and wearing, and may radiate widely Treatment consists in freeing the nerve from the scar tissue (p 384), or in its excision

6 **Malignant Disease of Scars,** or of old chronic sores but partially healed, is of an epitheliomatous type, and appears as a hard ulcerated tumour with everted edges and a thickened base (*Marjolin's ulcer*) The progress is very slow, since the vascularity of the tissue is slight It is painless from the absence of nerves, and as long as the disease is limited to the scar no lymphatic implication will be noted

CHAPTER IX

HÆMORRHAGE AND SHOCK.

By the term *hæmorrhage* is meant any escape of blood from the vessels, whether insignificant and immediately arrested by natural means, or more excessive and requiring treatment to prevent its continuance Although most commonly due to traumatism, it may occur in certain diseases, such as purpura and scurvy, whilst in hæmophilia there is a congenital lack of coagulable power, so that it is difficult to stop any flow of blood when started

Arterial Hæmorrhage consists in a flow of bright red blood, which at first escapes in jets, pulsating synchronously with the heart's beat It is derived not only from the proximal, but also from the distal end of the divided vessel, if the collateral circulation is sufficiently abundant If, however, it is derived from a deep artery the blood may well up from the depths of the wound and not escape in gushes In **Venous Hæmorrhage** the flow is usually continuous, and the blood of a dark red or almost black colour If, however, a large vein is wounded, such as the internal jugular, the blood may escape with a very definite spurt, owing to respiratory or other influences **Capillary Hæmorrhage** is marked by general oozing from a raw surface, the blood trickling down into a wound, if present, and filling it from below upwards By **Extravasation of Blood** is meant an effusion of blood from a wounded vessel or vessels, into the lax areolar planes immediately adjacent, which become swollen and boggy, resulting in the formation of a hæmatoma The usual constitutional signs are manifested in the cases of a large extravasation, and fatal hæmorrhage may even occur in this way without any escape upon the surface of the body, particularly in the case of bleeding into the serous cavities Subcutaneous or submucous hæmorrhage is also met with in the form of small localized petechiæ, arising from injuries or from changes in the blood or vessel walls (as in purpura, scurvy, and septicæmia) **Epistaxis** is the term given to bleeding from the nose By **Hæmatemesis** is meant the vomiting of blood It usually originates from the stomach, duodenum, or lower end of œsophagus, but may have been swallowed in the case of epistaxis If it has remained in the stomach any length of time, the blood becomes curdled and brownish in colour, somewhat resembling coffee-grounds, from the action of the gastric juice When gastric hæmorrhage is more active, the blood is bright red in colour, and may be vomited in the form of large clots **Hæmoptysis** is the escape of blood from the air passages, whether it results from injury or disease In the milder cases it is usually bright red and frothy from admixture with air, in graver cases, when larger

vessels are involved, the blood may escape unaltered, and be so abundant as to asphyxiate the patient **Hæmaturia** (*q v*) is a condition in which blood is passed in the urine By **Melæna** is meant the passage of dark tarry blood with the fæces, it is always an evidence of disease or injury of the intestinal canal sufficiently far from the anus to allow the blood to become altered in character by the action of the intestinal juices Blood derived from the rectal mucous membrane usually retains its bright red colour

The Clinical Features of Hæmorrhage.—The effects of hæmorrhage fall into two groups, local and constitutional The **local** features consist of either the escape of blood when there is an open wound or the formation of a hæmatoma when the hæmorrhage is internal In most cases when the bleeding site is accessible to palpation a swelling will become evident which is boggy at first, and later, if the bleeding continues, may become tense At other times the bleeding may be internal and concealed, as for instance with an intra-peritoneal hæmorrhage, in which case it may be possible to detect the presence of shifting dulness in the flanks and possibly signs of peritoneal irritation, but sometimes there will be no localizing features at all

The Constitutional Effects of hæmorrhage are twofold (1) There is a loss of the fluid content of the blood, but this is readily and rapidly made good within certain limits by the withdrawal of tissue fluid The blood-pressure falls, but unless the loss is great it quickly rises to the normal after the bleeding has ceased, this restoration is due partly to a diminution of the vascular area, owing to vasomotor contraction of the peripheral arterioles, but also to the rapid absorption of the tissue fluid already mentioned In severe cases, especially when shock is superadded, the blood-pressure may remain low (2) An even more important loss is that of the red cells with their oxygen-carrying hæmoglobin, hence after a severe hæmorrhage the supply of oxygen to the tissues is defective, and this may be of serious import in cases of shock For the changes that occur in the blood as a result of hæmorrhage see p 28

If the hæmorrhage is severe, as from division of a large artery, death may result from syncope The surface of the body becomes cold, clammy, and pale, the lips, ears, and eyelids are livid, the patient gasps, his respirations become quick and sighing, and death ensues after perhaps a few convulsive twitches of the limbs

If the hæmorrhage is less severe, the patient faints, and on recovery is in a condition of severe collapse and weakness, which continues for some time, he is also liable to recurrent attacks of syncope, especially if the bleeding persists

When the hæmorrhage is *concealed* and of moderate severity, as from ulceration of the stomach or duodenum, or by slipping of a ligature after an abdominal operation, the patient rapidly becomes profoundly anæmic, and his face shrunken and drawn as a result of the dehydration of the tissues of the cheeks The organs of the body generally suffer from want of oxygen, and hence the patient feels as if he were being suffocated, and is extremely restless, tossing about in bed, and clamouring for open windows and more air (*air-hunger*)

Any sudden exertion, or even sometimes the attempt to sit up, is followed by a sensation of faintness or actual syncope, noises are heard in the ears, the sight becomes dim, or is even temporarily lost (amblyopia), and severe headache may be complained of, all arising from cerebral anæmia The pulse often becomes what is known as *hæmorrhagic* in character, *i e* frequent and compressible, but collapsing entirely between the beats, and markedly dicrotic, this is due to the sudden passage of a small amount of blood through a vessel which is practically empty

Natural Arrest of Hæmorrhage.—This process, which applies in all types of bleeding, whether arterial, venous, or capillary, is accomplished in the following manner

The **Temporary** arrest of arterial hæmorrhage is brought about by three principal factors

(1) **The coagulation of the blood,** which occurs in and around the vessel, and without which death would ensue from the merest scratch The coagulability of the blood varies in different subjects, and is influenced by various conditions, *e g* the amount of calcium salts present In hæmophilia the blood coagulates with difficulty, and therefore hæmorrhage is always a serious phenomenon Loss of blood increases the coagulability to a certain degree

(2) **Diminution in the force of the heart's action** always follows hæmorrhage from anæmia of the cerebral centres, and thereby coagulation is facilitated and the flow of blood checked

(3) **Changes in and around the vessel** play a most important part in completing the process They consist in the **retraction** of the artery within its sheath by reason of its inherent longitudinal elasticity, if, however, it is only divided partially (or, as it is called, ' button-holed '), this condition cannot obtain and the hæmorrhage is more likely to continue As a result of this retraction, the rough and uneven inner lining of the sheath is exposed, and upon this the blood coagulates as it flows, thus gradually producing what is known as the **external coagulum.** At the same time the transverse muscular and elastic fibres in the vessel wall cause **contraction** of the open mouth, and thereby the external coagulum is able to increase in size by fresh deposits of fibrin, until at last its resistance is too great for the diminished cardiac impulse to overcome, and the sheath is filled with clot, which extends to the divided mouth of the vessel From this an internal coagulum occasionally develops, extending upwards as far as the nearest patent branch

The **Permanent** closure of the wound in the artery is brought about by a modification of the general process of repair When the escape of blood has ceased, the arterial wall contracts upon any clot which may be present As a result of the injury a simple arteritis is set up, evidenced by a hyperæmic condition of the vessel wall and its infiltration with leucocytes which also attack the coagulum, breaking it up and traversing the natural lines of cleavage which result from its contraction, and gradually remove it, a few giant-cells sometimes assisting in the process The endothelial cells of the tunica intima proliferate, leading to a secondary infiltration of the thrombus with

through the vessel wall by an ulcerative process akin to the separation of a slough, thus exposing the patient to the risk of secondary hæmorrhage

Division of the inner and middle coats is not an essential element in gaining satisfactory occlusion of a vessel, for it can also be effectively accomplished by merely bringing the vessel walls into close approximation by means of a 'stay knot'

In the place of ligature, simple **forcipressure,** which means that the divided end of the vessel is crushed between the strong and deeply serrated blades of a pair of forceps, of which the usual type is the Spencer Wells and the Kocher, may possibly suffice On other occasions, **torsion,** which consists in twisting the vessel after seizure in a pair of forceps, may be employed This procedure causes rupture of the inner and middle coats of the vessel just above the spot grasped so that they curl upwards into the lumen, whilst the outer coat is twisted distally to this point A coagulum then forms upon the injured surfaces, and the subsequent progress towards permanent occlusion is the same as that which has been described in connection with the natural arrest of hæmorrhage

C **Other Accessories to Hæmostasis** are also available and have a limited application They comprise the following measures

(1) **Position** When the bleeding is from one of the extremities, especially the lower, elevation by emptying the veins will determine a reflex contraction of the arteries, and thereby assist hæmostasis

(2) **Cold** may be employed in the form of ice, cold water, or lotion, or simple exposure to the air, all clots, swabs, pledgets, etc , being removed for this purpose, it must, however, be remembered that ice and unsterilized water may convey infective germs Such treatment is of most value for general oozing from vascular structures or into cavities such as the mouth, vagina, or rectum

(3) **Hot Water** (130° to 160° F) is a powerful hæmostatic It is supposed to act by stimulating the involuntary muscular fibres of the vessel wall, but probably the coagulation of the albumen of the blood is an important factor, as unless the water is hot enough to blanch the surface of the wound the bleeding is not stayed but rather encouraged

(4) **Cauterization** is but little employed as a hæmostatic, except for the bloodless removal of vascular tumours by one of the various forms of cautery Occasionally, however, it is used for bleeding from tissues which are infiltrated and thickened by chronic inflammation so that a ligature cannot be applied, *e g* a bleeding vessel on the nasal septum In order to seal effectually the mouths of the vessels, the cautery must be at a dull red or black heat, a bright red-hot iron cuts through a vessel as cleanly as a knife, and does not stop the hæmorrhage

(5) **Chemical Agents** may be used to assist in checking hæmorrhage from spongy tissues or from deep cavities or organs (*a*) They may act locally as *styptics* by causing direct coagulation of the blood, *e g* liq ferri perchloridi or pernitratis, tannic or gallic acid, alum, nitrate of silver, styptic colloid, etc In employing these the surface

of the wound must be cleaned and dried as far as possible, and the styptic then applied on lint or gauze Unfortunately, the more active, such as liq ferri perchloridi, are actively caustic, and may cause sloughing, it is seldom that such applications are necessary (*b*) They may increase the coagulability of the blood, and of these lactate of calcium is the most effective It is usually administered per rectum, in a small enema containing 15 grains, and this may be repeated two or three times a day The use of this drug before operations which are expected to be very sanguinary has been most satisfactory in many cases (*c*) They may be effective as *vaso-constrictors*, and of these the chief is adrenalin It is probably more valuable in preventing than in checking hæmorrhage, and is largely used in intranasal work, it is prepared in the dry form, since it loses its power when kept in solution more than an hour or two The addition of cocaine to its solution increases its activity Its effect is, however, very temporary, and provision must be made to control reactionary bleeding when its influence ceases (*d*) A large class of drugs of the astringent class are employed empirically under varying circumstances to assist in hæmostasis, *e g* turpentine, hamamelis, ergot, acetate of lead, etc , but it cannot be said that their action, though appreciated, is fully understood (*e*) Finally, it is most important in cases of internal hæmorrhage, as from the lungs or gastro-intestinal canal, to keep mind and body quiet, and there is no agent under these circumstances more valuable than *opium* and its salts

Methods of Dealing with Hæmorrhage from Special Sources.

It has been stated that a temporary control of bleeding may often be effected by **digital pressure,** and this method should always be tried in the first place, particularly when the bleeding originates from any of the following sources, thus the common carotid artery may be controlled by grasping the neck from behind and compressing the artery by the fingers placed along the anterior border of the sterno-mastoid against the transverse process of the sixth cervical vertebra (Chassaignac's tubercle) Such pressure will also control the vertebral and inferior thyroid vessels The *subclavian* is to be compressed in the third part of its course against the first rib by the finger or thumb placed immediately behind the clavicle, in the angle between it and the sterno-mastoid, the pressure being made downwards and inwards A good deal of force is sometimes required in order to maintain the pressure, and this may be gained by superimposing the fingers or thumb of the other hand When the pressure is to be kept up for some time, the padded handle of a door-key may be employed in the same way The *facial* artery is compressed against the lower jaw just in front of the masseter muscle, the *temporal* artery, against the zygoma just in front of the ear, the *occipital*, at a spot about $1\frac{3}{4}$ inches from the occipital protuberance against the superior curved line To control the *brachial* artery the arm should be grasped from behind, and the fingers pressed inwards along the inner margin of the biceps against the humerus The *abdominal aorta* is controlled in slim individuals with ease by pressure through the abdominal

wall, or (*b*) the coagula lying in the mouths of divided and unsecured vessels are not sufficiently firm to withstand the increasing blood-pressure which supervenes after the shock has passed away, or which may be due to excitement or the injudicious administration of stimulants This form is usually not very serious, inasmuch as it can only arise from the smaller vessels, all the larger ones having probably been recognized, and tied during the operation Dense structures, such as scar tissue of the parenchyma of the mamma, are favourable sites for the development of reactionary bleeding

Treatment —Elevation and the pressure of a firm bandage are often quite sufficient to arrest this form of bleeding, but, if unsuccessful, the wound must be opened up, washed out with hot salt solution, and any bleeding vessels tied The actual cautery may be employed to check oozing from the cicatricial surfaces, and if it is not allowed to touch the skin, and the wound kept aseptic, no delay in healing need be occasioned Should the bleeding persist, the wound should be firmly packed

Secondary Hæmorrhage —Under this title are included all forms of hæmorrhage from wounds which occur after the lapse of twenty-four hours It is almost always due to infection, and was formerly very common, often leading to a fatal termination, since the introduction of antiseptic surgery, it is but seldom seen, except where asepsis cannot be fully maintained, as in the mouth, pharynx, etc , or in the treatment of gunshot wounds

The **Essential Cause** is **infection** of the wound In a vessel which has been divided and ligatured, as on the face of an amputation stump, the projecting end of the vessel beyond the ligature is practically dead tissue, and, therefore, readily attacked by bacteria, which transform it into a slough, and this, together with the infected [illegible] to be cast off, when this happens, bleeding may occur [illegible] to this, however, the infection of the wound involves a suppurative inflammation around the vessel (*periarteritis*), which results in a softening of the vascular tunics by the bacterial toxins, and this may progress in time to such an extent as to render them incapable of resisting the blood-pressure, so that, sooner or later, they give way This latter condition is especially seen in vessels tied in their continuity, and also occurs in the secondary hæmorrhage which sometimes develops in connection with abscesses in the neighbourhood of large vessels, or in deep infected wounds where a drainage-tube, or other source of pressure, *e g* the spiculated end of a broken bone, is allowed to rest against an arterial wall

Anything which interferes with the vitality of the vessel wall may serve as a **Contributory Cause,** such as its separation from the sheath for too great an extent, thereby cutting off its blood-supply, or a diseased condition of the arterial wall, as from atheroma, or an unhealthy condition of the patient's blood, or undue elevation of blood-pressure, as in Bright's disease

After ligature of large vessels, such as the innominate, first part of the subclavian, or common iliac, secondary hæmorrhage may occur apart from infection, if the inner and middle coats have been divided

by the ligature The crumpled-up outer coat exposed just above the ligature by the retraction of the inner and middle coats is insufficient to withstand the blood-pressure in such large vessels, and undergoes an aneurismal dilatation, which is certainly followed by hæmorrhage at an early date Secondary hæmorrhage is nearly always arterial in nature, but may also be venous, and arises from infection around a vein which has been punctured or divided Under aseptic conditions repair of the wounded venous wall is effected without cessation of the circulation in the main trunk If the wound becomes infected, the ligature is invaded by germs, as also the portion of vein wall within its grasp In the smaller veins the inflammation induced will result in a protective thrombosis, but in a large vessel, such as the internal jugular, where the blood-stream is rapid, thrombosis may be hindered in its occurrence, and hæmorrhage may result from the wall giving way The bleeding from cases of this description will usually be severe, but can be easily controlled by pressure or ligature

The **Phenomena** are almost always preceded by those of infection of the wound, to which a slight occasional loss of blood is added This continues with more or less frequency and severity until the patient is either worn out by the constant repetition of small losses or destroyed by one or two severe gushes from the larger vessels The earlier the bleeding occurs the less serious it is, as it probably comes from the smaller vessels, and can be easily dealt with When, however, it does not supervene till later, as on the tenth or twelfth day, it usually arises from the larger trunks, and is increasingly severe When originating from a vessel tied in its continuity, it generally comes from the distal end, since repair is here less effective than on the proximal side of the ligature, and resistance to bacterial infection less vigorous The explanation of this is that the vasa vasorum reach the artery from the sheath, and the application of the ligature necessarily cuts off the blood-supply of the vessel wall just distal to the ligature

Treatment—The case must be watched night and day until the wound is healthy, as, although the bleeding ceases for a while, it may break out again at any time If the wound is in a limb, a tourniquet should be lightly adjusted above it as a precautionary measure, so that at a moment's notice it may be tightened

When arising *from an artery completely divided*, as in an amputation stump, elevation of the part after redressing and firm bandaging may be all that is needed in early cases A recurrence will necessitate the opening up of the wound, and the application of ligatures to the bleeding vessels, if practicable Sloughs should be cut or scraped away, and the wound packed with gauze soaked in flavine solution and firmly bandaged If this fails, the artery must be tied just above, or re-amputation performed When the bleeding comes from the main vessel near the trunk, as after amputation at the shoulder or hip, proximal ligature can alone be depended on, should local treatment be unsuccessful

When coming *from an artery tied in its continuity*, the wound is

opened up, and the artery secured again above and below, whilst every effort is made to combat the infection Failing this, proximal ligature may be practicable, but for the large vessels of the trunk pressure may be the only resource Should religature at a higher spot fail or be considered inadvisable, as is often the case in the leg, amputation must be undertaken without delay

In these cases blood transfusion is often of great value, because to the already debilitated patient the loss of blood may favour the spread of the ever-present infection

The entrance of air into veins is, fortunately, a very rare occurrence, as it is always fraught with grave danger to the patient, inasmuch as it interferes seriously with the circulation, and may even cause death The air sucked into the veins is carried to the right side of the heart, and there becomes entangled in the colomnæ carneæ, and is churned up into a frothy spumous mixture, which the heart can only eject with difficulty

Hæmophilia.

Hæmophilia is an hereditary disease in males, characterized by deficiency in the thromboplastic substance of the blood which renders the individual liable to severe and repeated hæmorrhage There is a tendency to persistent and uncontrollable bleeding from slight wounds, whether open or subcutaneous This condition is often associated with extravasation of blood into the joints and certain consecutive phenomena (Chapter XXII) The family history of the hereditary cases is interesting, the disease being usually transmitted through the females of one or more generations to the males, whilst the former may escape entirely Unless hæmorrhage is actually occurring, nothing abnormal is noticed, but any injury is sure to be followed by excessive bleeding, spontaneous subcutaneous ecchymoses frequently occur, as also bleeding from the mucous membranes Hence no operation must be undertaken on such patients unless absolutely urgent, even such a small matter as the extraction of a tooth having proved fatal

When blood escapes from a damaged vessel into the tissues, or from a wound on a free surface, the extravasated blood gradually coagulates or clots, due to formation of a meshwork of fibrin This clotting is a protective mechanism which safeguards the body against excessive loss of blood The fibrin is formed by the action of thrombin on fibrinogen Fibrinogen is a normal protein constituent of blood plasma, while thrombin is formed by the action of the thrombokinase on prothrombin in the presence of free calcium ions When the blood escapes from the vessels it is acted upon by thrombokinase present in the tissue fluids, or formed from the damaged endothelium of the vessels, and also from the blood-platelets and leucocytes With blood from normal persons, the time taken for shed blood to clot is practically constant under constant conditions Using Dale and Laidlaw's method, in which the blood is allowed to flow into a capillary tube containing a lead shot, and maintained at 37° C , the time taken by the

blood to clot sufficiently firmly to arrest the lead shot is one and three-quarter minutes This clotting time is prolonged in some cases of purpura, but the prolongation is especially marked in hæmophiliacs, and may be as long as thirty to forty minutes The delay in hæmophilia appears to be due to a deficiency of thrombokinase, especially in the blood-platelets The platelets are normal in numbers, but are defective in quality The addition of normal platelets to hæmophilic blood causes normal clotting, and it has been shown that there is no deficiency either in the calcium or fibrinogen in the disease

Treatment must be directed mainly towards the artificial provision of those substances which are defective in the blood Whole blood transfusion is undoubtedly the best procedure, but there is now available a serum of hæmostatic value, known commercially as Hæmoplastin, which contains prothrombin and other bodies required for determining coagulation, 2 to 4 c c of this serum, diluted perhaps with normal saline solution, are injected under the skin, or for choice into a vein Horse or ox serum given subcutaneously may also be of some use Locally, pressure and cold are mainly relied on, but adrenalin, Hæmoplastin, or cocaine may be applied on gauze to the bleeding spot

Snake venom (Russell viper) has of late been used in the treatment of this condition with encouraging results

When hæmo-arthrosis is present, the joint should not be tapped on account of the danger of sepsis, but should be kept at rest

Surgical Shock.

This term is applied to a condition resulting from trauma in which there is a marked depression or inhibition of the sensory and motor parts of the reflex arc, together with a marked fall of the blood-pressure, a lowering of the body temperature, and disturbance of the respiratory exchange In this connection the term 'trauma' is used in its broadest sense to include operation, and such lesions as perforated peptic ulcer, strangulated hernia, etc , in addition to ordinary injuries

Shock may be described as primary or secondary, according to its immediate or later relation in time to the causative lesion, although the former may pass readily into the latter The condition known as local shock is a curious insensibility to pain on handling the injured part, which is sometimes found immediately after a severe injury, and appears to be a temporary sensory paralysis akin to 'concussion' of a nerve

Primary Shock is the immediate outcome of the accident or lesion, and the fall of blood-pressure is in some measure beneficial, as it tends to limit hæmorrhage The rapid onset of the symptoms suggests that the condition is due to reflex inhibition of the heart and vaso-dilatation, particularly of the splanchnic vessels, resulting in a marked fall of blood-pressure and sometimes loss of consciousness from cerebral anæmia It is probably a reflex response to overwhelming efferent impulses and experimentally can be prevented by a preliminary cocainization of the nerves at a level proximal to the injury A common

All observers are agreed that the constant feature is the depression of the blood-pressure from the normal systolic pressure of 110 to 120 mm of Hg to 50 mm or below In the anæsthetized animal, with trauma applied to the muscular part of the thigh, the common finding is an initial fall of blood-pressure (stage of primary shock), followed by a rise (stage of reaction), and then from one to six hours later a profound fall to shock level

A marked reduction of the blood-volume is also recognized as a prominent feature of the condition This was originally thought to be due to a peripheral vaso-constriction, with consequent engorgement of the splanchnic and visceral vessels, but the pallor and bloodlessness of the viscera found at operation or post-mortem shows this view to be incorrect Moreover, various observers have noted an increased red cell count in the capillary blood as compared with that of the veins, together with an increased hæmoglobin content of the blood even up to 125 per cent This indicates that loss of the plasma is an important factor in the diminution of the blood-volume, and the consequent increased viscosity of the blood still further slows the peripheral circulation As a result of this, oxygenation of the tissues is diminished, and there is an accumulation of incompletely oxidized products of metabolism leading to a condition of acidosis

On the experimental side the field has long been dominated by the work of Bayliss, Cannon, and others during the later years of the war Their experiments appeared to show that secondary shock resulted from the production, in the injured tissues, of a toxic substance which entered the circulation and caused the general phenomena of shock The isolation of histamine from muscle tissue and the demonstration that histamine on injection produced a profound fall of blood-pressure was a further step, and although the post-mortem appearances of 'histamine shock' differ from those of traumatic shock, it seemed reasonable to assume that some similar product of injured muscle was responsible for the development of delayed shock

Recently this work has been severely criticized Blalock and others have shown that the extravasation and exudation into the injured part was not fully measured in the earlier experiments When this local extravasation is accurately measured it is found to amount to between 40 and 50 per cent of the total blood-volume, and they have shown that bleeding an animal to this extent will produce shock in the absence of trauma In addition, Blalock has shown that the transfusion of blood from a shocked animal into an uninjured animal does not produce shock in the recipient, thereby proving that there is no vaso-depressor substance circulating in the donor's blood This result has been confirmed clinically by Schneider, who failed to produce a fall of blood-pressure, either in men or animals, by the injection of blood from shocked patients

Recently O'Shaughnessy and Slome have brought forward further experimental evidence * They confirm the failure to demonstrate a vaso-depressor substance in the blood, and they agree that in severe trauma the reduction of blood-volume by local extravasation will

* *British Journal of Surgery*, XXII, No 87, p 589

account for the shock In less severe injuries they find the local fluid loss is itself insufficient to produce shock, and they have shown that shock will only develop if the nerves from the injured limb are intact Section of all nerves from the limb prevents the onset of shock, with the thigh as the site of trauma, spinal anæsthesia delays the fall of blood-pressure until the limb reflexes return Moreover, in an already shocked animal, spinal anæsthesia causes a marked recovery of the blood-pressure, which persists until the effect of the anæsthetic wears off

The conclusion thus reached is that the factors responsible for shock are the local fluid loss by extravasation, and vasomotor depression by reflexes from the site of injury The various workers are, however, careful to emphasize the fact that their conclusions apply only to traumatic shock, and that toxæmia may play a part in other types of shock

The **Symptoms** of secondary shock correspond practically to those of the later stages of primary shock The patient lies in bed in a condition of apathetic torpor, from which he is aroused with difficulty, when he will answer intelligently but faintly The surface of the body is cold and pallid, often covered with a cold clammy sweat, the lips and the extremities of the nose, ears and fingers gradually become blue and livid, the eyes are sunken, the mouth is parched, and the patient complains of intense thirst The temperature is subnormal and falls gradually, the pulse is weak and running, and may be uncountably quick, the systolic blood-pressure is 40 to 50 mm Hg or lower, respirations are rapid and shallow, and become irregular Gradually the patient passes into a state of complete unconsciousness, urinary and fæcal incontinence may ensue, and death occurs with respiratory failure At post-mortem examination nothing peculiar is found except a general bloodlessness of all organs

Diagnosis.—1 From the general results of **hæmorrhage.** Restlessness and thirst are then prominent signs, and the mental condition is less affected However, some degree of shock is often present, and in severe cases of shock the diagnosis may depend on careful examination to exclude internal or external hæmorrhage An estimation of the colour index of the blood may help, since it is normal in pure shock, but is lowered following hæmorrhage

2 **In concussion of the brain** shock is also present to some extent, but there is an additional evidence of injury to the head, with unconsciousness, followed by vomiting as recovery occurs After recovery the patient has no recollection of events which occurred immediately preceding the accident

3 The onset of vomiting under an anæsthetic may simulate shock, but is easily distinguished by the progress of the case

Treatment —In slight cases of primary shock very little is needed beyond resting quietly for a few minutes, and the use of some stimulant such as sal volatile or brandy In moderate cases the patient is also wrapped up and kept warm and some warm drink administered In more severe cases he is laid recumbent, with head low, and every care is taken to avoid loss of body heat during the necessary examination to determine the nature of the lesion

The question of immediate operation, assuming facilities to be avail-

able, calls for careful judgment In certain cases, *e g* internal hæmorrhage, operation is a life-saving measure and should be undertaken without delay In others, the risk of extension of the lesion, and of greater liability to secondary shock if operation is delayed, must carefully be weighed against the risk of operation during the stage of primary shock Thus, in cases such as perforated peptic ulcer, it is almost imperative to delay operation for an hour or so to give the patient a chance of resuscitation with appropriate treatment In other instances, where local or regional anæsthesia is possible, the blocking of nervous impulses from the lesion hastens the patient's recovery from primary shock, and immediate operation would be justifiable

When immediate operation is inadvisable, temporary measures must be taken to deal with the lesion, hæmorrhage should be checked, and the injured region immobilized as far as possible The patient is then put to bed with the head low, the end of the bed should be raised, and he is disturbed as little as possible The body temperature is raised by the use of warm blankets, suitably protected hot-water bottles, or by placing under the bedclothes, supported on a cradle, one or more electric lamps of sufficient strength to raise the temperature of the air round the body to between 100 and 105° F In the United States the oxygen tent is much in use for the treatment of severe shock and has proved of value Pain is relieved by the use of morphia in full doses, according to the age and condition of the patient If he is conscious, warm drinks are given, if unconscious, fluid should be given per rectum, as glucose saline (2½ to 5 per cent glucose in isotonic saline), or as hot coffee, which has a certain stimulating effect In severe cases it is advisable to give 1 or 2 pints of isotonic saline intravenously, the saline should be at a temperature of 104° F , and not more than an ounce should be given per minute

In all cases of **operation** during or immediately after shock, or where shock may be expected to develop, every care must be taken to protect the patient from the contributory factors indicated above

(i) He should not be unduly purged or starved beforehand, and the taking of fluids by mouth should be permitted until two or three hours before operation Where acidosis exists, alkaline drinks or an infusion of alkaline fluid should be given The incidence of shock may often be prevented by commencing intravenous infusion of saline or blood transfusion before operation, and continuing it slowly throughout

(ii) In nervous patients the pre-operative injection of morphia (gr ⅙ or ¼) or of omnopon (gr ⅓ or ⅔) is desirable, but should be combined with atropine to offset the possibility of depressant medullary effects

(iii) The bodily heat must be conserved by suitable clothing and the avoidance of undue exposure, while the temperature of the operating room should not be below 70° F

(iv) When practicable blocking of nerves by local, regional, or spinal anæsthesia is desirable, and if a general anæsthetic is required chloroform must be avoided Ether has some slight toxicity, but is prob-

ably more effective than gas and oxygen for blocking nervous impulses, and, in addition, possesses valuable stimulating properties

(v) In the course of operation rapidity of execution should be aimed at, but gentle handling and exactitude must not be sacrificed to speed

While attention to these points may prevent the onset of secondary shock, once the condition is established treatment becomes more difficult In view of the recent experimental work, the primary consideration should be to minimize further exudation at the site of injury, and to diminish the nervous impulses arising from the part Thus the success of the tannic acid treatment of burns is largely due to the coagulum preventing further exudation and diminishing the painful stimuli Similarly it should be remembered that efficient immobilization of an injured part is a most important factor in preventing further exudation and in diminishing the local nervous impulses, not only in the case of fractures, but also in injuries of the soft parts The use of local or regional anæsthesia will, as already mentioned, completely block the nervous impulses, and is of the greatest value where an operation has to be performed on a shocked patient, recently it has been put forward as a possible line of treatment for shock, although the patient may relapse as the anæsthesia wears off

After attending to the primary lesion, the question of restoring the blood-volume arises The intravenous infusion of isotonic saline has long been used for this purpose, but its effect is transient, as a pint of saline is lost from the blood into the tissues within thirty minutes of its administration If given by a 'continuous drip' method (3 to 5 pints in twenty-four hours), the effect on the blood-pressure is less marked but more prolonged, and the method is of value in severe cases of shock Bayliss advises the use of a 6 per cent solution of gum arabic in normal saline, since the colloidal gum remains within the blood-vessels and exerts an osmotic pressure, which attracts fluid from the tissue spaces, thus increasing the blood-volume further A pint of this solution (sterilized and filtered) should be given slowly, and in favourable cases will produce a rise of blood-pressure which persists Recently the use of hypertonic saline has been described 40 c c of a 30 per cent solution are given intravenously and produce an immediate rise of systolic pressure, often to above normal, followed by a fall, but this is not marked, and the blood-pressure is usually maintained above 'shock level' This solution acts by osmotic attraction of fluid from the tissue spaces, thus increasing the blood-volume, but it is particularly indicated in conditions of shock associated with a deficiency of the blood chlorides, *e g* intestinal obstruction

The actual transfusion of blood is often useful (*vide* Fig 111), but may be disappointing in its effect (Fig 112) It is most valuable in cases of shock associated with severe hæmorrhage where the patient's condition is aggravated by anoxæmia from the lowered hæmoglobin In pure shock the loss of blood-volume is a loss of the fluid portion of the blood, and transfusion in these cases is of less value than the use of intravenous saline The hæmoglobin content of the blood may

be taken as a guide, in shock a fall of hæmoglobin below 70 per cent would form an indication for a blood transfusion

Attempts to raise the blood-pressure by stimulants should be made, but are often of small avail, coramine, icoral and pituitrin are the most useful and should be employed in full dosage Adrenalin and ephedrin may also be tried, but are usually of little practical value Hot, black coffee per rectum is sometimes a valuable help

General treatment regarding posture and the maintenance of body temperature should be carried out as described for primary shock

CHAPTER X

THE GENERAL TECHNIQUE OF OPERATIVE SURGERY

No one who has been brought up in the modern school of antiseptic or aseptic surgery can have any idea of the horrors that were perpetrated under the name of surgery by our ancestors Anæsthesia was unknown, and perhaps this was an advantage rather than otherwise, as it limited the number and the scope of operations Patients had to be forcibly restrained during the procedure, hæmostatic forceps were not in existence, and the operating theatre was not the quietly decorous spot that it now is, but rather resembled the shambles The wards were a hotbed of surgical fever, and erysipelas, pyæmia, and other manifestations of pyogenic infection led to an appalling post-operative death-rate Hospital gangrene, wound phagedena, and other affections now happily extinct, were common enough, and not unfrequently wards had to be entirely closed in order to limit the ravages of such diseases The almost synchronous discovery of anæsthesia and antisepsis has transformed surgery, and from being an art dangerous, barbarous, and almost repulsive, it has been changed into a scientific procedure, beautiful in its details and beneficial in its results

The **Antiseptic** plan of treating wounds, as originally introduced by Lord Lister, is an outcome of the germ theory of putrefaction It has for its object the prevention of bacterial development in wounds by the use of *chemical agents*, some of which are true germicides, capable of destroying the bacteria, whilst others merely prevent or inhibit their growth

Biniodide of Mercury is a potent antiseptic, which has been chiefly employed in the form of a 1 in 500 solution in 70 per cent methylated spirit for the purification of the hands or of the skin of the patient It is, of course, extremely toxic A 1 in 2,000 aqueous solution is also employed for the hands, and is less harmful to instruments than the perchloride

Boric Acid is a mild and weak antiseptic, which may be utilized when stronger remedies might prove harmful, *e g* in plastic operations and for infants It is also useful when antiseptic fomentations are required in treating inflammatory phenomena, and in ophthalmic surgery

Iodine is a most valuable antiseptic, and at the present time is largely employed to sterilize the skin before operations in alcoholic solutions, varying from 2 to 5 per cent To be effective, it is essential that the skin surface be previously freed from grease, and therefore in emergency cases it should be washed over with ether or acetone

Iodoform is a yellow powder of characteristic and unpleasant odour, which probably acts by being decomposed in the tissues and slowly giving off iodine Commercial iodoform is usually contaminated with a variety of germs, it is therefore wise to wash the iodoform before use in 1 in 20 carbolic lotion Its chief value is in foul or tuberculous wounds, and, indeed, it seems to have a specific inhibitory action upon the development of the *B tuberculosis*

Lysol (or one of the many substitutes for it) is another useful antiseptic derivative of coal-tar It is freely soluble in water, and as a 2 per cent solution may be used in syringing out cavities, such as the vagina, external ear, etc Its solution is somewhat soapy, and tends to cling to the tissues and prolong its action

Dettol is a useful general antiseptic It is a halogen derivative of xylenol dissolved in a mixture of aromatic essential oils The oils are dissolved in a neutral solution of a suitable soap to render them miscible with water, thus forming a permanent emulsion when diluted Dettol is a clear, light yellow fluid It is miscible with water in all proportions, forming a fine emulsion It can be used for sterilization of the skin, for sterilization of instruments, or for lotions

Permanganate of Potash, Sanitas, and **Peroxide of Hydrogen,** all act in the same way as oxidizing agents, they are necessarily unstable, and cannot be utilized for dressings, and are therefore chiefly employed in the disinfection of cavities or wounds already contaminated The most potent of these is peroxide of hydrogen, which is sold as a fluid capable of setting free 10 to 20 times its volume of nascent oxygen It is quite unirritating, and may be poured directly into an infected wound, or even into the peritoneal cavity, forthwith it commences to effervesce, liberating its oxygen, and forming a frothy foam, which is likely to bring to the surface any loose sloughs or foreign bodies Hydrogen peroxide is therefore particularly useful for washing out wounds which are liable to be infected with anaerobic organisms, *i e B welchii* or *B tetani*

Hypochlorous acid and the **hypochlorites** have been much employed recently in the treatment of infected wounds, and undoubtedly have great antiseptic power *in vitro* They are derived from bleaching powder or chloride of lime, and the chief forms in which they are used are as follows

Eusol is prepared by the action of boric acid on bleaching powder in the presence of water, and contains about 5 per cent of hypochlorous acid If kept cool and in the dark, it retains its antiseptic power for three or four weeks, but rapidly loses it in contact with living tissues or on warming, and hence must be used cold It may be employed as a lotion to irrigate wounds, or may be applied directly on gauze as a compress, or even as a substitute for Dakin's solution in the Carrel treatment It is, however, strongly alkaline, and when once the wound is clean, its prolonged application is harmful and hinders healing

Dakin's solution (or rather Daufresne's modification thereof) is free from caustic alkali, and contains from 0 45 to 0 50 per cent of hypochlorite of soda, if a smaller percentage of hypochlorite is present, the

solution is inefficient, if more than 0·50 per cent is present, it is irritating The preparation requires much care, and inasmuch as bleaching powder is not of a uniform strength, its chlorine content varying from 20 to 37 per cent, it ought always to be tested first, and the amount of carbonate and bicarbonate of soda is regulated by this, the higher percentage of chlorine requiring more alkali, the finished product is again tested to ensure its accord with the standard indicated above

Chloramine-T is a stable hypochlorite compound which retains all the advantages of the above solutions It is readily soluble in water at ordinary temperatures, and a 2 per cent solution is generally advised for wounds It may also be employed in the form of an ointment (10 per cent), or to infiltrate gauze (5 per cent). As a lotion it may be applied not only for irrigation purposes, but also to wet gauze for packing wounds, and for washing out mouth, nose, throat, or vagina

The **Aseptic Method** of treating wounds consists in the elimination of chemical antiseptics as far as possible, and the substitution of heat, dry or moist, as a sterilizing agent Every efficient antiseptic is more or less toxic and irritating, and there can be no question that from an ideal standpoint the less they are introduced into wounds the better No more satisfactory germicide can be imagined than heat, in the form either of boiling water or of steam under pressure, and if everything brought in contact with the wound is aseptic, then no antiseptics need be employed Dressings, swabs, towels, aprons or coats, and caps are sterilized in drums or kettles by means of steam at ordinary pressure, or by superheated steam at high pressure The latter, of course, is the more satisfactory, owing to its greater penetrative power, but the former can be effective if the drums are so constructed as to permit a free passage of steam through the articles to be sterilized, and if the latter are packed loosely and not tightly The drum is first lined with a layer of lint or gauze, and a similar covering must be placed over the contents beneath the lid A sliding shutter, or some suitable contrivance, allows the entrance of steam into the drum When the drum is removed from the sterilizer, this shutter is closed, and the contents may be expected to remain sterile for a day or two, but not for long unless hermetically sealed

For large hospitals an extensive and expensive sterilizing plant has to be installed, and probably some variety of the Washington-Lyon sterilizer is the best Gowns, caps, and towels are usually dealt with in drums, but dressings and swabs are treated separately in packets wrapped in two layers of towelling, and for ward dressings two or three towels are added to these The absence of antiseptics lays a heavy responsibility on those whose duty it is to prepare these materials, and all practicable foolproof checks should be utilized to avoid mistakes Sterilizers, like all other machines, can get out of order, and it is quite possible for the process to be conducted without any steam reaching the contents A 10-inch vacuum should first be produced to extract all air from the dressings Steam is then admitted at 15 pounds pressure per square inch and allowed to circulate for twenty minutes A 15-foot vacuum then follows to extract all the steam and so dry

the dressings The danger of unsterilized packets getting mixed with the sterilized must also be provided for, as also of sterilized packets becoming subsequently contaminated A recording steam gauge should always be connected with the inner chamber of the sterilizer, and each packet of dressing should contain a slip of paper with the date of preparation written thereon in an ink which changes colour only when effectively exposed to heat An indelible silver ink which writes red, and is turned black on exposure to heat, and runs in the paper with moisture, is suitable for this purpose, and can be obtained

For small establishments a Schimmelbusch's low-pressure dressing sterilizer or a small high-pressure (5 to 15 pounds) steam sterilizer answers excellently For private practice supplies of effectively sterilized articles in hermetically sealed tins or drums can now be obtained from many instrument makers and chemists

The **actual details of operative technique** vary somewhat with different surgeons, but the main principles which govern modern operative surgery are much the same in all, and the following sketch of the preparations required and of the routine usually practised in undertaking an operation may be considered more or less typical of modern methods

1 **The Operating Room.**—The arrangement of this necessarily depends upon considerations of space and finance It should not be unnecessarily large, and the old-fashioned 'theatre' with tiers of seats overlooking the central area is not desirable Onlookers should have a low gallery provided for them, but little raised above the floor-space and shut off from it not merely by a rail, but by a glass barrier half-way to the ceiling It may with advantage be placed between the operating area and the source of light, but clear of the window, or to one side, and should be entered by a separate passage A north light is desirable, and it should come, not from the top, but from the side, in the form of what is known as a 'studio light' The walls should be free from ledges on which dust may accumulate, and lined with white tiles or glazed bricks, or, better still, present a smooth enamelled surface, which can be washed down with a hose, of course, all corners should be rounded The floor must be impermeable, and slope towards an open channel on one side of the room, so as to allow of suitable flushing with a hose All shelves must be made of glass, but the fewer fixtures the better The heating arrangements should be such that the temperature can be raised, if necessary, to 75° or 80° F A suitable series of smaller rooms should be available for the surgeon and anæsthetist, for sterilizing purposes, etc Artificial light must be provided, and electricity should always be employed for the purpose Gas must be excluded as an illuminant, firstly from the risks of igniting ether vapour, and secondly from the chemical changes induced thereby in chloroform, resulting in the production of poisonous fumes The lamps should, for choice, be fixed to the extremity of a long arm attached to one of the walls, thereby avoiding the presence of dust-collecting wires and pulleys over the table

In a private house the room must, if possible, be carefully prepared beforehand The carpet should be taken up and curtains removed The walls should be wiped over with an antiseptic solution, and the floor

thoroughly scrubbed, all unnecessary furniture is removed Should the operation be an emergency one, without time for such complete preparation, it is often wiser to leave things alone, and not stir up dust and dirt by a hurried attempt to make the place look a little better than it really is A suitable supply of hot and cold boiled water must be secured beforehand, and basins and dishes, etc , should, if possible, be previously boiled

2 The **Surgeon** must remember the very grave responsibility that rests upon him in undertaking any of the modern operations, and he must be willing and ready to submit himself to the strictest régime In a general hospital he will lay aside all his clothes and boots, and don an operating suit consisting of a soft white shirt, white 'drill' trousers, and a pair of clean shoes, he will then proceed to purify his hands and arms, and finally puts on a sterilized gown reaching to the wrists, a sterilized cap and mask covering the whole face except the eyes, and sterilized gloves reaching *over* the lower end of the sleeves The *assistants* will be similarly prepared Where such a complete change is impossible, the shirt-sleeves must be turned up well above the elbows, and other preparations made as before During the operation unnecessary talking is forbidden, and if one has to cough or sneeze the head is turned completely aside

Similar rules hold good in regard to the *nurses*, who should wear sterilized gowns, and caps to cover the hair Those actually assisting in the operation will also wear masks and gloves, and all others present wear gowns, caps and masks In all operations involving the upper part of the body the *anæsthetist* must also be suitably garbed, and his hands and apparatus sterilized or protected

The **hands** and **arms** must be as thoroughly and effectively purified as if no aseptic coverings were available They are scrubbed thoroughly with soft or ether soap and hot water, the nails are cut close, special attention being directed to the semilunar folds of skin at the base, where infected material is apt to collect For this purpose a purified nail-brush is employed with advantage, and if a running stream of hot water can be obtained, so much the better It is possible that simple washing with soap and hot water for ten minutes is sufficient to purify the hands and arms

The thin **rubber gloves** used in general work can be sterilized by dry heat, or boiled in water without soda Dry sterilization is preferable, but unless care is taken the gloves are liable to be damaged The interior is well dusted with talc powder, and a piece of gauze introduced to keep the surfaces apart, the ends should be folded up over a piece of gauze so that the glove can be put on without touching the outer surface, the gloves are finally placed in a cotton bag for sterilization To put on such gloves, the hands after effective washing and purification are dried on a sterilized towel, and dusted over with sterilized talc The glove is held by the turned-back cuff and slipped on so that the bare hand never touches the outer surface, this point is of particular importance If gloves are boiled, they must be partly filled with water and placed in a bag or cage, otherwise they float to the surface and do not get completely sterilized Boiled gloves are

best put on by everting them, and anointing the interior with sterilized glycerine; or the hand may be immersed in methylated spirit, and the glove then slips on easily

3 **Instruments** are sterilized by boiling in a weak solution of bicarbonate of soda (1 per cent) for ten minutes, or more if they have been previously used for a dirty case To prevent them from rusting they should be carefully plated, and the water ought to boil for some minutes before they are immersed, in order that the suspended air may be driven off After boiling they may be laid out on a sterilized dry towel and covered over with a similar towel till they are required, or kept in a weak antiseptic solution, *e g* carbolic lotion, 1 in 60 Mercurial solutions should be avoided, as they spoil the instruments If during an operation an instrument which has not been previously sterilized is required, it may be quickly purified by immersing it for half a minute in liquefied carbolic acid, the excess of which is removed by washing thoroughly in alcohol or hot sterilized water The same process or re-boiling must be adopted for any instrument which falls on the floor or becomes otherwise soiled Special care must be directed towards the forceps, to see that the serrations are freed from dried blood-clot and other dirt Hæmostatic forceps should be opened before boiling

4 **Swabs** have now so completely taken the place of sponges in surgery that it is unnecessary to consider the preparation of the latter Swabs are made of absorbent wool wrapped in a single square layer of gauze, the corners of which are tied across and tucked in, or they may be composed of gauze alone, folded over, and perhaps stitched so as to leave no free edge which may fray out, or they may be formed of larger squares of absorbent material, such as gamgee tissue A sufficiency of these, suited in size and shape to the requirements of the case, is provided before the operation They are sterilized in a suitable autoclave or sterilizer, and kept in the drum until required, when they are removed by sterile hands or instruments to a sterile receptacle, being used dry or after immersion in lotion In case of need, where a sterilizer is not available, they may be boiled and then kept either in boiled water, covered over till required with a sterilized cloth, or in an antiseptic solution, or may be dried in an oven after being enclosed in a suitable cloth

Cloth and gauze strips for abdominal operations are prepared in a similar manner In these cases a careful record must be kept of the numbers used, so that all may be accounted for afterwards, indeed, it is wise always to have swabs, etc , done up in packets or bags containing a known number, such as a dozen Furthermore, any swab inserted into the peritoneal cavity should always have a pair of artery forceps attached to a piece of tape at one corner of the swab Strict adherence to this rule will often prevent the calamity of a lost swab in the abdomen

5 The **Ligatures** and **Sutures** demand very thorough purification, which varies with the material used Silkworm gut, horsehair, and silver wire, which do not imbibe fluids or become absorbed, merely require to be boiled, but silk and catgut need much more care if stitch

suppuration is to be avoided **Silk** must be boiled for thirty minutes, and should be wound loosely on reels or winders, so that the deeper strands may become sterile as well as the superficial It may be used at once after being kept in spirit or in some antiseptic lotion, such as a solution of sublimate (1 in 1,000), for a week or until required, so that its strands may become well impregnated with the salt Silk should also be sterilized by steam previously to the boiling, as it is doubtful whether spores are always killed by prolonged boiling

Catgut is still more difficult to purify, inasmuch as boiling in water is out of the question Lord Lister claimed that catgut, prepared according to his directions (p 315), remains actively antiseptic for an indefinite period, and that it suffices before use to immerse it in a 1 in 20 solution of carbolic acid for a quarter of an hour The majority of surgeons, however, prefer to sterilize it before use, and especially so if they use non-chromicized gut or catgut which has been hardened in a 5 per cent solution of formalin for twenty-four hours Many different processes have been recommended, but perhaps the simplest and most effective is that known as the 'iodine' method The catgut is wound loosely on a glass spool or winder, and immersed in a solution containing iodine, 1 part, iodide of potassium, 1 75 parts, and distilled water, 100 parts It is kept thus in the dark for twelve days, and then removed and kept dry, wrapped in sterile gauze or placed in sealed sterile bottles Before use it is placed for a few minutes in alcohol (rectified or methylated), so as to dissolve out a little of the excess of iodine present Catgut so prepared is not only aseptic, but also actively antiseptic, and rarely causes trouble in the tissues (except perhaps, in delicate children) An extensive experience of this material for some years has proved its reliability and value Various instrument-makers provide sterilized catgut in sealed glass tubes, which can usually be trusted

6 The **preparation of the patient** must be directed not only to the site of operation, but also to the general condition If the operation be one of any gravity, it is often wise to let the preceding day be spent quietly and restfully, possibly in bed An effective evacuation of the bowels should be secured, but undue purgation is quite unnecessary, only a light evening meal is permitted A good night's sleep is essential, and if need be a hypnotic is administered, this is the more important if by any chance the operation is put off, and for want of it mishaps, such as attempted suicide, have occurred An operation is to many a terrifying procedure, and the *morale* of the patient must be studied, and undue fear countered by cheery conversation and company Nurses by chattering about previous cases and experiences may do an infinity of harm On the morning of the operation an enema is usually desirable, and some simple fluid nourishment is administered two or three hours previously

The *skin* of the patient must be cleansed beforehand, in accordance with the instructions of the surgeon Many methods are available and effective, but the following, which has been tested abundantly, is perhaps the best and simplest The part is shaved, possibly the preceding evening, and washed with ether soap and hot water It is

then thoroughly dried with a sterile towel, and if thought necessary swabbed over with ether or acetone A 2 per cent solution of iodine in 95 per cent alcohol is then painted over it and allowed to dry, and a sterile dressing applied This painting with iodine is repeated once again at the time of operation

Picric acid (1 per cent in water or 3 per cent in spirit) may be employed instead of iodine It is more penetrating, and therefore more effective and persistent, it is much cheaper, as methylated spirit may be used with it, but it is liable to stain the dressings and bedding, etc, and is therefore disliked by nurses After the preliminary washing with soap and water a piece of sterilized lint soaked in the aqueous solution is applied, and over this non-absorbent wool (sterilized) is bandaged At the time of operation the 3 per cent spirituous solution is painted over the part

H[illegible]'s solution is used by some surgeons in the final preparation of the skin, the area is swabbed over with it, and after a few moments it is washed off with methylated spirit The formula is as follows

Methylated spirit 94 per cent	640 c c
Acid hydrochlor (commercial strong)	60 c c
Hydrarg perchlor	0 8 grm
Water	300 c c

Special care must, of course, be given to all parts where dirt is liable to accumulate, such as the umbilicus, external ear, toes, or corona glandis in a person with a long prepuce, but undue scrubbing and rubbing are to be deprecated as likely to determine a certain amount of dermatitis, or to wake up into activity germs lying dormant in the deeper part of the skin

7 The **area of operation** is surrounded by sheets, which should always be sterilized, and these in turn are covered with dry sterilized towels, fixed to the skin by suitable towel-clips Failing dry sterilization, the towels may be boiled and subsequently dried by baking in an oven, or soaked in an antiseptic solution As soon as the incision has been made, sterilized cloths or towels made of 'tetra' or other similar material may be clipped over the edges of the skin so as to prevent the surgeon's hands from being in contact with it and thereby causing defilement

8 The **operation itself** should be carefully thought out in advance and carried through without undue delay The mere exposure of the subcutaneous tissues to the air does some amount of harm and necessarily increases the risks of infection The absence of pain granted by anæsthesia is no justification for dawdling, but nothing is gained by undue and showy rapidity Gentle handling of the tissues and the absence of unnecessary force are essential elements of good operating that must never be overlooked Clean cutting does less harm than tearing tissues apart, which always means increased reaction Bleeding should be reduced to a minimum, and known vessels may be picked up with advantage by hæmostatic forceps before division, especially in the axilla and neck

9 Before closing the wound absolute **hæmostasis** should be secured, and then the wound may usually be stitched up completely and without drainage It is important to build up again the divided tissues of the part by suitable buried sutures, so as not only to secure more perfect apposition, but also to obliterate ' dead spaces ' in which blood-clot or effusion may collect In this way wounds through fleshy and vascular structures may sometimes be closed completely without drainage On the other hand, where accurate apposition of tissues and obliteration of cavities cannot be obtained, as after clearing out the axilla, and where some amount of oozing may be expected, it is always desirable to insert a drainage-tube or a ' cigarette ' drain and stitch it flush with the surface It is removed at the end of forty-eight hours at most, in such cases the removal of the discharge and the changing of the soaked and perhaps stiffened dressings add materially to the comfort of the patient

When the operation has been completed, the skin around is cleansed with lotion, but *only after a piece of dressing has been placed as a protection over the wound* This cleansing should always be accomplished by wiping peripherally away from the wound, and any swab utilized for this purpose should not again be allowed to touch it

10 Finally, a carefully arranged **Dressing** is applied, and the part bandaged and placed at rest on a splint or in a sling, if such is indicated by the requirements of the case, absolute rest and quiet are essential if rapid healing is to be obtained

Most surgeons, however, employ simple sterilized gauze without any antiseptic ingredients, and where complete asepsis has been maintained and no great amount of discharge is expected, this will suffice admirably An antiseptic dressing is, however, an extra safeguard that may be wisely adopted, and especially in cases where a good deal of post-operative oozing is likely to occur

11 **After-Treatment** —If no drainage-tube has been employed, and the dressing is not soaked through, it may be left untouched for seven or eight days, at the conclusion of which period it is removed, the stitches are taken out, and in all probability the wound will be completely healed When a drain has been inserted, it is usual to take it out at the end of twenty-four or forty-eight hours, there is no advantage in retaining it longer, since it is only required for the removal of the sero-sanguineous fluid which exudes immediately after the operation Should this early discharge be very abundant and soak through the dressings, there is no actual need to remove them and re-dress during the first twenty-four hours, if cyanide gauze has been employed, all that should be done is to damp the stained external bandages with 1 in 20 carbolic lotion, and then pack on some more gauze or wool, this may even, if necessary, be repeated a second time. Where merely sterile gauze has been used, it is essential to re-dress the wound completely

The **after-dressings** of the wound need to be conducted with the same precautions as to asepsis of hands, instruments, etc , as the original operation, and not a few instances of infection at the first dressing occur It is essential that everything likely to be required

should be prepared before the dressings are removed, so that exposure to the air may last as short a time as possible If the first dressing is undertaken after twenty-four or forty-eight hours, and all is going on satisfactorily, the drain is removed, and the wound re-dressed in exactly the same way as formerly, though probably much less gauze will be required If the case is left for eight days, the stitches can probably be taken out, and the skin incision will then be found united A small dressing of sterilized or cyanide gauze is applied, fitting closely to the scar, and sealed down with flexile collodion, which will not only prevent the gauze from slipping, but will also by its contraction serve to steady the parts This should be covered with wool and a bandage, so as to support the parts, and may be finally removed at the end of another week

An **open method** of treating certain operation wounds may sometimes be adopted with considerable advantage Absolute hæmostasis is the first essential, and the wound must be completely closed without drainage It is carefully dried and painted over with 2 per cent solution of iodine in spirit A sterilized towel may be placed around the part for the first twenty-four hours, but this may be discarded afterwards, and the wound is left uncovered, and merely painted daily with the iodine solution In the case of children some arrangement of the bedclothes must be devised to keep their fingers away from the part Hernia operations and similar wounds do excellently under this régime, especially in warm weather

CHAPTER XI

THE USE OF PHYSICAL AGENCIES IN SURGERY.

WITHIN recent years there has been so large a development in the application of various physical agencies in the realm of medicine and surgery that it is desirable to discuss their powers and application in one chapter, and we propose in this to treat of the use of massage, remedial exercises, heat, light, electricity, and radio-activity, etc

Position.—It must be remembered that the surgeon's work is not completed when the immediate lesion for which he is responsible is repaired, his duties also extend to the subsequent period of restoring functional activity to the parts involved Thus it is not enough merely to secure the union of a broken bone, it is the duty of the medical attendant to take such precautions as shall prevent, if possible, the limitation of movement in neighbouring joints, or to institute treatment for the removal of such stiffness, if it has unfortunately occurred The excision of a cancerous breast is a beneficent operation, but the surgeon is doing no kind turn to his patient if he allows her to recover with an arm which is so fixed to the side that it can only be raised with pain and difficulty, a little forethought can prevent many a painful disability

The prolonged fixation of a limb causes many changes which the surgeon must carefully study if harmful effects are not to be produced In the first place the blood-supply suffers, and this may result in defective nutrition, and diminished resistance to bacterial infection Muscles become stiff from want of use, and if the limb is the seat of hæmorrhagic extravasation due to traumatism or of septic inflammation, extensive fibroid infiltration may follow which it is difficult subsequently to remove Volkmann's ischæmic contracture is probably of this nature Joints are not seriously disabled by prolonged immobility unless intra-articular pressure due to weight-carrying or to muscular spasm is superadded, and then fibrosis of ligaments and thickening of the synovial membrane with the production of adhesions may result in limitation of movement, fixity in a bad position, or other troubles Still more likely is this to occur if peri-articular inflammatory troubles of bacterial origin are in existence, or if the patient is suffering from any marked degree of toxæmia Definite atrophy of bone also occurs when prolonged rest is maintained

It is essential, therefore, that if a limb is to be fixed in one position for any length of time, that position shall be selected which will lead to as little subsequent disability as possible and shall permit rapid restoration of function when once the necessity for fixation has come to an end It must be remembered as a cardinal principle that *it is*

lation in the parts thus struck is much quickened, and when skilfully done no pain should be caused

As a modification of the last proceeding, *Vibro-massage* has been recently introduced, in which rapidly repeated blows of the affected region give rise to a vibratory effect, which is often of the greatest value Hand vibrators are sold, and may be used with advantage, but the best results follow from the employment of vibrators worked by electricity Rheumatic inflammation of joints and fasciæ, such as occurs in lumbago, some forms of sciatica, and other neuralgic conditions, are often much benefited by this procedure

It is only possible to allude here to a few of the many conditions for which massage is beneficially used

1 When applied lightly, and only dealing with the superficial parts, it is soothing in its effects and may be employed for the relief of pain, all hyper-sensitive areas should be treated in this way to commence with, not only to ensure comfort, but also to gain the patient's confidence The lightest finger-tip massage (stroking) is most soothing, and its application to a patient's head and face late at night will sometimes assist in overcoming sleeplessness (as the writer can gratefully testify) It may also be employed to allay muscular spasm soon after a fracture

2 Deeper massage of all types is valuable in assisting in the absorption of inflammatory exudates and in increasing the amount of healthy blood in a part The driving out of the stagnant lymph and blood from the tissues prepares the way for a better supply of healthy blood, and thereby repair can be expedited It is obvious, however, that massage must be sparingly employed where infective material is present, and might be dislodged or driven into the general circulation by injudicious manipulation It is therefore more frequently employed in chronic affections, and only in the later stages of acute troubles

3 It is largely used and extremely beneficial for its purely mechanical effects in freeing adherent tissues and restoring to them their power of independent utility As a result of hæmorrhagic or inflammatory effusion, muscles get matted together, or fixed to bones, or perhaps all the tissues of a limb seem to be hopelessly welded into a solid mass, especially if it has been necessary to maintain prolonged rest after a septic injury, as in many gunshot wounds In such cases, as soon as possible consistent with safety, massage should be commenced so as to free the parts from their intimate union with each other, and make them once again independent entities Adhesions in tendon sheaths and joints may be largely influenced for good by suitable massage, but active movements under an anæsthetic to break these through are sometimes required

4 Massage is of great value in many cases simply by increasing the blood-supply to the part, and thereby encouraging repair Many a fracture which is slow in its progress and in which union is delayed may be hurried up by suitable massage, and sluggish wounds of all sorts may be stimulated thereby

5 Deep organs may be affected equally with the superficial, and in

many abdominal conditions massage may be beneficially employed Thus in chronic constipation massage along the course of the colon is often of more use than medicine, especially if combined with suitable exercises for employing the muscles of the abdominal wall

6 General massage of the limbs and trunk is often ordered so as to maintain the general health of the body during a period of enforced rest It thereby provides exercise without effort, and function without fatigue Perhaps it is of most value in cases of nerve prostration when sleep and over-feeding are required to build up the tone of the nervous as well as of the physical system Similarly local massage is employed to maintain the vitality and flexibility of parts that must be kept at rest for a long time, *e g* limbs with fractured bones or divided nerves

Remedial Exercises.—There are limits, however, to the usefulness of massage as a remedial agent, for the effective restoration of the functions of muscles and joints can only be brought about by movement There is but little doubt that in the past the medical profession has been unduly conservative and cautious in this direction, thereby playing into the hands of unqualified practitioners of the bone-setter type Remedial exercises are both passive and active in character, and some little discrimination must be employed in the selection of suitable exercises in particular cases

Passive Movements do not involve any great strain upon a part, and are to be employed at as early a date as possible They are usually undertaken by a trained rubber, but any intelligent nurse can do what is required All parts which do not require to be immobilized should be exercised in this way daily Thus in a closed fracture of the forearm it is quite possible to move each joint of the fingers daily, and even with care the elbow and wrist, pronation and supination must be delayed until the bones are united, but in two or three weeks it is possible that this movement may be commenced In a case of fractured clavicle passive movements of the elbow may be permitted from the first, and active movements of the fingers and wrist, but the shoulder and clavicular joints are kept at rest for about a fortnight, and then cautious movements are permitted In inflammatory troubles of the hand and foot one cannot emphasize too strongly the necessity for early passive movements of all parts other than the chief focus of trouble

When once stiffness of a joint has supervened, whether due to intra- or extra-articular causes (other than osseous ankylosis), it is often a matter of grave difficulty to restore mobility It may be necessary for the surgeon forcibly to break down adhesions under an anæsthetic as a preliminary to further treatment, and then after a short interval to institute suitable exercises

Active Exercises must replace passive movement as soon as possible so as to introduce the important element of will-power In muscle re-education the limitations of the weakened structures must be respected, however, and an impossible strain must not be placed upon them Thus in abducting the arm from the side the deltoid has not only to influence the humerus, but also to lift the weight of the arm—

often too great a task for a weakened muscle If the patient is placed lying on a couch so as to support the weight of the arm, the deltoid can often effect the angular displacement of the limb into a position of abduction when it would be impossible to lift it in the standing posture A similar suggestion applies to the knee, the quadriceps may be able to extend the leg if the weight be removed by lying on the outer side, whereas it is impossible at first to take the 'maximum load' by lifting the unsupported leg and foot All re-educational exercises must take such facts into consideration

Weakened muscles may at the same time be helped and toned up by massage, electrical stimulation (sinusoidal current), etc , but these are to be looked on merely as accessories

Machines have been much vaunted as valuable helps in regaining movements of joints, and rightly employed they may be useful Some machines provide passive movement alone, and merely replace a masseur by mechanism Others introduce the principle of the fly-wheel, the continuous revolution of which will maintain and increase the movements of the limb which is attached to it. In still others the patient uses sound muscles to lift a weight by a rope passing over a pulley, and on letting it fall a contracted muscle may be stretched

Active Exercises against Resistance are also much employed in order to tone up muscles which have lost power, and ligamentous or tendinous structures which have been damaged The efforts are made either against the trained muscles of a masseur, or against the increasing friction of a machine As the structure becomes stronger, the resistance is increased, so that finally the part may be safely exposed to the unlimited strains of normal life This method of treatment is particularly valuable in dealing with the knee-joint after an operation involving ligaments, the strain of weight-carrying, especially if the patient is tall, is very severe, and until a full course of exercises against resistance has been given, the patient should not be allowed to walk

There is an undoubted place for all these varieties of exercise, but they have their limitations, especially when a nervous defect is superadded to the muscular or articular lesion The patient's will must be brought into action, as well as his muscles rubbed or his limbs moved by machinery, and in this direction **Active Exercises in the Gymnasium** under suitable supervision are of more value than many machines It is impossible here to elaborate gymnastic methods, but a few general principles may be referred to

1 It is useless to expect a patient to exercise one damaged muscle by itself The associated action of a group of muscles, of which the damaged one is a member, should always be attempted, and the patient often uses the damaged part unconsciously when his interest is mainly concentrated on other things Thus in re-educating the supinators, which frequently become very weak, it is better to teach the patient how to swing an Indian club than to set him to the monotonous task of rotating handles against resistance The pendulum-like swing of the club is helpful, and the improvement of the general tone and vascularity of the whole arm is a most valuable asset.

2 Equally important is it to remember that bilateral movements are often more easily acquired than when only one limb is used, and effects are hereby often produced in a short time that previously seemed impracticable

3 Not unfrequently it is possible to secure movements of joints by suitable games, in which the patient does not realize all that he is doing For stiff arms and legs there is nothing much better than a game of skittles or bowling, if the patient is made to bowl the ball properly, most of the joints in the body are exercised

4 One must insist, in conclusion, on the immense influence mind has over matter The fact that some response is obtained to the efforts put forth is a great incentive to further effort, when a man's fingers have been kept stiff and rigid for a long time, it is a great thing when he realizes for the first time that he can impress and indent something with them A useful plaything for this type of patient is the handbag or abacot, a leather-covered air cushion shaped like an Indian club Constant handling of this contrivance gives the man's sensorium a feeling of satisfaction and confidence as his grip improves

Heat (Thermo-Therapy)

Apart from its value as a sterilizing agent, heat is of use in treatment on account of the active arterial hyperæmia it produces, whereby the part to which it is applied is bathed with fresh blood containing defensive agents, such as leucocytes, opsonins, antitoxins, and other antibodies, by means of which the activities of harmful bacteria and their toxins are neutralized Moreover, when applied to a part which is infiltrated and brawny, it assists in the restoration of a healthy circulation by softening and relaxing the tissues

Heat is employed in two chief forms, *viz* as moist or dry heat, and either may be utilized as a general or a local application

1 **Moist Heat** is utilized *locally* in the form of the fomentation or poultice (p 25), in order to assist an inflamed part to healthy repair It matters little as to the material employed when the skin is unbroken, so long as it retains the heat, and, with this object in view, a linseed poultice is often preferable to a fomentation When, however, there is an open wound, the fomentation or poultice must be aseptic at least, if not antiseptic, in character The *boric fomentation* is useful in these cases, consisting of boric acid lint wrung out of boiling water, or a *carbolized poultice* may be employed This latter consists of linseed-meal mixed with boiling carbolic lotion (1 in 60), and applied to the wound over a few layers of cyanide gauze

Generally, moist heat is employed in the form of a *hot bath*, and, apart from its cleansing purposes, this is most valuable in many conditions and for varying purposes, *e g* to act as a sedative in cases of slight shock and general bruising of the body after accidents, to assist in the painless removal of extensive dressings which might stick to raw surfaces, such as burns, especially in children, to dilute toxins and help in their removal from the body, as in extensive infected wounds

The *hot bath* is also used in various schemes of hydro-therapy in order to act upon many foci of chronic inflammatory trouble, *e g* in general muscular rheumatism and fibrositis the heat of the bath helps to relax and loosen the parts, and thereby to restore them to a healthy function Plain water may be utilized for this purpose, or hot mud or peat baths Massage of a portion of the body over which a stream of hot water, either in one large jet or from innumerable small ones, is passing constitutes the basis of the so-called *Aix or Vichy douche baths*, which are both pleasant and profitable methods of treatment for chronic inflammatory lesions of the fibrositis type Active chemical substances, such as alkaline carbonates, sulphur, etc , naturally present in the water, or artificially added to it, are readily absorbed through the skin, and influence the patient considerably, natural mineral waters are probably more active than those artificially prepared Alternating hot and cold baths are also of value in stimulating reparative changes

2 **Dry Heat** may also be made to serve as a therapeutic agent, generally or locally, but in most instances introduces a new element, *viz* diaphoresis as well as superficial hyperæmia It is especially valuable in chronic cases, and, of course, higher temperatures can be borne without discomfort than in the preceding variety

Generally, various methods of hot air or vapour baths are available *Turkish baths* consist in the exposure of the unclothed body to dry heat at varying temperatures (up to 250° F or more) for twenty or thirty minutes, by this means an abundant perspiration is induced, and thereby toxins are eliminated It is followed by massage, douching, and rest for an hour or so, during which an abundance of plain cold water should be drunk A *Russian bath* is very similar, but the air is full of the vapour of steam, and therefore cannot range so high, perspiration is induced more rapidly, and the bath is of shorter duration In both of these agents the object is to induce the rapid elimination of toxins and other poisons, and at the same time to assist in maintaining the free mobility and function of the various parts of the body by massage

In patients who are incapable of leaving their beds or homes, *e g* in cases of uræmia, or of very bad chronic rheumatism, hot-air baths may be given by covering the patient with a large cradle over which is placed a blanket or two, and under it, in such a way as not to endanger him, a lighted spirit-lamp or a suitable number of electric lights of sufficient power Occasionally, however, wet packs have to be relied on in such cases

Locally, there are many methods of applying dry heat to a part, of which the following are the chief

(1) *Hot-air baths*, such as the Sheffield-Tallerman apparatus, etc , consist essentially of a box or chamber with walls composed of felt or asbestos, and arranged so that the contained air can be heated to a required temperature by an oil or gas burner or by electricity The affected limb is introduced into the chamber through a window with a closely-fitting curtain, and carefully suspended to prevent the skin touching the hot walls

(2) *Radiant-heat baths* have electric incandescent lamps as their heating agents The therapeutic value of these baths depends not only on the hot air evolved, but also, and probably mainly, on certain light rays which have no heating power A bath consists of a cabinet containing a number of lamps, which may have various-coloured globes, so that, by absorbing rays corresponding to certain portions of the spectrum, the quality of the light may be varied They may be used for the whole body or for individual limbs

(3) In *Diathermy*, or thermo-penetration, a high-frequency current of extremely rapid oscillation (about a million a second) is employed, the oscillations being so rapid and more sustained, the current can be passed through the body without pain, unless from over-heating of the tissues The potential being high, the body offers resistance to its passage, and thus the temperature is raised along the track of the current, as when any other current passes through a resistance The action of this agent therefore differs from that of hot-air baths, etc , in that the *internal* temperature of the part is raised rather than the external air, and hence the therapeutic results are increased It is easy to localize the effects by the use of suitable terminals

Applications —Hot-air and radiant-heat baths are chiefly employed to promote the absorption of chronic inflammatory exudates, and for such conditions as chronic arthritis, adhesions, neuralgia, lumbago, and sciatica They are also used to aid elimination by determining diaphoresis in general toxic conditions, such as gout, Bright's disease, and obesity Diathermy is useful for chronic inflammation, osteo-arthritis, rheumatic and gouty fibrositis, as also in gonococcal lesions

Heat is of great value in preventing or counteracting shock The importance of keeping a patient warm during a lengthy operation has been emphasized more than once, and to this end operating rooms are now maintained at a high temperature (70° to 80° F) and the patient is carefully clothed To combat the shock which follows operations or serious injuries, such as bad burns, especially in children, when the patient's temperature often falls as low as 95° or 96° F , it is important to surround the body with air at a higher temperature, and this can be effected by covering him with a cradle over which a blanket is placed, merely leaving the head uncovered, and within which is placed an electric lamp of 50 or 100 candle-power, so that it cannot touch or be touched by the patient's limbs The result of this hot-air bath is often most valuable

Cauteries are employed in the application of heat to the tissues of such an intensity as to burn them Their uses in this direction are twofold

1 As a *counter-irritant*, with a view not only to affect indirectly the underlying process of disease, but often rather to assist in the diminution of pain Thus a painful joint or spine can be beneficially influenced by searing lightly the overlying skin Some resistant forms of neuritis can be improved by this means

2 More often cauterization is employed as a *hæmostatic* agent Small bleeding points in situations difficult to reach or to control may be effectively dealt with in this way, *e g* in the nose, or where small

he utmost caution must be exercised when using ether anæsthesia [t is much better to use gas and oxygen in these cases

It may be said that electro-surgery is now extensively used, not only in general surgery, but in gynæcology, in eye, ear, nose and throat conditions, and in dermatology

Light.

Light as a curative agent, apart from its thermal effects, is chiefly employed in the form of (1) the arc light, (2) Finsen and mercury vapour lamps, and (3) sun-baths

1 The light from an *arc lamp*, projected by means of suitable mirrors, can be employed as a general bath or locally to diseased tissues Whilst it contains a sufficiency of heat rays to necessitate caution when focussing it upon a part, its activity mainly depends on the presence of an abundance of *ultra-violet rays* similar to those in normal sunlight, and thus it is sometimes termed *artificial sunlight* [t may be employed for all conditions, local or general, for which direct heliotherapy is advised, *e g* tuberculous disease, lupus, rickets, and many types of malnutrition Pigmentation of the skin is produced in exactly the same way as from exposure to sunlight, and the precautions needed in heliotherapy must be adopted

2 The Finsen and mercury vapour lamps are methods of exposing small areas of disease to large doses of light containing an abundance of chemically active rays A *Finsen* lamp consists of a powerful arc, the rays of which are collected and focussed by quartz lenses on a small area of skin, which is cooled and rendered anæmic by a quartz compressor, through which a stream of cold water flows Compression aids the penetration of the rays by rendering the part bloodless, the blood having the power of absorbing the violet rays The *mercury vapour* lamp consists of a glass tube exhausted of air, and containing mercury and mercury vapour The passage of a suitable current through this produces a light rich in ultra-violet rays These lamps are chiefly used in the treatment of lupus

3 *Heliotherapy*, or exposure to the sun's rays, has already been referred to as having beneficial results in the treatment of tuberculous lesions, whether applied locally or to the whole body, and its effects and the precautions which need to be taken therewith have been indicated It must not be overlooked that an element of aerotherapy usually enters into the cure produced by this means, sunshine and fresh air join hand in hand to promote the physical welfare of mankind

Apart from tuberculosis, sunlight is of great value in cases of anæmia, rickets, and malnutrition, and also has a distinctly beneficial influence on the treatment of open wounds, which are stimulated to increased activity All that is needed is to protect the surface with a layer of sterilized gauze Sometimes the sunlight is so active as to cause considerable irritation, and it is unusual for a wound to be able to stand more than twenty to thirty minutes a day of this treatment

The fact that normal sunlight is a complex of varied coloured rays has not been forgotten, and the influence of the different elements of

the spectrum has been exploited It is probable that exposure of the body to different coloured lights has a definite effect, especially to individuals of a receptive temperament Green light appears to be soothing, red to be stimulating, and even irritative, and blue depressing Neurasthenic patients with irritable hearts and constitution may be soothed, stimulated, or depressed by exposure to varied lights, and a definite therapeutic result may be expected

Electricity.

Electricity, apart from its thermogenic power, has many important applications in the domains both of diagnosis and treatment

1 **As a Diagnostic Agent.**

(1) By means of the *faradic and galvanic currents*, the electrical response of muscles and nerves can be investigated and valuable information obtained as to the condition of the nervous and muscular systems

A muscle with a normal nerve-supply contracts under stimulation from both the faradic and galvanic currents in sufficient strength, the contraction being most readily obtained when the electrode is applied over a definite skin area, varying for every muscle, and called the 'motor point' With the galvanic current the contraction obtained when the current is closed is greater than that produced when the current is opened Again, the contraction elicited when the electrode applied to the muscle is attached to the kathode of the battery is greater than that resulting when the anodal electrode is used This fact is expressed in the formula —K C C >A C C.

In the muscular degeneration which follows nerve injuries, neuritis, anterior poliomyelitis, etc, these reactions are modified, and constitute the *reaction of degeneration* (R D) The response of the muscle and nerve to the faradic current quickly disappears, and with the galvanic current the anodal closure contraction becomes greater than the kathodal (A C C >K C C) A greater strength of current will be required than in the sound side of the body, and the response will be sluggish, and not brisk As long as the R D persists, however, the possibility of repair in the muscle remains, should the centres and conducting apparatus be restored This persistence of the R D may exist for years When once the R D is lost, all hope of repair is gone In spastic conditions the electrical irritability of muscles and nerves is often increased

It is most desirable that muscles and nerves should be treated on a standardized scale, inasmuch as the results naturally vary somewhat with the strength of the electrical stimulus To this end *condensers* have been introduced, whereby it is easy to regulate the strength of the current, and to state in simple and obvious terms the result of the test

(2) *Radiography*—When a current from the secondary circuit of an induction coil is passed between two suitable metal electrodes in a vacuum tube of a high degree of exhaustion (Crookes tube), a stream of rays, called 'kathodal' or 'β-rays,' which consists of negatively charged electrons, is generated from the kathode If the kathode is concave, and the rays are thereby made to converge to a focus on

a third electrode called the 'target,' or 'antikathode,' from their impact thereon results a production of rays of a very special character, known as the 'X-rays of Rontgen' X-rays have the power of penetrating most opaque bodies in varying degrees, and in general terms substances are opaque to X-rays in proportion to the atomic weights of their constituent elements X-rays also have the power of acting upon sensitive silver salts in the same way as light, so that if a structure, such as a limb, be interposed between the source of the rays and a sensitive photographic plate, the rays will readily penetrate the softer parts, but their passage will be hindered by the more resistant structures, such as bones, which will thereby throw a shadow on the plate Radiograms or skiagrams are the shadow-pictures produced in this manner The greater the vacuum in the tube, the greater will be the strength of current needed to traverse it, and the greater the penetrating power of the X-rays produced These are known as 'hard tubes' Soft tubes are those in which less strength of current is required to produce the rays, which have a less penetrating effect, and therefore are more useful in permitting a greater differentiation of shadow

Barium platino-cyanide and certain uranium salts are rendered fluorescent by the passage of X-rays, so that, if a screen covered with one of these substances is held distal to the limb or part to be examined, a shadow similar to a radiograph is produced and can be seen The *radiographic screen* is of great value in many conditions as a means of rapid diagnosis, and sometimes gives better results than the radiograph, especially when absolute immobility cannot be obtained Thus the movements of the heart, of the diaphragm, the pulsations of an aortic aneurism, etc , can be better examined by the screen than by taking a radiograph As an illustration of this may be mentioned a case where a silver probe had slipped down through a tracheotomy wound into a bronchus An attempt to photograph it failed completely, but on examination with the screen the probe was seen lying transversely in the left bronchus, moving up and down at each beat of the heart

Great care is necessary in the interpretation of radiographic pictures, as, the rays being divergent, some distortion of the resulting shadows occurs, according to the distance of the object from the source, and the exact angle at which the rays impinge upon it To avoid this deception, stereoscopic photographs, or views in two directions at right angles to one another, are necessary Moreover, the results vary much according to whether the radiograph is taken from before or behind Thus, if a shoulder is radiographed from behind, the details of the coracoid process and of the head of the humerus will be most clearly defined, whereas if the plate is posterior, and the picture is taken from the front, the acromion and spine of the scapula are more sharply represented In practice the outlines of bones are clearly seen, cartilage and callus are often transparent, muscles and tendons are sometimes visible if a very soft tube is employed Calculi vary according to their composition, oxalates being most opaque, and uric acid stones most transparent Gallstones are seldom impervious (12 per cent

visible) By the use of soft tubes the outlines of viscera, such as the liver and kidneys, may often be obtained

In the case of foreign bodies it is not sufficient merely to know that they are present in a particular locality Every operating surgeon knows the difficulty of finding them, and the most serious damage has often been inflicted in the soft parts by attempting their removal on insufficient data The *exact localization* of foreign bodies is now easily determined by many methods which it is impossible to describe here, but every expert radiographer can give the surgeon invaluable assistance in this direction, and no operation for the removal of a foreign body embedded deeply in muscular tissues, and hence impalpable, should be undertaken without this exact information being previously obtained Even more help is available from the use of the radiographic screen during the operation, by the use of which it is possible to see the foreign body during the manipulation necessary for its removal

In the localization of brain tumours, air may be injected into the lateral ventricles (ventriculography) (see Chapter XXVII)

It often suffices to take radiographs in two directions, *e g* antero-posterior and lateral, and by a careful comparison of these sufficiently satisfactory data are obtained to enable the surgeon to find the foreign body

For the employment of X-rays in fractures, see Chapter XX

2 As a **Therapeutic Agent** electricity is employed in many ways

(1) The *galvanic and faradic currents* are employed, both generally and locally, for their stimulating action Under the former heading one would include the use of the *electric bath*, in which a patient lies in water to which a small addition of salt is made, and through which a galvanic current is passed The effect of this is to increase the superficial circulation and produce cutaneous hyperæmia It is often useful in diffuse rheumatic and gouty fibrositis, as also in conditions in which the general muscular and nervous tone of the body has been lowered It is of considerable value in the treatment of conditions depending on arterial spasm, such as Raynaud's disease, as also to prevent chilblains in paralyzed limbs Care must be taken only to increase or decrease the strength of the current gradually, otherwise the patient may experience an unpleasant shock

Locally the galvanic and faradic currents find their chief employment in cases of muscular paralysis or wasting, both to prevent degeneration or atrophy, when nervous control has been lost, as by division of the motor nerve, and to build up healthy muscular substance after nerve-suture or when atrophy has occurred from disuse The *sinusoidal* current is perhaps the most useful to employ in the earlier stages, in this the current is continuous, but is made to vary in strength in a smooth and wave-like fashion without sudden interruptions Later, the *interrupted galvanic* current is more useful, and is often the only one to which response can be obtained, whether before operation or in the earlier stages of repair The current must be made and broken at regular intervals, a metronome introduced into the circuit being a useful contrivance Failing this, the patient may be instructed

to remove and replace one of the terminals at regular intervals, thereby stimulating his interest in his own case When once response is obtained to the faradic current after an operation for nerve-suture, this type of electricity should be substituted for the galvanic current as being more effective

(2) *Electrolysis* is used chiefly for the destruction of superfluous hairs, moles, etc , and the treatment of nævi, where excision is undesirable The passage of a current of sufficient strength between metallic poles actually inserted into the tissues sets up an electrolytic action, and coagulation of the blood or local destruction of hair follicles, etc , results

(3) *Static electricity* generated by a machine such as Wimshurst's or the *high-frequency current* is used in the treatment of neurasthenia, general or nervous debility, or neuralgia, but is of value rather as a general tonic than as having any specific effect

(4) *Ionic medication*, or cataphoresis, consists in the introduction of drugs directly into the tissues of the body by means of an electric current It is based on the principle that the passage of a current through a solution of a salt is accompanied by movement of the constituent ions The positively charged ions (kations), which include those of all metals, alkalies, and alkaloids, are attracted to the negative pole, while the negatively charged ions (anions), such as those of chlorine, iodine, the acids, and hydroxyl, are attracted to the positive pole If the human body is interposed in the current, instead of a solution of salt in a vessel, and lint pads, soaked in a solution of the salt or drug, are placed between the skin and the electrodes, kations at the positive pole and anions at the negative pole will enter the tissues and be disseminated in them for a variable distance, probably from 1 to 10 millimetres The pads should be thick and of large area, and the strength of current 2 to 3 milliamperes per square centimetre of area of the pads

Ionization is largely used in the treatment of chronic inflammation of joints and other tissues and in the softening of scars, but good results have also been obtained in sinuses, chronic ulcers, rodent ulcers, lupus, warts, etc

(5) The *diathermic current* has already been mentioned as employed as a means of heating the tissues (thermo-penetration, p 297) or as a cauterizing agent

Radio-Therapy and Radium.

Soon after the discovery of X-rays by Rontgen in 1895 it was found that they were capable of setting up severe dermatitis, often accompanied by ulceration, and also had a considerable depilatory power The question therefore arose whether they could not be employed therapeutically in certain skin diseases requiring either a stimulative or depilatory action, and in no long time sundry cases of lupus were found to benefit by treatment A large amount of experimental work quickly followed to determine the action on various tissues and organs

It is now well known that repeated exposures may lead not only to dermatitis and X-ray burns, but also under certain conditions to the development of actual neoplasms, blood changes of a serious type

also follow The genital cells are found to be remarkably susceptible to the action of the rays, the germinal cells of both testis and ovary being easily and permanently damaged, with the subsequent production of sterility Upon the lining cells of the intestinal mucosa X-rays also have a powerful destructive effect, with the production of severe enteritis From these facts it is evident that radio-therapy must invariably be carried out with due regard to the safety of both patient and operator

It may be mentioned here that X-rays have now been proved to be electro-magnetic vibrations, similar in character to the Hertzian waves, heat waves, the rays of visible light, and the ultra-violet rays, though of shorter wave length The respective wave lengths expressed in Ångstrom units* are

Visible light	7,200–4,000 A U	The shorter the wave length, the greater the penetrating power
Ultra-violet rays	4,000– 200 A U	
X-rays	500– 0 06 A U	

It was soon noticed that the parts chiefly affected by X-rays were the face and eyes and dorsum of the hands In the latter the effects were sharply delimited by the coat cuffs, showing that the clothing had in some way acted as a protective agent, although upon examination either by the fluorescent screen or by means of a photographic plate the clothing appeared to be quite transparent to the rays It is now known that the clothing acts by cutting off the rays of longest wave length, which at the same time are the least penetrating and the most active in producing changes in living tissues

The Pastille Dose —The fact that undue exposure to the rays produces serious results upon the skin has made it essential that some means of gauging the dose given should be available For this purpose the *Sabouraud pastille* is sufficiently accurate and is easy to use It consists of a paper disc coated on one side with barium platinocyanide This, in its normal condition, is of pale apple-green colour, but with exposure to X-rays it passes through a gradation of tints until it becomes brown The amount of exposure which just results in a definite erythema also produces a given brown tint in the pastille, and this is known as a pastille dose and is taken as the unit of dosage The exposed pastille is compared with a series of tinted pieces of glass in a tintometer, estimated to represent one-fourth, one-third, one-half, etc , of a pastille dose

It must be clearly understood that this method, though convenient, is not scientifically accurate, since the ' softer ' (less penetrating and with longer wave length) rays are more active in producing this colour than are the ' harder ' (more penetrating and with shorter wave length) rays Needless to say, the Sabouraud pastille is useless to estimate the dosage of the very penetrating X-rays used in deep therapy For practical purposes screens of aluminium are usually placed between the X-ray tube and the patient, so as to cut off more or less of the softer radiations, they vary in thickness from 0 5 up to 6 or 8 mm of aluminium

* The Ångström unit (A U) $= 10^{-8}$ cm $= \frac{1}{100000000}$ cm

One of the dangers in connection with X-ray therapy is that its effects upon the skin are not apparent at once, a certain latent period elapses between exposure and any obvious change, varying with the conditions and individual, but is generally from a week to fourteen days If, therefore, a skin surface is irradiated, and the dose repeated before the time has elapsed for the former dose to have produced a reaction, a cumulative effect will result A single exposure to an overdose may result in anything from a slight transient erythema to a deep, painful, and slowly healing ulcer Continued exposure of an area which has already been the seat of an X-ray burn may lead to the development of a definite carcinoma

Among the lesser evils which affect the patient more than the operator are the production of bronzing and the formation of telangiectases, but these are largely due to idiosyncrasy Some patients undergo repeated exposures, *e g* at the site of an old mammary carcinoma, or on the neck for Graves' disease, without any marked result of this type, others, on the contrary, rapidly acquire a deep brown pigmentation, or a network of telangiectases may form Whenever a slight erythema appears after irradiation, a soothing calamine lotion should be applied, and indeed in many places this is used as a routine preventive measure It must, however, be remembered that this lotion or any application containing metallic salts must be thoroughly removed before the part is again irradiated, owing to the production of what are known as secondary radiations, when a beam of X-rays impinges upon them These secondary rays are of longer wave length than the primary, and may therefore have a destructive effect upon the tissues

The methods of applying X-ray radiation therapeutically may be broadly grouped into two main divisions according to the kilowatt voltage **High Voltage Therapy** (400 to 200 kilowatts) is the type employed for deep therapy, and the best results by this method are seen in connection with the treatment of carcinoma of the breast, in conjunction with surgery, and of glandular neoplastic deposits when these are accessible, as in the neck A dosage of 6,000 'r' units is aimed for, but is not always given when large areas have to be treated, as in the case of the breast In such cases a reduced dose of between 4,000 and 5,000 'r' units would be employed **Low Voltage Therapy** (50 to 60 kilowatts) is useful for all types of superficial malignant disease, and therefore is most commonly employed in the treatment of cancer of the skin, mouth, and bladder, when a suprapubic opening in the latter is available The tube conveying the radiation must be almost touching the lesion, and the field should cover an area of between 3 and 5 cm In appropriate lesions this type of radiation is most effective It is sometimes referred to as the Ghaoul type of therapy, after the name of the worker who was the first to make use of it

Radium.

Radium salts were first isolated from pitch-blende by Madame Curie in 1898, but the radium element itself not until 1911 The radium salts commonly used are the sulphate, bromide, and chloride

The chloride and bromide are soluble in water, the sulphate is insoluble, and is the salt generally used for filling radium apparatus, as its insolubility is an obvious advantage in the event of any minute perforation occurring in the applicator

Radium itself is a metallic element belonging to the group of radio-active substances It undergoes spontaneous disintegration, and breaks up into a number of unstable atoms As each change takes place, energy is lost by the substance and appears as a characteristic type of radiation The activity of radium, and therefore its therapeutic effects, are due to a number of disintegration products

Radium transforms slowly compared with most radio-active bodies About half the atoms of an amount of radium are transformed in 1,700 years The first disintegration process leads to the production of radium emanation or radon, a heavy gas, used widely in therapy

The radiations liberated during the process of disintegration of radium are complex, but have been recognized as falling into three groups—α, β, and γ rays It is estimated that of the total energy emitted 90 per cent is attributed to the α rays, 9 per cent to the β rays, while the gamma rays are responsible for only 1 per cent

The α rays are composed of doubly charged helium atoms which are emitted with a velocity equal to one-twentieth part of the velocity of light Their penetrating power is, however, exceedingly small, since they are stopped by a screen such as a sheet of paper They are, therefore, of little therapeutic use, as they will be stopped by outermost layers of the tissues

The β particles are electrons or unit charges of negative electricity associated with a mass of $\frac{1}{1850}$ that of a hydrogen atom, and with a velocity almost as great as that of light Roughly speaking, they may be regarded as having a penetrating power about a hundred times as great as that of the α particles They are, however, screened off by relatively thin layers of various metals In soft tissues the β rays penetrate to a distance of 1 5 cm Consequently, in actual practice the beta rays are used only when dealing with lesions of the skin not greater than 1 5 cm in depth

For most surgical purposes, therefore, the β radiations are purposely cut off by metal screens of suitable thickness The thickness of different metals necessary to screen off 50 or 99 9 per cent respectively of β rays may be summarized as follows

Substance	*Thickness Necessary for Absorption of—*	
	50 *per Cent Radiations*	99 9 *per Cent Radiations*
Monel metal	0 15 mm	1 5 mm
Silver	0 13 mm	1 3 mm
Lead	0 12 mm	1 2 mm
Gold	0 07 mm	0 7 mm
Platinum	0 06 mm	0 6 mm

of radium element in solution, *i e* as one of its soluble salts, will give 150 millicuries of radon capable of utilization for therapeutic purposes in twenty-four hours

The Choice of Surgery or Radium as a Therapeutic Agent is still a matter which has not been settled satisfactorily At the present time the position is somewhat changed, and the question in the treatment of neoplasms is rather what combination of surgery and radium therapy is likely to be the most efficacious Two advantages may be fairly classified for radium surgery

(1) The limitation of extent of the operation

(2) Generally speaking, the introduction of radium is devoid of any operative mortality

The insertion of radium needles has now become a recognized piece of surgical technique, wherein the objects aimed at are, firstly, a uniform irradiation of the neoplasm itself, and, secondly, a uniform control of possible areas of lymphatic dissemination Remarkable results have been attained by this means, but it is a fatal error to regard radium as a panacea for disease in all its forms, and as ousting operative procedure as the method of choice in all cases

The actual results of radium treatment cannot be discussed *in extenso* in this book, but one or two facts and general principles may not be out of place

(*a*) **Superficial Lesions** —Many forms of superficial growths, both innocent and malignant, are effectively and satisfactorily treated by radium

Cavernous nævi are made to disappear by surface applications of radium, with the advantage over surgery that no scar remains and a good cosmetic result is obtained Keloids can be made to disappear by a similar treatment The surgical treatment of keloids is unsatisfactory, as they invariably recur after operation

• Rodent ulcers usually respond to radium treatment with one application It is, however, necessary to caution the patient—even when the lesion is apparently cured—to return for inspection If a rodent ulcer does not respond well to radium, it is generally desirable to resort to surgery, as continual irradiation of an intractable rodent ulcer may lead to the development of a typical squamous-cell carcinoma

Both radium and X-rays have been employed in the treatment of lupus, but the results obtained are inferior to those treated by means of ultra-violet light However, in those cases which do not respond to light treatment, good results may be obtained by a surface application of radium It is also true that a squamous-cell carcinoma has followed repeated applications of radium for lupus

(*b*) **Carcinoma of the Breast.**—The treatment of carcinoma of the breast by radium is now a recognized procedure Previously its use was confined to those cases which are inoperable, and large fungating growths were made to disappear Recently, operable cases have been treated, but as the method is still under trial, it is not yet regarded as a substitute for operation

The principle underlying the treatment of carcinoma of the breast is to cause the disappearance of all the malignant cells by delivering a lethal dose of radiation to—

(1) The whole of the affected breast,
(2) The axillary lymphatic glands,
(3) The supra- and infra-clavicular lymphatics, and
(4) The parasternal lymphatic glands

In order that the dose may be adequate, the field of irradiation in the breast substance and the associated lymphatic areas must be as homogeneous as possible This is best achieved by means of the insertion of radium needles The needles used contain 2 or 3 milligrammes of radium, and are inserted parallel to one another at intervals of 1 5 cm , deep to the growth and on the pectoral fascia Sometimes in a large breast an additional row of needles has to be inserted in a superficial plane Needles of suitable length are inserted into (1) the axilla, (2) beneath the pectoralis major, (3) the infraclavicular region, (4) into the supraclavicular area beneath the deep cervical fascia, and (5) obliquely into the first four intercostal spaces

The quantity used depends on the size of the breast, and in the case of a large breast as much as 100 mgm of radium may be used The needles are left in position for seven days The full effect of this treatment is not seen for six weeks A surface application of radium or a course of deep X-ray therapy is then given to the breast and lymphatic areas This irradiation aims at the sterilization of the cells which have not been affected by the needling, and to provide for the irradiation of the mediastinum and pleura

(*c*) **Carcinoma of the Buccal Cavity.**—In cases of mouth cancer, the treatment of the primary growth has been revolutionized during the last few years by the introduction of 'bomb' therapy In these cases the results obtained by surgery alone were very poor At the present time radium is undoubtedly the method of choice in treating most growths in the buccal cavity By its use the primary growth can be made to disappear permanently

The treatment of carcinoma of the mouth is conveniently divided into two stages The first is the treatment of the primary lesions, and the second includes treatment of the glandular areas of the neck The lesion in the mouth is treated first and the glandular areas are dealt with six weeks later

In treating the primary lesion, teleradium is the method of choice, but interstitial radiation in the form of radium needles or radon seeds may be employed when the former is not available For the anterior two-thirds of the tongue needles are customarily employed, because it is possible to obtain a more even distribution of the rays, but in the posterior third of the organ, the tonsil, or the pharynx, seeds are preferable, because they are easier to insert in positions which are not always readily accessible and because they tend to remain *in situ* better than the needles, when the latter are not tied in place (Figs 121 and 122)

The treatment of the regional glands may be considered under three headings, depending on the clinical stage of the disease

(*a*) When the glands are not palpable, surface irradiation alone is all that is needed

(*b*) When the glands are palpable but not fixed, the method of choice is a block dissection of the neck followed by surface irradiation

he artery, and may only be lighted up later by injudicious movements or violence

Symptoms—The patient usually complains of feeling a snap, as though something had given way, accompanied by a sudden pain, localized to the injured part and often shooting down the limb in the line of the vessel These are succeeded by the following phenomena (*a*) *Locally*, a diffuse rapidly increasing swelling forms, which may be well described as a *Pulsating Hæmatoma*, this is tense and firm to the touch, and as the amount of fibrin increases may feel distinctly hard It is not as a rule reducible, and indeed manipulation to determine this point is injudicious, as it may dislodge a portion of clot Distinct pulsation of an expansile type is usually present, and often a systolic bruit and some degree of thrill, but these may not develop if the cavity is very tense, or if much fibrin is present, or if the wounded artery is very deep The skin is stretched, but remains unchanged unless the swelling is approaching the surface (*b*) *Distally*, the signs depend on the amount of interference with the circulation and with surrounding structures, especially the nerves If the artery is torn completely across, the pulse in the vessels below ceases, and œdema may result from pressure of the blood-clot on the veins, if the artery is only partially divided, some amount of circulation distally may persist Pressure on the nerves at first causes numbness, tingling and neuralgic pain, but later on may determine loss of power or complete anæsthesia It must not be forgotten, however, that some of the nerves adjacent to the injured vessel may have been wounded simultaneously with the artery (*c*) *Generally*, the signs of hæmorrhage and shock manifest themselves in varying degree, according to the amount of blood lost and the character of the violence

Results—(1) The swelling may increase steadily in size until the skin becomes so distended as to *rupture* or slough, and then, if help is not at hand, the patient dies of hæmorrhage Occasionally the bleeding continues into an internal cavity, or into the tissues of a limb, to such an extent as to cause death without any external loss of blood (2) *Suppuration*, accompanied by the general signs of fever, may result from auto-infection, or from the entrance of bacteria through the small valve-like wound The whole swelling becomes red, hot, œdematous, and excessively tender, looking like a large abscess Rupture and external hæmorrhage will probably conclude the case if surgical assistance cannot be obtained (3) The pressure of the extravasated blood upon the veins or on the arteries needed for the collateral circulation may determine *gangrene* of the extremity, which is almost always of the moist type (4) The process may become more or less *limited* after a time by coagulation occurring in the divided mouth of the vessel, which is thus occluded Collateral circulation may be established, and thereby the health and vitality of the limb are maintained, whilst the blood-clot is absorbed or organized

Treatment—Whenever practicable, the part should be laid open, the clots turned out, and the injury to the arterial wall repaired To undertake this, temporary hæmostasis must be secured by the use of a tourniquet in a limb, or by digital compression, or by applying

a temporary ligature or a Crile's clamp to the trunk above In some cases, *e g* a torn artery in the buttock, none of these plans are feasible, and then it may only be possible to make an opening in the sac just large enough to introduce a finger, and with this the actual bleeding-point must be sought and controlled, and then the wound can be laid freely open and the vessel secured In some cases it will be necessary to release the tourniquet or clamp for a moment or two in order to find the upper end, but as a rule this is not a difficult task The lower end is often more difficult to find, though if it can be exposed at a lower level it may be possible to trace it up, if, however, this is unsuccessful, owing to the infiltrated condition of the parts, then the cavity, after being emptied of clot, is well packed with gauze, and a tourniquet kept on the limb for immediate use, if need be It is most important to ligate or deal with the actual wounded end of the vessel, proximal ligature may be quite ineffective, owing to the existence of a branch between the ligature and the wound

A **Penetrating Wound** of an artery, if completely dividing the vessel, is always followed by hæmorrhage, although the blood may be unable to escape externally If a large artery is cut cleanly across, the bleeding is copious, whilst from a small vessel it soon ceases, owing to the contraction and retraction of the coats

When an artery is 'button-holed,' *i e* when a small segment of the wall is cut through, the hæmorrhage is often continuous and prolonged, since retraction opens up the wound, and contraction is thereby hindered The treatment of this condition consists in completing the division of the injured trunk if it is a small one, but if it is of large size, it must be dealt with according to the rules given below for punctured arteries

A clean incised wound of an artery varies in its results somewhat according to its direction, thus if it is in the long axis of the vessel, it gapes but little, and the loss of blood may be but slight, whilst if transverse or oblique, both contraction and retraction tend to increase the size of the opening, rendering it more nearly circular, increasing thereby the hæmorrhage

A punctured wound of an artery varies in its results with the size and character of the penetrating body Thus a vessel may be traversed by a needle without hæmorrhage, or subsequent ill-effect, but a larger puncture, as by the blade of a knife or stiletto, results in extravasation If it ceases after a time, the blood-clot is absorbed and the wound in the vessel closed by a cicatrix, which may subsequently yield and give rise to a circumscribed aneurism This is not unfrequent in the neighbourhood of the wrist from glass wounds, involving the radial or ulnar trunks, and hence is usually seen in window-cleaners or mineral-water bottlers

Treatment.—So much progress has been made of recent years in connection with the surgery of arteries that it is now accurate to say that the ideal treatment of all penetrating lesions of arterial walls is the repair of the lesion and restoration of the lumen of the vessel, of course, this dictum applies only when the arterial tunics are healthy, when they are in a pathological condition repair is rarely possible,

vessels engaged in establishing collateral circulation may be compressed by the sac, and thus the vitality of the limb impaired Pressure on the accompanying vein or *veins* results in diminution of their calibre, and possibly a localized thrombosis, together with distal congestion and œdema Compression of *nerves* occasions neuralgia, spasm, or paralysis *Muscles* are displaced, expanded, and attenuated, *bones* may be eroded, as evidenced by a deep, constant, boring pain, and even spontaneous fracture may ensue, whilst *joints* are encroached upon and disorganized *Tubes*, such as the trachea or œsophagus, are often constricted and even laid open by ulceration It is interesting to note that resisting tissues, like bone, are much more liable to be eroded than elastic, yielding structures, such as cartilage, where the vertebral column is encroached upon by an aneurism, the bones are always destroyed more than the intervertebral discs

A certain amount of compensatory hypertrophy of the *heart* is often present Fibrinous masses are occasionally set free as *emboli*, and lead either to a spontaneous cure, or to gangrene of the parts supplied by the vessel, or to death if the brain is involved *Gangrene* may also result from the diminished blood-supply to peripheral parts, it is usually of the dry type, involving merely one or two fingers or toes, unless the veins are compressed, when it may be of the moist variety

The **Differential Diagnosis** of a circumscribed aneurism is usually not difficult, but the following conditions may simulate it somewhat closely 1 A *tumour* or *chronic abscess* situated near an artery, and deriving *transmitted pulsation* from it, is recognized by the impulse being merely heaving in character, and not expansile, by the pulsation ceasing entirely if the tumour is lifted from the vessel, or allowed to fall away from it by assuming a suitable position, by the size of the tumour not diminishing if the pulsation is stopped by pressure on the vessel above, and by the fact that after stoppage of the pulsation the first beat is equal to the subsequent ones, whereas in an aneurism it almost always requires more than one beat to re-establish the strength and force of the impulse Moreover, the pulse below is not affected in the same way or to the same extent as when an aneurism is present 2 An *artery* is sometimes *pushed forwards* by an underlying growth, and its pulsation in a more than usually superficial position may suggest an aneurism The distinguishing features are the limitation of the pulsation to the line of the vessel, and the absence of pulsation in the underlying growth 3 A *pulsating sarcoma* or *nævus* is known by being rarely limited exactly to the line of the artery, pulsation being present in situations where an aneurismal dilatation could not be felt, and being less forcible and regular in its character The consistency of the swelling is more variable, and pressure over the afferent trunk does not diminish its size to any marked extent Moreover, a sarcoma is usually more adherent to the deeper structures, and its limits are not so accurately defined 4 The pain caused by an aneurism may cause it to be mistaken for *rheumatism or neuralgia, e g* for sciatica in popliteal aneurism, and in every case of obstinate pain of this kind the arteries should be carefully examined

Natural Terminations and Results.—1 **Spontaneous Cure,** though very unusual, may occur in sacculated aneurisms (*a*) It may be due to the *gradual* deposit within the sac of fibrin, which, in the first place, limits the expansion and extension of the aneurism, but may finally increase to such an extent as to occupy the whole cavity and close up its mouth This condition can only obtain in saccules with small mouths, and in vessels of the second magnitude, hardly ever in the aorta or larger trunks, the impetus of the blood-stream being too great to permit of the necessary deposit of fibrin (*b*) It may arise as the result of the *sudden* coagulation of all the blood in the sac from the stoppage of the circulation, owing to the lodgment of an embolus either at the mouth of the aneurism or in the trunk immediately below (*c*) The aneurism may become so large as to compress the main vessel, either going to or coming from it, thus bringing about its own cure (*d*) Again, if the sac becomes inflamed, consolidation may occur with or without suppuration, although the latter process, as will be seen anon, is attended with serious danger to life and limb

The sac becomes more and more firm, the pulsation less forcible and distinct, the bruit diminishes, and finally consolidation is effected, a firm fibroid tumour alone remaining, which gradually shrinks, whilst the collateral circulation is opened up so as to supply the limb below It is sometimes by no means easy to recognize the fibroid mass which results from a *consolidated aneurism*, and in making a diagnosis the history has mainly to be depended on The existence of a tumour in the line of an artery, the probable occlusion of the main trunk, and the fact that the circulation is carried on by means of collateral branches, are the chief points which can be ascertained by a physical examination

2 **Diffusion and Rupture** result from yielding of the walls of an aneurism, as an outcome of some mechanical injury or from simple over-distension

When an **internal** aneurism gives way, the patient usually experiences a sensation of pain in the part, and becomes pale, cold, and faint, possibly dying within a few minutes or, at most, hours, or there may be a sudden gush of blood from the mouth if the trachea or œsophagus has been opened Sometimes internal aneurisms leak slowly, and the final stage lasts some days

When an **external** aneurism yields, it may do so slowly or quickly If the blood becomes effused *slowly* (a *leaking* aneurism), the tumour gradually increases in size, and its outline is less clearly limited, the pulsation diminishes in force and distinctness, and the signs of pressure upon the veins or nerves become more urgent, until gangrene sometimes supervenes If the sac yields *suddenly* (a *ruptured* aneurism), the patient experiences severe pain in the part, which becomes tense, swollen, and brawny, all pulsation ceases, both in the aneurism and below it, and gangrene of the limb follows, or even death from syncope, if the skin gives way Suppuration may also occur in these cases

3 **Suppuration** is an exceedingly serious, but by no means a usual, complication It may arise in the following ways (*a*) After ligature of the main vessel, especially when the wound becomes infected, and

there is a good deal of loose cellular tissue around the sac, as in the axilla, (*b*) after diffusion, partial or complete, of an aneurism, where there is great tension upon surrounding parts Auto-infection or the presence of an infective embolus may finally determine the suppurative process The tumour shows signs of inflammation, becoming hot, red, painful, and swollen, and the skin over it may pit on pressure, whilst fever and general constitutional disturbance are also present Sooner or later, if left to itself, the tumour points at one spot and bursts, giving exit to a mixture of blood-clot, pus, and a greater or less amount of bright red blood The patient either dies at once from syncope, or a little later from secondary hæmorrhage and toxæmia, unless efficient treatment is adopted

Treatment —I **General** treatment is employed as an accessory to surgical measures, or must be relied on entirely in cases where local means are impracticable, as in internal aneurisms

In *plethoric* individuals, where the disease often runs a rapid course, absolute rest, both mental and physical, must be enjoined, with the removal of all sources of irritation and worry The bowels should be kept gently open, and constipation and straining avoided The heart's impulse may be diminished by the use of drugs, or even by venesection when it is very forcible Iodide of potassium is usually prescribed, on account of the frequent association of aneurism with syphilis, and calcium lactate (grs v , t d s) may be useful in increasing the coagulability of the blood The diet must be suitably diminished, and only highly nutritious material allowed, and that mainly of the nitrogenous type, with as little fluid as possible (not more than about a pint a day)

In *weakly individuals*, whilst strictly enjoining a recumbent posture, the surgeon should prescribe iron and a somewhat more liberal diet, in order to improve the quality of the blood

II **Surgical Treatment.**—A The ideal plan consists in dealing with the arterial walls so as to obliterate the aneurism, but without occluding the original lumen of the vessel, according to the suggestion of Matas of New Orleans This is obviously only possible in selected cases of sacculated aneurism, but a number of satisfactory results have been reported The circulation is controlled temporarily, and the aneurism laid freely open, so that its interior can be emptied completely and carefully examined The orifices of the smaller collateral branches are secured by purse-string sutures, and the margins of the main opening are approximated by a row of Lembert's sutures, if need be, over a piece of rubber catheter, which is subsequently removed, the continuity of the original vessel being thus restored, the aneurismal walls are brought together by superimposed rows of Lembert's sutures It is probable that in many instances the artery becomes obliterated in spite of the surgeon's care

B **Complete Extirpation** of the aneurismal sac, as if it were a tumour, may be looked on as the best method of treatment in the majority of cases The limb is exsanguinated by elevation, and in suitable cases the aneurism is removed without opening it, and the vessel secured by ligature above and below, as also any branches which

may arise from it Sometimes, however, it is necessary to open it and turn out its contents before attempting its extirpation, which is often a matter of considerable difficulty owing to the adhesions present Not unfrequently the vein will be encroached on in this dissection, and it may have to be removed, bad results are not likely to follow, since the pressure of the sac has already probably established an efficient collateral venous circulation The results of this operation are most satisfactory, since the length of treatment is curtailed, and all chances of local recurrence are removed Gangrene also is uncommon, since only one set of collateral circulation is called upon, *viz* that required to bridge the gap made by removing the aneurism, whereas in the Hunterian operation a double set is needed, *viz* at the site of the ligature, and round the consolidated aneurism

C The **deposit within the sac of fibrin,** which shall subsequently organize and thus lead to the obliteration of both sac and supplying vessel, was the ideal aimed at by the earlier surgeons, and has still to be relied on in many cases It is obvious that a slow and gradual deposit of laminated fibrin is likely to be more satisfactory than the sudden distension of the sac with soft red clot

The various plans adopted with this end in view are as follows

1 **Compression** of the main vessels, usually on the proximal side of the aneurism, was much vaunted by the Dublin school of surgeons in the last century, and gave not a few good results It may be applied either continuously or at intervals

2 **Ligature** of the main vessels leading to or coming from the aneurismal sac must next be considered The oldest procedure, the **Operation of Antyllus,** consisted in laying open the sac, turning out the clots, securing the vessel above and below, and allowing the wound to heal by granulation (Fig 131, A) Performed, as it was originally, without antiseptics, it was naturally attended with great mortality from secondary hæmorrhage

In **Anel's Method** (Fig 131, B) the artery was tied just above the sac on the cardiac side, with no branch intervening, this also proved dangerous, since secondary hæmorrhage frequently resulted, either from suppuration within the sac, or from injury to the sac during the operation, or from yielding of the arterial wall at the site of ligature from septic periarteritis At the present time it is not unfrequently undertaken successfully

Hunter's Operation (Fig 131, C), which consists of ligature of the main vessel on the cardiac side at some distance from the aneurism, was first performed by him in 1785 The object is not to cut off absolutely the blood-supply to the sac, but to allow the blood to enter it with a greatly diminished impulse, and in small amount at first, thus permitting of the contraction of the sac wall and of the gradual deposit within it of fibrinous clot, which in time becomes organized into a mass of firm fibroid tissue It is desirable, though not essential, that no branch of large size should intervene between the point of ligature and the sac

Distal Ligature is only practised for aneurisms situated in positions where it is impracticable to deal with the artery on the cardiac side

just above the wrist, in the latter case by enlarging the original wound Various stereotyped operations are described, but are more often seen in the examination-room or dead-house than in the operating theatre It should be borne in mind that the artery curves inwards from the centre of the bend of the elbow to the radial side of the pisiform bone The lower two-thirds of its course is indicated by a line drawn from the internal condyle of the humerus to the same spot below

1 *At the Wrist*—An incision about 1 inch in length is made directly upwards from the flexure of the wrist in the line of the vessel (Fig 141) The deep fascia is opened, the tendon of the flexor carpi ulnaris drawn to the inner side, and the vessels are then seen, accompanied by the nerve which lies to the ulnar side of the artery

2 *In the Middle of the Forearm*—An incision is made along a line drawn from the anterior edge of the tip of the inner condyle to the radial side of the pisiform bone (Fig 141) The white line indicating the intermuscular septum between the flexor carpi ulnaris and flexor sublimis digitorum is then sought for and opened up, it is often very slightly marked, and may be difficult to distinguish If the correct interspace has been opened, the surgeon is directed towards the ulna, and readily finds the vessels under cover of the flexor carpi ulnaris, with the nerve lying a little way to the inner or ulnar side

3 The upper limit of the ulnar artery can be reached through an oblique incision along the upper border of the pronator teres, thus opening up the ante-cubital fossa, and exposing the bifurcation of the brachial

Radial Artery—The line of the vessel extends from the middle of the bend of the elbow to the interspace at the wrist between the flexor carpi radialis and the supinator longus It then turns outwards, and may be felt beating in the space between the tendons of the extensor primi and extensor secundi internodii muscles

1 *At the Back of the Wrist* the vessel may be secured by opening up the above-mentioned intertendinous hollow, where the artery is found coursing onwards to the base of the first interosseous space The incision is placed obliquely between the tendons, extending from the back of the styloid process of the radius to the base of the first metacarpal bone

2 *Above the Wrist* an incision is made in the line of the vessel (Fig 141), which is found after division of the fascia between the supinator longus and flexor carpi radialis

3 *In the Middle or Upper Third of the Forearm* an incision is made in the line of the vessel (Fig 141), and the inner border of the supinator longus sought for and retracted The vessels are found under cover of this structure, with the radial nerve to the outer side, though separated by an interval above

Ligature of the Abdominal Aorta has been undertaken in fourteen instances for severe primary or secondary hæmorrhage, or for diffuse inguinal or iliac aneurism, when no other method of treatment was practicable All these cases have proved fatal, in most instances from infection and secondary hæmorrhage

The **Common Iliac Artery** extends for a distance of 2 inches from

the bifurcation of the aorta opposite the left side of the body of the fourth lumbar vertebra to the front of the sacro-iliac synchondrosis It may be reached through an incision made in the median line with its centre a little below the umbilicus The vessel is sought for and exposed by an incision through the posterior layer of the parietal peritoneum, and a ligature passed and tied The ureter which crosses the artery just above its bifurcation must be carefully avoided

Collateral Circulation —Blood reaches the *external iliac* and its branches by means of the anastomosis of the lumbar arteries *with* the circumflex iliac, and of the superior epigastric, lumbars, and intercostals *with* the superficial and deep epigastric The *internal iliac* and its branches are supplied by the union of (*a*) the lumbar branches *with* the ilio-lumbar, (*b*) the middle sacral *with* the lateral sacral, (*c*) the retropubic anastomosis of the two obturator arteries, and (*d*) the communications of the pudic, hæmorrhoidal, and vesical trunks *with* those of the opposite side

Ligature of the Internal Iliac Artery is occasionally performed for hæmorrhage from, or aneurism of, one of its branches, the gluteal being that most commonly affected The trunk is a short one, at most 1½ inches in length, and is best reached by opening the abdomen in the middle line below the umbilicus (Fig 142), pushing aside the intestines, and searching for the bifurcation of the common iliac The posterior layer of the peritoneum is then carefully incised, the ureter avoided, and an armed aneurism needle passed without wounding the vein

The *Collateral Circulation* is the same as that given for the internal iliac division of the common iliac

The **External Iliac Artery** is easily accessible in any part of its course, which measures from 3½ to 4 inches in length, it has but few branches, and those situated low down Its position is indicated by the lower two-thirds of a line drawn from the bifurcation of the aorta to midway between the anterior superior spine and the symphysis pubis, *i e* to a point a little internal to the middle of Poupart's ligament

Many suggestions as to the best means of reaching the artery have been made, and both trans- and extra-peritoneal methods have been adopted It is so readily secured, however, by the latter that it seems unnecessary to open the peritoneum There are two chief forms of extraperitoneal operation

Astley Cooper's Operation —An incision is made parallel to the outer half of Poupart's ligament, commencing a little to the inner side of its centre, and ⅜ inch above it, and extending upwards and outwards to about 1 inch internal to the anterior superior spine (Fig 142) The external oblique aponeurosis is divided along this line, and the exposed lower margins of the internal oblique and transversalis muscles arching over the inguinal canal are drawn upwards by retractors The transversalis fascia and loose subperitoneal fat are now opened with forceps and director, and the vessel is felt pulsating immediately under the finger The epigastric and circumflex iliac arteries must not be damaged during this manipulation, since they are important factors in the collateral circulation The needle is passed from within

The **Peroneal Artery** can be reached through an incision along the posterior border of the centre of the fibula, the leg being laid on its inner side (Fig 144, C) The outer edge of the soleus is defined and drawn inwards, the lower fibres of attachment to the fibula being divided if necessary The flexor longus hallucis is thereby exposed, and incised in such a manner as to allow the surgeon to reach the postero-internal border of the fibula, the artery is then readily found lying in an osseo-aponeurotic canal

CHAPTER XIII

AFFECTIONS OF THE VEINS—ANGIOMATA

Venous Thrombosis.

By **Thrombosis** is meant intravascular coagulation in any part of the circulatory system Normally, the blood remains in a fluid condition, owing to some interaction between it and the vessel walls Any factor producing a disturbance of this normal equilibrium may determine thrombosis, and any part of the vascular tract may be affected by it, whether the heart, arteries, veins, or capillaries, but it is in the veins that it occurs most frequently

Causes —(1) *Changes in the vessel walls*, as a result of which the integrity of the endothelium is disturbed, *e g* injury (either division, rupture, puncture, compression, or contusion), inflammation or degeneration (as in varicose veins)

(2) *Changes in the constitution of the blood* whereby its coagulability is increased In clinical work this is brought about most frequently by infective conditions, which lead to an excess of toxins in the blood Hæmorrhage up to half of the whole amount in the body also increases its coagulability, but excess of leucocytes, as in leukæmia, has the opposite effect

(3) *Diminished rate of the blood-stream* predisposes to thrombosis if some other condition is present to determine it Lister showed years ago that blood can remain fluid for a long time if confined in a tube formed of a suitable length of healthy vein wall, but when either of the preceding factors is present, a retardation of the blood-stream materially assists in causing coagulation Thus, when a vein is pressed upon by a tumour, the obstruction to the blood-flow produces a clot at the spot where the nutrition of the wall is interfered with After fevers, such as typhoid, where the character of the blood is somewhat altered and the action of the heart weakened by changes in the myocardium, the defective *vis a tergo* causes a retardation of the flow in the veins, and coagulation is probably determined by some slight injury or pressure which is not noticed by the patient

The **Character** of the clot varies with its rate of formation. If developed slowly, the so-called white thrombus is met with, consisting merely of layers of fibrin, similar to that formed in an aneurism If the process is more rapid, a certain number of red corpuscles are entangled in the meshes of the clot, sudden coagulation produces the ordinary red thrombus, which at first is not adherent to the wall, but becomes so later on, especially at its base

The **Effects** of thrombosis may be considered under the following headings local, distal, and proximal

and irritation of a tumour or aneurism, (*b*) it may be gouty or rheumatic in nature, attacking the larger veins of the lower extremity, or vessels which have been long subject to varix (*c*) It may follow primary thrombosis, either in the main trunk or in a varicose peripheral vein, or (*d*) it may be induced by inflammation of the tissues around the vein (*periphlebitis*), usually of bacterial origin In the last case the bacteria gradually spread through the vein wall, and finally invade the clot

2 **Infective Phlebitis** is a much more serious condition, inasmuch as the thrombus resulting therefrom always contains micro-organisms, and the disease is often of the *spreading* type It arises (*a*) in traumatic cases where asepsis has not been maintained, the organisms invading the clot which lies in the open mouth of the vein, or (*b*) as a result of infective periphlebitis in wounds, or in infective inflammation of bones, such as when a suppurative mastoiditis leads to thrombosis of the lateral sinus, and (*c*) by auto-infection of the clot present in simple phlebitis, as, *e g* , in varicose veins

Morbid Anatomy —The walls of the vein are congested and thickened, and the endothelial lining is hypertrophied The thrombus, if aseptic, early becomes adherent to the vein wall and organized, or is absorbed, if infected, it becomes soft and pultaceous, resembling dirty-looking pus, a localized abscess may form, and the suppuration may extend for some distance along and around the vein

The **Symptoms** of inflammation of a **superficial** vein are sufficiently obvious The vessel becomes swollen, hard, and painful, with localized enlargements or knobs corresponding to the valves or to the pouches in varicose veins The skin over them is dusky and congested, and there may be some œdema of the region from which the blood flowing in the vein is gathered, this, however, rarely amounts to much, since the collateral circulation is always abundant The temperature is usually raised, and the patient feels ill If suppuration occurs, the signs of a localized abscess are noted, and perhaps pyæmic manifestations supervene

When the **deeper** veins are involved, it may be impossible to detect them on palpation, although a blocked common femoral can usually be felt, but acute deeply-seated pain over the vein and well-marked fever are characteristic evidences of what has occurred Œdema of a more or less solid character develops, although if the limb is maintained in the horizontal position throughout the attack this need not occur Obliteration of the vessel and any of the local, distal, or general processes detailed as characteristic of thrombosis (p 356) may result

The onset of an **infective periphlebitis** is marked by fever and perhaps rigors, whilst the local signs are due to rapid extension of a suppurative inflammation along the vein and its branches, so that a large tract of tissue is very quickly invaded, and diffuse suppuration follows The presence of pyæmia is indicated by a repetition of rigors, and the development of secondary abscesses

Treatment.—In the **simple** variety the limb is kept at rest to limit inflammation and prevent the detachment of emboli, and also elevated to assist venous return Locally, belladonna fomentations may be

applied, or the parts may be painted with glycerine and extract of belladonna, the limb is then lightly bandaged over a thick layer of cotton-wool The intravenous injection of 5 to 10 ounces of a 0 5 per cent solution of sodium citrate in normal salt solution appears to cause a rapid cessation of pain and tenderness, whilst it stays the spread of the trouble and hastens the disappearance of the œdema The injection is sometimes followed by a rigor, but that does not seem to do any harm The patient should be kept on an unstimulating though nutritious diet, and the general health attended to When every sign of inflammation has subsided, and sufficient time has been allowed for the absorption or organization of the clot (three weeks as an absolute minimum, six weeks for choice), massage may be commenced, to assist in the removal of œdema and local thickening, and an elastic bandage is usually serviceable in restoring the circulation

Infective phlebitis is treated in a similar fashion until suppuration occurs, and then the pus must be evacuated, and it is sometimes remarkable to note how quickly the process quiets down when once drainage is effected A **spreading periphlebitis** will often involve an extensive area, but the process must be followed up ruthlessly by the knife and the parts laid open The wounds thus made should be lightly packed and allowed to granulate, at the same time the limb is raised, and kept absolutely quiet Should pyæmic phenomena develop, it may be necessary to place a ligature between the disintegrating clot and the heart, and to scrape or wash away the infective material, thus, in thrombosis of the lateral sinus, following suppuration in the middle ear, the internal jugular vein should be ligatured, the lateral sinus opened, and the clot removed Of course, such treatment is only feasible in cases where a single trunk is affected When the process involves the veins of a limb, and cannot be stopped by either of these plans of treatment, the question of amputation may have to be raised

Varicose Veins, or Varix.

A vein is said to be in a condition of varix when it has become dilated, permanently lengthened, and more or less tortuous The superficial veins of the leg, especially the internal and external saphena, are those most commonly affected, the spermatic veins are often in a similar condition, constituting what is known as a varicocele, whilst piles are primarily due to varicosity of the hæmorrhoidal plexus We shall here only deal with the first of these three manifestations

Causes —Varix is possibly due to some inherited weakness of the venous wall, or irregularity in the arrangement of the valves, or peculiarity in the lower fascial border of the saphenous opening, though these may produce no ill-effect until some exciting cause comes into action The condition sometimes appears quite early in life, and often involves the same vein in different members of a family

The condition also results from persistent distension of a vein, as by wearing tight garters, or by the pressure of a pregnant or displaced uterus, or of a pelvic tumour, or from prolonged standing, which

of the forearm is selected and caused to become distended by the application of a bandage above, whilst the fist is alternately clenched and opened The needle is passed through the skin alongside the vein for a short distance and then driven through the wall, thus making an oblique puncture The bandage is at once released, and the injection then made Of course, care is taken to avoid the risk of injecting air No dressing need be applied to the minute puncture, but it may advisedly be dabbed over with tincture of iodine

Angiomata.

Tumours of blood-vessels present varying appearances according to the situation and the character of the vessels of which they are composed They are frequently of congenital origin or developed soon after birth They involve most commonly the skin or mucous membrane, together with the underlying tissues, and are then known as **nævi**, but they are occasionally acquired and develop in deeper organs, such as the liver According to their structure they are divided into three main groups the simple or capillary nævus, the cavernous nævus, and the plexiform angioma

1 The simple or **Capillary Nævus** (mother's mark) is exceedingly common, and consists of a mass of dilated capillaries held together by a small amount of connective tissue It is usually located in the skin, but may also involve the subcutaneous tissues, the tubular form of the constituent vessels always remains It occurs in the form of a slightly raised flattened mass, bright red or purple in colour, according to the relative amount of arterial or venous blood present, and with occasionally a somewhat irregular or nodulated surface, in which larger vessels may be seen ramifying Several such growths may be present in the same individual, and they are usually quite small, rarely exceeding an inch or two in diameter, they are present at birth or appear soon after The head and face are the parts most commonly affected Angiomata of the mucous membranes are often a source of considerable danger and trouble from hæmorrhage, especially in the bladder and nose

A more superficial variety known as the **port-wine stain** often extends widely over the face and neck, and is somewhat dusky in colour, this condition consists merely of a network of fine vessels, and does not project above the surface

Occasionally a nævoid development may be observed having a linear distribution down the long axis of a limb, or running transversely half round the trunk, and limited almost exactly by the middle line, this condition is known as *nævus unius lateris* It may consist purely of a vascular manifestation, or the skin may be hypertrophied and covered with small soft papillary excrescences

The term **Spider Nævus** (*N araneus*) is applied to a small angioma, which develops usually in young people, and generally on the face, from which radiate a considerable series of fine red lines When irritated they bleed easily, but are readily cured by the application of carbonic acid snow or a pointed cautery

It is not uncommon in middle-aged people to find a number of small red spots on the trunk, which sometimes persist for a while and then disappear These **telangiectases** (or *De Morgan spots*) consist of dilated capillaries, and are possibly degenerative in origin

Left to themselves, simple nævi may remain unchanged, or disappear, more often they increase in size more or less rapidly, and may invade surrounding tissues, requiring active treatment in order to check their progress Sometimes they persist unaltered till middle life, and then may increase rapidly, giving rise to a considerable vascular tumour, purple in colour, and occasionally becoming prominent and pendulous Such a tumour is soft and easily compressible, being in reality a cavernous angioma, it may ulcerate, and profuse hæmorrhage may result

Treatment is usually simple in the extreme Small superficial nævi can be completely cured by some form of cauterization, the best results being obtained by the use of carbonic acid snow Appliances for the supply and employment of this agent are obtainable from instrument makers In exposed situations electrolysis may be the best plan to adopt, but excision will often give a good result Radium may be used in some cases

2 A **Cavernous Nævus** (Fig 153) most commonly involves the subcutaneous or submucous tissues, but is sometimes associated with a superficial nævus It consists of dilated spaces where the tubular form of the constituent vessels is lost, the arteries often opening directly into thin-walled cavities lined with endothelium without the intervention of capillaries The tumour thus produced is a more or less prominent swelling, soft to the touch, and easily compressible, but refilling when the pressure is removed There is usually no pulsation or bruit, although both may be present, and the mass may be definitely circumscribed, or more or less diffuse If subcutaneous, the skin over it is somewhat bluish in colour, when the skin is involved, the mass presents a dusky red appearance Occasionally these growths undergo spontaneous cure from inflammation and thrombosis, and cysts are sometimes found in the centre of a nævoid mass, indicating that a partial attempt at this process has occurred A similar condition arises in the viscera, especially the liver, and it is not difficult in certain suitable cases to demonstrate that it has been formed by a dilation of the capillaries between the lobules, the liver substance meanwhile disappearing by a process of simple atrophy

The **Treatment** is by no means as simple as in the former variety The following plans may be mentioned

(1) Excision of the growth should always be adopted where practicable The bleeding is never great, even if the nævoid tissue is encroached upon by the knife, and only a few vessels will need to be tied Circular growths should be removed by crescentic incisions, and a little undercutting will usually enable the edges to be approximated

(2) Where excision is impossible, **diathermy cautery** should be employed It consists in the passage of an electric current through the mass producing chemical and physical changes in the contained blood

soften and fluctuate These phenomena are associated with fever and malaise, the temperature rising to 102° or 103°, possibly attended by rigors, vomiting, and diarrhœa

Under suitable treatment resolution rapidly follows, but suppuration may occur either in the glands or in some loose mass of cellular tissue traversed by the lymphatic trunks, or as a chain of abscesses in the course of the vessels Occasionally the lymphatic vessels become permanently occluded, and a form of solid or lymphatic œdema results Recurrent attacks of this type are not uncommon in connection with chronic eczema or ulcers of the leg, and may lead to elephantiasis In the worst cases the patient dies from general septicæmia, or from exhaustion following diffuse suppuration

Treatment is at first directed to the causative focus, which must be cleansed and fomented so as to cut off the supply of bacteria and toxins to the lymphatics The limb itself is kept at rest in a slightly elevated position, and fomented or soaked in a hot bath, Bier's treatment of induced hyperæmia is sometimes useful Abscesses are opened as soon as they develop Any subsequent œdema is remedied by massage and firm bandaging, provided no venous complications are present

Chronic Lymphangitis either results as a sequela of an acute attack, or is met with as a separate condition It is most frequently seen in connection with venereal disease, the dorsal lymphatics of the penis ' enlarged, hard, and cord-like, especially in cases of primary syphilis This is usually accompanied by a solid œdematous condition of the prepuce and enlargement of the inguinal glands Under appropriate antisyphilitic treatment, the swelling quickly subsides

A *tuberculous* type of chronic lymphangitis also exists in which a primary focus, say on a finger, is associated with secondary deposits along the lymphatics up the arm Each nodule is at first of firm consistency, but gradually softens and breaks down Naturally, such a case is liable to be followed by general dissemination The *treatment* consists in the excision, if possible, of each focus

The cheeks and nose are occasionally the seat of a chronic relapsing lymphangitis, due to the absorption of septic material from sores within the nostril It is characterized by patches of hyperæmia and some amount of tissue infiltration, and for its cure the causative lesions must be treated The thick lips of a tuberculous child are of a similar nature, and due to the constant irritation of cracks along the lip margin

Lymphatics, like blood-vessels, are liable to distension and dilatation, which may be either congenital or acquired, and are known as **Lymphangioma** or **Lymphangiectasis** It is impossible to draw an absolute line of distinction between the two conditions, but the latter term is applied mainly to cases where normal lymphatics are dilated and their continuity with the normal lymphatic circulation persists, whilst a lymphangioma is the result of a new formation Not unfrequently the two conditions develop side by side

Lymphangiomas are growths composed of newly-formed lym-

phatics, together with a variable amount of connective tissue, which is sometimes of a fatty nature They may be congenital or acquired, but even in the latter case there is probably an underlying congenital element, which was only awaiting some irritation or localized injury to determine its development Two varieties may be described, the capillary and cavernous

(*a*) The **Capillary Lymphangioma** is usually congenital in origin, but often increases considerably as the child grows, and may attain large proportions When developing in the skin, it may be termed a **lymphatic nævus,** and in origin and development it well merits the title The patch is usually of a dull yellowish-brown colour, but this varies with the amount of blood present, it may be smooth-topped like a wheal, or wart-like in appearance, but on examination with a lens each projecting point contains a vesicle This type of growth is sometimes very extensive, and may be associated with tumours of the underlying connective tissues Thus, a large fatty mass was removed from the anterior thoracic wall of a child, the greater portion of the projecting surface of which was covered with a capillary lymphangioma The only *treatment* for this condition is excision or cauterization

In the subcutaneous tissues the capillary variety is often associated with large cysts of the cavernous type It constitutes a soft swelling which when cut into has a spongy texture and exudes a large amount of lymph, with some blood This form is rarely well defined, and may burrow widely, invading and infiltrating the tissues, and, indeed, in some cases may almost be looked on as of a malignant nature Free excision is the only cure

(*b*) **Cavernous Lymphangioma** —The lymphatics here lose their tubular condition and give rise to cyst-like swellings which vary much in size

In the skin they are rarely larger than a split pea, and may co-exist with the capillary variety Any part of the body may be affected, and the lesion manifests itself as a series of small vesicles, which persist and are unaccompanied by any inflammatory redness, thus serving to distinguish it from herpes They contain lymph, and, if opened, a considerable flow of this fluid (lymphorrhœa) may result, lasting for some time They have been observed most frequently on the inner side of the thigh and on the prepuce **Treatment** consists in excision, or in laying them open and cauterizing the base

In the deeper structures large multilocular cystic swellings may be produced, these are most frequently seen in the neck, and the condition is often termed a **Cystic Hygroma** (Fig 154) Removal by dissection is often very difficult, especially in old-standing neglected cases, the limitations of the mass are sometimes very indefinite, and it may be necessary to leave the wound open and pack it, so as to ensure healing by granulation Radium may be used

Lymphangiectases are more frequently acquired than congenital, but the latter condition occurs, and is then probably due to some abnormal development of the lymphatics or to ante-natal inflammatory mischief

involved, amputation may be desirable When the scrotum is affected, the morbid tissue can be freely dissected away, sufficient skin being left to cover in the wound if possible, the penis and testes must first be isolated, and then the scrotum amputated, a tourniquet being used to restrain the bleeding

Affections of Lymphatic Glands.

Acute Lymphadenitis, or Inflammation of Lymphatic Glands.—The **Cause** of this condition is almost always the absorption of some irritative material (toxic or infective) from the periphery There is always an increased flow of lymph from an inflamed part, resulting in an enlargement of the glands to which the lymph is carried, which quickly subsides when the inflammatory process is at an end In infective conditions the enlargement is more obvious and painful, and suppuration frequently results, in fact, the lymphatic glands must be looked on as the filters by means of which many sources of disease are eliminated It is curious that certain peripheral infective conditions are not at all liable to produce lymphadenitis, *e g* spreading gangrene and many forms of cellulitis, possibly the acuteness of the process causes lymphatic thrombosis, and thus hinders absorption A certain amount of periadenitis is always present, even in the early stages, it may be of little importance, or be so severe and extensive as to constitute a diffuse suppurative cellulitis

Clinical History —The glandular trouble may be associated with a typical lymphangitis, or be independent of it, and the causative lesion may have almost disappeared before the glands become affected The glands become enlarged and tender, and if superficial, the skin over them is red and œdematous, and the surrounding tissues are infiltrated and brawny When pus forms, softening occurs in the centre of the mass, and fluctuation may become evident, where there is much loose areolar tissue around the glands, as in the axilla, the pus may burrow widely Fever, malaise, and all the general phenomena associated with an acute inflammation, are usually well marked

Treatment.—The offending wound or causative lesion must be dealt with by such measures as may be needed to hasten its restoration to a healthy state Fomentations or poultices are applied over the gland, and the patient, after the administration of a purge, may be given quinine and iron, if necessary As soon as pus has formed, it should be let out by an incision, and the wound dressed antiseptically

The **Axillary Glands** are usually affected as a result of poisoned wounds of the hand or fingers, although other glands exist lower down in the arm, *viz* the supracondyloid, just above the internal condyle Boils in the axilla and excoriations or infected wounds of the breast may also cause an axillary abscess In this region a suppurative periadenitis is often superadded, extending widely under and between the pectoral muscles, reaching even up to the clavicle Care must be taken in opening such an abscess to avoid the main vessels by cutting from above downwards, midway between the anterior and

posterior axillary folds, whilst Hilton's method should be adopted in all cases where the pus is situated deeply

In the **Groin** there are three groups of glands (1) The oblique set, running parallel to Poupart's ligament, and becoming inflamed in affections of the penis, scrotum, perineum, anus, buttock, and lower part of the abdomen, (2) a superficial vertical set, running with the long saphena vein, and receiving lymph from all the superficial parts of the limb, except perhaps those from which the blood is returned by the external saphena vein, the popliteal glands receiving the lymph from this region, and (3) the deep vertical set, receiving the deep lymphatics of the limb Abscess in the groin is opened by a vertical incision, so as to allow the wound to gape when the patient sits, and prevent pocketing of matter

Suppuration in the glands of the **Neck** is exceedingly common, arising most often from affections of the scalp (eczema or pediculosis), ear (otorrhœa or eczema), throat, or lips As to the exact distribution of the lymphatics, we must refer students to anatomical textbooks When opening a cervical abscess, care must be taken to avoid important structures, such as the external jugular vein, and to make incisions across the fibres of the platysma in order to gain space for efficient drainage

Chronic Lymphadenitis.—Three chief varieties of chronic inflammation of lymphatic glands are met with, *viz* the simple, syphilitic, and tuberculous

1 **Chronic Simple Lymphadenitis** is a condition resulting from some peripheral irritation, which is insufficient to cause an acute attack Occasionally it is due to blows or to strains, as in over-walking, being then the outcome of obstruction to the lymphatic flow from compression or rupture of the efferent vessels The glands become enlarged, tender, and painful, but as a rule they are not adherent to one another or to adjacent structures, and show but little tendency to suppurate This condition often precedes, and, indeed, may be looked on as a predisposing cause of, tuberculous lymphadenitis The **Treatment** consists in keeping the part at rest, and removing, if possible, all sources of local irritation The general health should also be attended to, especially in children predisposed to the development of tuberculous disease

2 **Chronic Syphilitic Lymphadenitis.**—The lymphatic glands are involved in several ways in the course of syphilitic disease (*a*) The primary lesion is associated with the development of an indolent bubo in the nearest lymphatic glands (p 151) (*b*) In the second stage, when general infection has occurred, the glands in many parts of the body are infected in the same indolent fashion (p 153) (*c*) In the tertiary period the lymphatic glands may undergo a true gummatous change, or become enlarged and tender owing to the absorption of infective material from a broken-down gumma

3 **Chronic Tuberculous Lymphadenitis** occurs most commonly in children or young adults, and especially in those whose surroundings are unhealthy, and whose general condition is deteriorated by insufficient or bad food and want of fresh air Some local focus of

CHAPTER XV

AFFECTIONS OF NERVES

Contusions and **Strains** cause a sensation of tingling, or of pins and needles, which usually wears off in the course of a few hours In severe cases variable degrees of loss of power and sensation may ensue, associated with more or less neuralgia, and in patients suffering from gout, syphilis, or rheumatism chronic peripheral neuritis develops, often of a somewhat intractable type **Treatment** consists in friction, with stimulating liniments in the slighter cases

Concussion of a nerve is characterized by the more or less complete loss of its function without any apparent lesion It has been frequently observed as the immediate result of the passage of a bullet or fragment of shell close to a nerve There is no shooting pain associated with the injury, and the anæsthesia does not correspond with any definite peripheral nerve distribution, but is limited to the area over which the loss of power is confined The muscles rarely waste, and faradic excitability persists Apart from infection, repair shows itself within two or three weeks, and is usually completed within three or four months If, however, the wound becomes infected, the condition may be followed by compression due to cicatricial contraction It is probable that the loss of conductivity is due to molecular disintegration of the axis cylinders or to minute hæmorrhages

Massage and electricity are desirable elements in the treatment, but in the later stages much can be done by suggestion and persuasion

Compression of a nerve may arise from many different causes, and the clinical picture varies somewhat according to the history and the particular nerve involved (1) It may be due to *direct traumatism*, *e g* the pressure of a crutch in the axilla, the musculo-spiral nerve being generally affected, the presence of a cervical rib may cause pressure on the lower brachial nerves (p 411), undue prominence of the ulnar nerve behind the elbow, perhaps due to cubitus valgus, exposes it frequently to injury, or a superficial nerve may be compressed between the splint and an underlying bone, as where the external popliteal nerve passes over the neck of the fibula (2) It may be caused by the *contraction* of cicatricial tissues in an infected wound, or by the development of *callus* in a fracture, *e g* the musculospiral in fractures of the shaft of the humerus, whether open or closed Some immediate loss of function may result either from concussion or partial laceration, or from a combination of these factors Improvement of the symptoms may for a short time accompany healing of the wound, but subsequently the nerve is constricted by contraction of the scar tissue (3) *Tumours and aneurisms* frequently produce nerve compression

In the majority of cases the symptoms are more or less similar Irritative phenomena appear early, and are manifested by cramp or spasm of muscles, associated with neuralgic pain, later, there is loss of function of the muscles supplied by the damaged nerve, together with anæsthesia, corresponding to its peripheral distribution As a rule, the paralysis is incomplete, the nerve not being divided, and wasting is not generaly a prominent feature The loss of protopathic sensation (pain on pin-prick) is greater than that of the epicritic sense (touch with camel-hair brush), which is contrary to that usually seen in division of a nerve (Stopford) Some degree of recovery may be looked for after removing the cause of the compression, and the progress will depend upon the amount of permanent structural change which the nerve has sustained In many cases operative measures (*neurolysis*) are indicated, and care must be taken to prevent the recurrence of the development of scar tissue Implanting the nerve within a healthy muscle belly or wrapping it round with an autogenous pad of fat is probably the most satisfactory method of securing this end In some cases the cause can be effectively dealt with, as by removal of a cervical rib, or by transplanting the ulnar nerve from the back to the front of the internal condyle

The nerve is sometimes merely *adherent* to a scar, in which case the main symptom is pain brought about by movements which drag on the nerve The prognosis of these cases is fairly good, providing the nerve can be freed and protected from further pressure by a fatty pad Ionization of the scar or its treatment by radium emanations may be tried as a preliminary measure

Rupture of nerves without an external wound only occurs in connection with severe injuries such as dislocations or fractures, and even then total division is rare, the sheath retaining its integrity, although the axis cylinders may have given way Immediate paralysis and loss of sensation usually follow, and may persist for a time, although repair not unfrequently occurs, since the sheath remains intact The doubt always existing as to the condition of the sheath regulates the **Treatment** which must be followed, *viz* one of expectancy Massage and electricity should be applied to the affected muscles, which are placed in a position permitting their complete relaxation so as to prevent them from stretching, only when a sufficient trial has been given to these should operation be undertaken Secondary nerve suture under these circumstances is not a very successful proceeding

Total Division of a Nerve may result from any type of penetrating wound, *e g* stabs, or from the missiles used in war In civilian practice wounds produced by ragged fragments of glass are often associated with nerve injuries At the moment of infliction of the wound the patient usually experiences a sharp shooting neuralgic pain, which he describes as similar to an electric shock, shooting up or down the limb

The **Immediate** effects are (*a*) Paralysis of the muscles supplied by the nerve, (*b*) complete anæsthesia of the parts supplied by it, which, however, is not necessarily permanent, since sensation may be conveyed by collateral trunks, the anæsthetic area passing through

The mere exposure of an undivided nerve in a suppurating wound is similarly liable to be followed by fibrosis

Regeneration of a divided nerve must necessarily precede restoration of function Attempts at regeneration are always evident in the distal segment, whether or not it has been sutured to the upper end, but in the latter case the phenomena are never carried to perfection, owing to the intervention of the end-bulb When this has been removed and effective end-to-end suture established, the axis cylinders of the proximal segment grow downwards and force their way along the sheath of the nerve, in which active preparations have been taking place, and from which the restoration of the varied elements of the sheath is determined In any case, the process is slow and takes many months to reach completion It is possible that under favourable circumstances an interval of half an inch or even more may be bridged by this process, but it is unusual A nerve-graft may serve to direct the energies of the neuroblastic cells, but is probably quite passive Clinically, the earliest evidence of regeneration is a slight return of sensation, which is at first protopathic, and only slowly becomes of an epicritic type Motion is generally much later in its restoration than sensation, and may never be entirely recovered

Treatment —It is of the utmost importance that every divided nerve of sufficient size, especially if containing motor fibres, should be at once dealt with, if possible, by **Primary Nerve Suture** This is best accomplished by using a domestic sewing needle without cutting edges, or a fine Hagedorn needle, and the finest catgut or silk, the nerve-ends should be brought into apposition without tension or torsion, and secured by sutures passing merely through the sheath Steadying stitches through the nerve are undesirable if they can be avoided Absolute asepsis is essential in order to obtain satisfactory results It is most desirable that the nerve should be protected from the pressure of adhesions by burying it in a bed of healthy muscle, or by wrapping around it a thin pad of fat or fascia In wounds involving the nerves about the wrist the deep fascia should also be carefully sutured to prevent the formation of adhesions between the nerves and tendons to the skin, whereby subsequent mobility would be impaired

It is often impossible to undertake nerve suture as a primary procedure, and operation for **Secondary Nerve Suture** at a later date is frequently found to be necessary (1) It is as a rule useless to attempt suture in an infected wound, and inasmuch as organisms remain in a latent state in the scar tissue of such a lesion operation must be delayed for some months after healing has occurred (2) In not a few cases it is difficult at first to make certain that a nerve has been actually divided, and that the loss of power, etc , is not due to concussion or partial laceration from which spontaneous recovery may be expected Here again operation may be justifiably delayed

Pre-operative treatment during the period of waiting is most important (1) *Postural* —The limb is placed on a splint or in a contrivance that will relax the paralyzed muscles and prevent them from becoming over-stretched Thus, in a musculo-spiral lesion the hand must be kept in a position of hyper-extension at the wrist-joint, in

order to prevent wrist-drop If the sciatic or external popliteal nerve is paralyzed, 'foot-drop' occurs, and a gaiter must be worn to prevent this by the use of springs or elastic tractors (2) During this time the joints of the limb—fingers, toes, wrist, ankle, etc—must be kept supple by daily *manipulation and movement* so as to prevent stiffness The application of a splint for a long time without this precaution may result in extensive adhesions in joints and tendon sheaths, which will increase the trouble already present (3) The tone of the paralyzed muscles must be maintained by *massage* and regular *electric treatment* The galvanic current should be employed in the form of an electric bath, or the sinusoidal current may be used The limb must also be kept warm by suitable coverings, as its circulation and nutrition are defective, and the limb must always be well warmed before either massage or electricity is applied

The **operation,** though easy to describe, is one often performed with difficulty owing to the density of the scar tissue in which the ends of the nerve are buried It is essential, therefore, to make extensive incisions in order to expose the nerve-trunk both above and below the lesion, the scar tissue is divided cleanly, and if possible removed, until the bulbous end above and the atrophied end below are freed The bulb and fibrous junction are removed sufficiently to expose healthy nerve-fibres both above and below, it is desirable to test the lower end of the severed nerve by a weak faradic current The ends are then stitched together as accurately as possible so as to appose similar portions of the nerve sections

Some practical points may be noted which, if adopted, will enhance the success of the operation (1) The nerve must be very gently handled, broad gauze strips passed under the nerve are more satisfactory than metal retractors (2) The nerve must not be allowed to become chilled, but should be wrapped in gauze soaked in warm salt solution (3) The question of *bridging an extensive gap* between the nerve-ends is one that is often difficult to settle (*a*) There is a certain amount of extensibility of a nerve-trunk if it is completely freed for a considerable distance up and down (*b*) Position of the limb is of great assistance, *e g* flexion of the wrist, elbow, and knee, but it must be remembered that when dealing with the ulnar nerve above the elbow, flexion of the joint increases the tension, it is wiser under such circumstances to dislodge the nerve from its interval between the internal condyle of the humerus and the olecranon process, and bury it in the muscles in front of the condyle (*c*) Bridging the gap by the union of flaps cut from the upper and lower ends, the lateral implantation of the divided ends into a healthy nerve, the interposition of a tube, such as a vein or of a nerve-graft, between the two ends in the hope that the axis cylinders may thereby be enabled to travel downwards—all these methods have been tried sufficiently often to demonstrate their inefficiency (*d*) The removal of a segment of the bone of the limb so as to shorten it permits of the accurate apposition of the nerve segments, but it is a serious addition to the operation, and should never be undertaken lightly (*e*) Where all such procedures fail or do not commend themselves to the operator, the

be in measure restored Orbital cellulitis not unfrequently causes pressure on the nerve, either immediately as a result of the inflammation, or subsequently by cicatricial contraction Syphilitic disease of the sheath, or the formation of a gumma in its neighbourhood, or intra-orbital aneurisms or tumours, may likewise interfere with vision from pressure on the trunk Optic neuritis, or more accurately acute papillœdema, is an œdematous condition of the intra-ocular termination of the nerve in the fundus oculi, due to increased tension of cerebro-spinal fluid, it is a frequent result of cerebral tumours or inflammation, and is generally followed by optic nerve atrophy and blindness

The **Third Nerve** (*motor oculi*) being entirely motor, paralytic symptoms are those to be looked for They may arise from *central* causes, such as syphilitic or degenerative changes in the floor of the third ventricle, or from *peripheral* lesions, such as aneurisms, tumours, gummata, trauma, etc , either in the orbit, sphenoidal fissure, or base of the skull The **Symptoms** of complete paralysis are as follows (*a*) Ptosis, or drooping of the upper eyelid, from loss of power in the levator palpebræ, (*b*) external strabismus, or squint, from paralysis of the inner, upper, and lower recti, the eye being also directed a little downwards from paralysis of the inferior oblique, (*c*) mydriasis, or dilatation of the pupil, from palsy of the iris, (*d*) loss of accommodation, from the ciliary muscle being paralyzed, and (*e*) some slight protrusion of the eyeball (exophthalmos), owing to most of its muscles being flaccid and relaxed Diplopia is the most marked functional result In consequence, however, of its close proximity to the fourth, fifth, and sixth nerves in the walls of the cavernous sinus and sphenoidal fissure, symptoms referable to these trunks are often associated with the above, as also venous congestion of the eye and orbit from pressure on the sinus Should the eyeball be totally immobilized from paralysis of all its muscles without venous congestion, the condition is known as ' ophthalmoplegia externa,' and is always due to central disease affecting the floor of the third ventricle, and probably of syphilitic or tabetic origin The **Treatment** in most cases consists in the administration of mercury and iodide of potassium

Paralysis of the **Fourth Nerve** (*Pathetic*), which supplies the superior oblique muscle, results in defective movement of the eyeball downwards and outwards, with diplopia on attempting to look down

The **Fifth or Trigeminal Nerve** is occasionally torn in head injuries, giving rise to anæsthesia, with perhaps ulceration of the cornea, but such cases are exceedingly rare Much more common is the affection known as *trigeminal neuralgia*, or tic-douloureux, which occurs most often in old people, particularly women It is to be distinguished from the simpler forms of neuralgia due to some local irritation or general weakness by the paroxysmal character and violence of the pain, hence the term ' epileptiform tic ' has been applied to it, and not inaptly represents its terrible nature As a rule it commences in the infra-orbital or inferior dental branches, radiating thence to all the other divisions of the nerve The paroxysms are not very frequent at first, but they increase both in number, duration, and severity,

and may be induced by any peripheral stimulus, a sudden noise, a draught of air, etc , until at last the patient, utterly prostrate, either becomes a morphia habitué or may even attempt suicide The condition is often influenced considerably by the general health, and intermissions of varying length occur The attacks are accompanied by twitching of the muscles of the face, and even of the neck, also by unilateral sweating and hyperæmia of the head, which becomes so tender and hypersensitive that the patient cannot brush the hair or wash the face on the affected side Lachrymation is a marked feature during the attacks, and the secretion of saliva or of nasal mucus may be increased

Trigeminal Neuralgia.—The **Cause** is unknown, in a few cases tumours of the ganglion itself may be caused by gummata in the region of the ganglion Very occasionally aneurisms in the middle fossa may press on the ganglion, but in the great majority nothing abnormal can be found either in the ganglion or its branches

Treatment —There can be no dogmatic advice with regard to patients suffering from trigeminal neuralgia as to which form of treatment is the best, every patient must be considered independently If the patient is in good health, apart from the neuralgia, then open operation and division of the sensory root is undoubtedly the treatment If, on the other hand, the patient is aged and debilitated, alcohol injection is the obvious treatment

Even in those cases where open division of the sensory root is contemplated, it is a sound procedure to inject the Gasserian ganglion prior to the operation, so that the patient may experience the numbness of the face which is permanent after the division of the sensory root, but temporary after alcohol injections This is most necessary, as quite often patients, when cured of their neuralgia, complain bitterly of the numbness or ' deadness ' of the face, and even go so far as to blame the surgeon for not telling them before the operation that such a condition would ensue

Alcohol Injections.—There is only one way in which the technique of alcohol injections into the second and third divisions of the fifth nerve or into the Gasserian ganglion itself can be perfected, and that is by repeated attempts on the cadaver Not until the surgeon is quite familiar with the method on the cadaver should he attempt the injection on the living patient In the past, failure of injections to cure the pain has quite often been due to the fact that they have been carried out by inexperienced individuals

The equipment required consists of a 2 c c Record syringe and a set of needles, as shown in Fig 167 There are many varieties of needles, but they should be made of stainless steel and vary from 3 to 5 inches in length and should be graduated in centimetres Some 1 per cent solution of novocain and some 90 per cent alcohol complete the requirements Although some authorities advise a general anæsthetic for the injections, this should always be avoided, as it is very important to have the co-operation of the patient

Injection of the Maxillary Nerve.—There is only one real method for injecting this nerve, which should always be done at the foramen

The **Brachial Plexus** may be injured in gunshot wounds, or occasionally divided by *cuts or stabs* in the lower part of the posterior triangle, and the accident will be characterized by the motor or sensory phenomena corresponding to the particular nerves involved, the lower nerve-trunks are more often involved than the upper

Tears or contusions of the plexus, a more common accident, may be complete or partial, and result from injuries in which the arm is dragged suddenly upwards, as when in falling a person clutches at some projecting body, or from forcible depression of the shoulder in a fall whilst the head is driven towards the opposite side, the nerve-roots being thereby wrenched from their attachments or the nerve-trunks compressed by the clavicle against the first rib Long-continued hyper-extension and abduction of the arm, as during an operation in the Trendelenburg position, also cause undue traction upon the roots of the plexus, especially of the fifth and sixth nerves A fracture of the clavicle by direct violence may result in injury of the plexus, and the pressure of a cervical rib may affect the inner cord Dislocation of the head of the humerus into the axilla, or the attempts to reduce it, may also be responsible for injuries, especially to the inner cord The lesions consist either of a complete rupture of the nerve-trunks, or of a partial rupture with hæmorrhage into and around the sheaths If the sheaths remain untorn, repair is usually established after a time, but where a complete laceration has occurred, much cicatricial tissue is likely to form, and unless operation is undertaken, repair is improbable

In infants a *brachial birth-palsy* is observed, due to forcible stretching and tearing of the roots of the plexus It is caused by over-stretching of the head during delivery, and may occur equally in vertex or breech presentations, it is usually unilateral, and affects more frequently the left arm At first supraclavicular tenderness may be noted, and then the loss of power of the arm becomes manifest, this may affect the whole arm to begin with, but with suitable treatment the condition usually limits itself either to the upper arm or Erb-Duchenne type (80 per cent), or to the lower arm or Klumpke type (20 per cent)

Symptoms.—If all the **nerve-roots** are involved, the whole arm is paralyzed, and lies flaccid and anæsthetic by the patient's side Sensation is alone present down the inner side of the arm as far as the elbow (intercosto-humeral nerve), and for a more limited portion on the outer side Paralysis often involves the pectoralis and scapular muscles, but the rhomboids and serratus magnus retain their nerve-supply Oculo-pupillary changes may be manifested if sympathetic fibres are involved in the injury, the pupil is contracted, and mydriasis defective on excluding the light

The **upper-arm type** is [illegible] due to tearing or stretching of the fifth and sixth cervical nerves, and corresponds to what is known as the *Erb-Duchenne paralysis* There is loss of power of the deltoid, spinati, biceps, brachialis anticus, and supinator longus muscles, as well as the clavicular fibres of the pectoralis major, the latissimus dorsi, teres major, rhomboids, and subscapularis Sensation is usually

but little involved, as the area supplied by the fifth and sixth roots is not extensive (Fig 187) The result on the limb is very characteristic The arm lies close to the side and cannot be abducted or rotated, but in children fixed internal rotation may become evident later on The forearm is extended and in a position of pronation, all supination being lost, and the elbow cannot be flexed Usually the movements of the hand and wrist are unimpaired, but occasionally the wrist extensors are paretic

The **lower-arm type** is caused by injuries to the eighth cervical and first dorsal nerves, the resulting paralysis being described as of the *Klumpke type* The flexors of the wrist and fingers (Cviii) and the intrinsic muscles of the hand (Di) are paralyzed, and a claw-hand (Fig 183) results Anæsthesia along the distribution of the ulnar nerve becomes evident

Lesions of the cords of the brachial plexus below the clavicle are uncommon, and it is unnecessary to describe their effects, which are controlled by their well-known anatomical distribution

Treatment necessarily varies with the situation and degree of injury, but follows that for lesions of the peripheral nerves

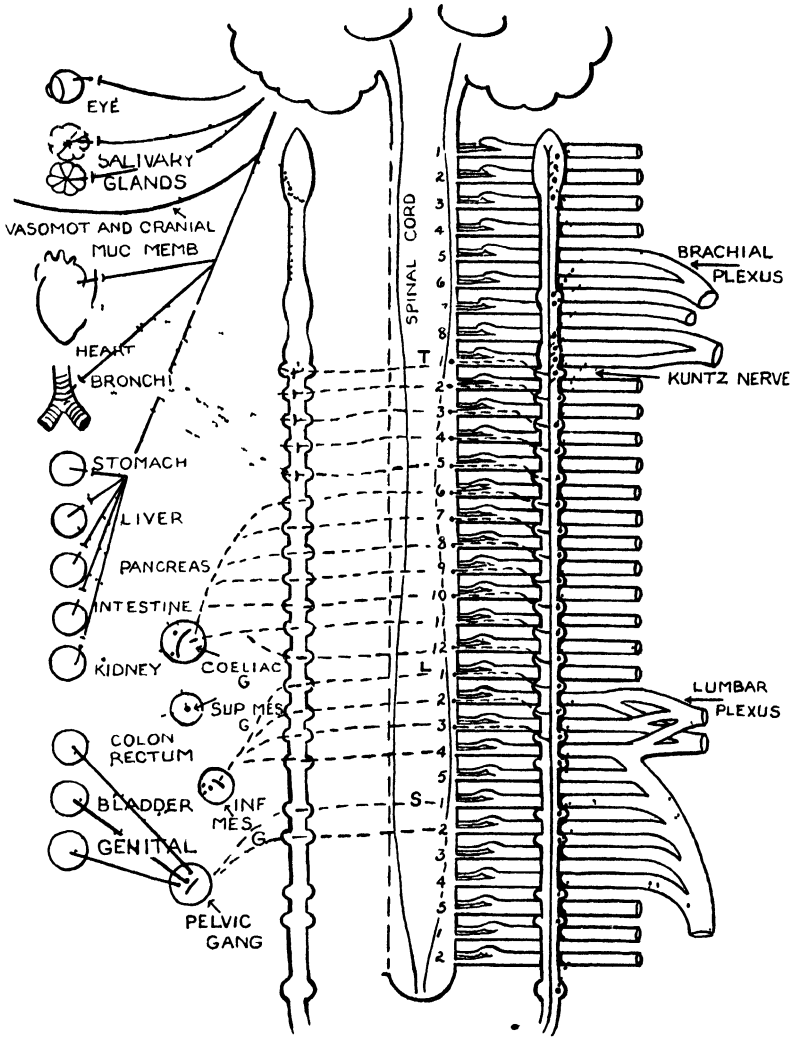
Aseptic cuts and stabs are of course explored, and divided nerves secured, if possible, by primary suture

In infected lesions, such as the majority of gunshot wounds, suture must be delayed until the infection has disappeared and the wound healed, and in the meantime massage and electricity are employed to maintain the nutrition of the muscles

Obvious causes of pressure, such as the depressed fragments of a broken clavicle, or the callus resulting therefrom, must be removed, and a cervical rib, if causing symptoms, should be excised

In traumatic cases without open wound, and this includes the birth-palsies, the arm is placed at right angles to the trunk and kept at rest, whilst local pain and tenderness are relieved by fomentations The position is important in that it limits tension on the nerve-ends and approximates them as much as possible After a short while passive movements are employed to keep the joints supple, and massage and galvanism are commenced to maintain the tone of the muscles Power and sensation gradually reappear in those regions where the nerve-supply has not been severed, but the paralysis persists in the muscles supplied by the divided nerves, and the reaction of degeneration appears in due course, a thickened cicatricial mass can usually be felt at the site of the lesion Under these circumstances operation is desirable in order to secure the restoration of continuity of the injured nerve-trunks

The brachial plexus is exposed through an incision running downwards along the posterior border of the sterno-mastoid and prolonged downwards, if need be, across the clavicle The scalenus anticus is defined, and the nerves are found emerging from between it and the scalenus medius, cicatricial tissue is removed, and the nerve-ends are freshened and sutured together In cases involving the lower section of the plexus, it may be necessary to divide the clavicle in order to expose the affected portion of the nerves The results of operations



THE AUTONOMIC NERVOUS SYSTEM IN DIAGRAMMATIC REPRESENTATION

- - - - - - - - - - - - - - - - - - = Preganglionic fibres
= Post-ganglionic fibres
——————————— = Parasympathetic nerves

On the right-hand side of the chart the somatic outflow is depicted, the viscera outflow is shown on the left-hand side

there is as yet no effective surgery of the parasympathetic system it will not be further considered

The sympathetic nervous system consists of

The preganglionic fibres
The ganglionic trunks
The visceral ganglia
The post-ganglionic fibres

The preganglionic fibres or white rami communicantes are fibres arising from the cells of the lateral horn of the grey matter of the spinal cord in all the thoracic segments and the upper three lumbar segments These fibres leave by the anterior spinal roots and pass to the ganglionated trunks They may arborize in the nearest ganglion or pass up and down the ganglionated cord to higher or lower ganglia, or they may pass through the ganglionated cord to end in a visceral ganglion A few run direct to the medulla of the suprarenal gland

The ganglionated trunks extend from the under aspect of the skull to the coccyx as a paired chain of ganglia and fibres There are three cervical ganglia, eleven or twelve thoracic, four lumbar, and four sacral The cords join over the coccyx to form the ganglion impar (see Plate VII)

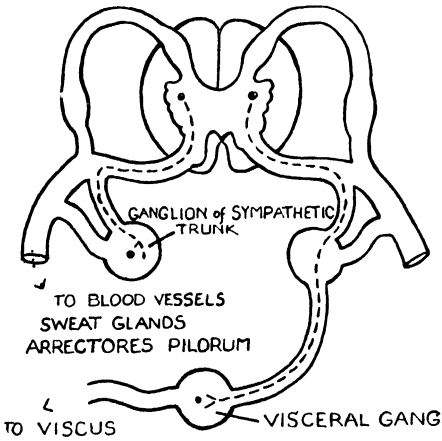


FIG 190.—TRANSVERSE SECTION OF THE SPINAL CORD SHOWING THE SYMPATHETIC OUTFLOW

The visceral ganglia contain the cells whose axons pass direct to the abdominal viscera Their preganglionic fibres pass through the ganglionated trunks, but they do not synapse there The main visceral ganglia are the cœliac and the superior and inferior mesenteric ganglia

Post-ganglionic fibres or grey rami communicantes run from the cells of the ganglionated trunk via the spinal nerves to their ultimate distribution in blood-vessels, sweat glands, etc These grey fibres form a definite bundle, and they enter every somatic nerve-root (Fig 190)

Certain ganglia and nerves require special description because of their surgical importance They are

The stellate ganglion
Kuntz's nerve
The lumbar ganglia
The presacral nerve
The pelvic nerve of the parasympathetic

The Stellate Ganglion.—The sympathetic nerve-supply to the upper extremity comes from the inferior cervical and the first and second thoracic ganglia The inferior cervical and the first thoracic ganglia are frequently fused into one mass, the stellate ganglion To denervate the upper limb it is important to remove more than the stellate ganglion, as the second thoracic ganglion frequently sends a contribution termed 'Kuntz's nerve,' which either runs direct to the first thoracic spinal nerve or to the first thoracic nerve via a branch from the second thoracic nerve The stellate ganglion lies anterior to the spinal nerves in a groove on the neck of the first rib

The Lumbar Ganglia—These ganglia, four pairs in number, are somewhat irregularly disposed The right chain lies behind and slightly lateral to the inferior vena cava, while the left chain lies lateral to the aorta The first ganglion lies just above the renal pedicle The other ganglia are irregularly disposed below it The ganglia give off branches to the pre-aortic plexus, a very irregular network of fibres anterior to the aorta From this plexus arises a collection of fibres of great surgical importance—the presacral nerve This nerve, more accurately termed prelumbar, consists of those sympathetic fibres which lie in front of the fourth and fifth lumbar vertebræ It lies at the bifurcation of the aorta between the common iliac vessels It is about 2½ inches in length, and it is the nerve of supply to the pelvic viscera Lying close to the presacral nerve on its left side is the pelvic splanchnic nerve, the parasympathetic portion of the nervi erigentes, and the motor nerve to the colon This fact is of importance, as in dividing the presacral nerve it is important not to damage the pelvic splanchnic nerve This nerve runs up to the inferior mesenteric artery near, but not at its origin from the aorta It is distributed with that artery to the colon

Indications for Operations on the Sympathetic Nervous System

At the present time full agreement has not been reached as to the conditions likely to benefit by sympathectomy Sympathetic denervation has been widely tried for a diversity of conditions, and many disappointments have been encountered which could readily have been predicted It must be appreciated that the only operation known is a denervation, and the problem resolves itself into finding suitable diseases, suitable individual cases, and finally the correct amount of denervation to perform Certain disease groups emerge with definiteness, while some remain in the experimental state They may be enumerated as follows

Diseases of the Vascular System :

I *The Peripheral Vessels*
- Raynaud's disease
- Buerger's disease
- Acrocyanosis
- Erythromelalgia

II *The Central Vessels*
- Angina pectoris

Diseases of the Abdominal Viscera :

Hirschsprung's disease
Spastic constipation
Cardiospasm
Renal sympathetico-tonus
Cord bladder

Sympathectomy for Pain :

Dysmenorrhœa
Tuberculous cystitis
Carcinoma of the bladder
Causalgia
Trigeminal neuralgia
Painful ulcers
Pain of gangrene

Symptomatic Group

Scleroderma
Chronic arthritis
Retinitis pigmentosa
Anterior poliomyelitis
Hyperidrosis

This list is in no sense exhaustive, and it deliberately omits many suggested indications which are highly experimental

These disease groups can now be considered individually with their investigations to determine suitability for operation

I **Diseases of the Vascular System** —There is a group of related diseases of the peripheral vessels which is characterized by the fact that the symptoms of ischæmia and pain appear before any pathological changes are detectable in nerves or vessels It is also characteristic that these diseases are progressive, and that later gangrene will occur These diseases may be termed vaso-spastic in their origin, the spasm later leading to an obliterative change in the vessels If these cases are seen in the preliminary period of spasm they are essentially amenable to sympathectomy, and much improvement amounting to an immediate cure may be expected If organic changes have supervened, however, the case is unlikely to benefit The surgical problem after the preliminary examination and diagnosis resolves itself into an estimation of the degree of sympathetic activity Chief of these diseases is Raynaud's disease

Raynaud's Disease —This is a disease of the extremities, the fingers, feet, ears, and nose may all be affected, but the hands and fingers are more frequently and more severely attacked than the other parts The disease is much more common in women than in men, and characteristically occurs as a series of attacks These attacks are usually in response to cold, but they may be precipitated by emotion In an attack the hands become cold and numb, due to contraction of the digital vessels Fine movements become impossible, and the fingers ache The colour may be pale or cyanosed, depending on the capillary state The attack is followed by a stage when the fingers become red

grams taken after the injection of thorotrast into the femoral artery There is evidence to suggest that such thrombosed portions of the arteries are as much the cause of the pain felt as any resultant ischæmia, and there is also reason to believe that these areas act as foci of irritation and are liable to cause a spread of the disease

Treatment.—If the investigations point to the presence of vasospasm, then a lumbar sympathectomy should be performed The technique of this operation will be described at the end of the chapter Some authorities advise a bilateral operation even in an early case where the symptoms are unilateral They argue with some force that the second limb is usually involved at a later date, and that sympathectomy at this stage might prevent the onset It is true to say that ill-effects as a result of sympathetic denervation have never been observed, although the beneficial effects anticipated have not always eventuated This observation is true of all sympathetic operations in all the regions of the body The only possible exception is the minor inconvenience of a Horner's syndrome

The results of lumbar sympathectomy for Buerger's disease are still under consideration Relapses after a two to three year period of improvement are not unfrequent This, however, should not preclude operation, as the period of relief and improvement means much to the patient It merely should act as a brake to a too optimistic prognosis Buerger's disease contrasts with Raynaud's disease in that in the former organic changes in the vessels appear at a much earlier date, and hence the amount of benefit is not likely to be so great During an active stage of the disease, *i e* when phlebitis or deep thromboses are present, the treatment should be medical

Angina Pectoris —This disease was one of the earliest to be treated by operations on the sympathetic nervous system The operations have had two underlying conceptions one, the abolition of the sensory pathway for cardiac pain, the other the removal of the pathway down which noxious impulses causing an attack might travel At the present time the rationale is considered as an attack upon the sensory pathway Many authorities still hold that the pain of angina is of value to the patient, as it is a warning signal of the heart's capacity limit, and the fear of an attack with its dreadful pain is a lively and wholesome deterrent from too much exercise On the other hand, the pain is so severe that with a patient sufficiently fit and amenable to instruction afterwards, then to relieve the pain of the attacks is only humane Cervico-thoracic ganglionectomy has proved of benefit in a number of these cases (about 60 per cent) As an alternative to this rather extensive operation a paravertebral alcohol injection may first be tried The criterion of a successful injection is the production of a Horner's syndrome It is usually sufficient to operate or inject on the left side only While the pain is relieved in a successful case, the patient often on effort experiences peculiar sensations in the præcordial region These sensations should be taken as a danger warning that the safety limit has been overstepped

II **Diseases of the Abdominal Viscera—Hirschsprung's Disease** (*syn* Megalo-colon) —In 1886 Hirschsprung defined this condition

as 'a congenital high-grade dilatation of the colon with thickening of all its tunics, especially the tunica muscularis, with retention of large quantities of fæcal matter' The disease is commonly manifest in childhood, and is rather more common in males Adult cases have been reported, but 60 per cent have symptoms before fifteen years of age Sometimes a similar condition occurs in the urinary tract with hydronephrosis, hydro-ureters, and a large bladder It is important to remember that in the colon there are numerous sphincters, notably at the recto-sigmoid junction and the middle of the transverse colon It is these sphincters that account for the not unfrequent limitation of this condition to one portion of the colon only In 50 per cent of cases only the sigmoid loop is affected The distension, however, may be enormous It is partly fæcal, but mainly gaseous in origin The distension may cause circulatory and respiratory embarrassment The leading symptom is constipation For days or weeks no motion is passed Aperients are valueless, but enemata give temporary relief Attacks of subacute obstruction are not unfrequent Signs of auto-intoxication supervene later, and the child has a sallow cachectic look (Fig 191)

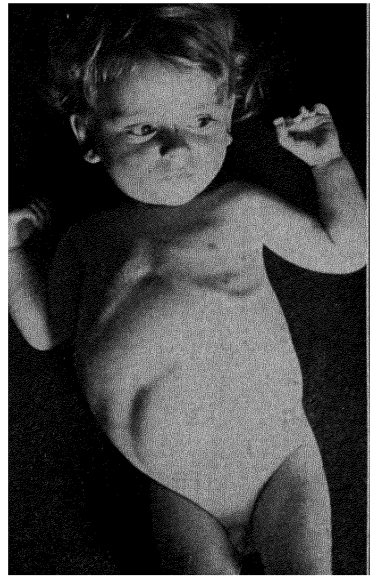


FIG 191 — CHILD WITH HIRSCHSPRUNG'S DISEASE SHOWING ENORMOUS DILATATION OF THE SIGMOID COLON

The diagnosis is confirmed by radiological examination after a barium enema has been administered This procedure can also be combined with an investigation as to suitability for operation An enormous amount of enema (8 pints or more) can often be run into the bowel Skiagrams are taken and the absence of haustration noted The child is then rolled on his side and a spinal anæsthetic administered, sensation being abolished to the level of the umbilicus In a favourable case fairly vigorous peristalsis is induced and some of the enema is returned Skiagrams will now show haustration and a diminished bowel calibre (Fig 192) If there is a definite change under the anæsthetic which temporarily paralyzes the sympathetic outflow, then benefit is to be anticipated from a sympathectomy

There are numerous operations in vogue at the present time, the two most popular are

(*a*) Removal of the upper part of the presacral nerve and periarterial neurectomy of the inferior mesenteric artery

(*b*) Bilateral division of the lumbar splanchnic nerves

Following the operation a period of colonic irrigation and medical treatment may be necessary The results are as a rule very gratifying, and sometimes highly dramatic Failures may follow a too timid operation or the selection of a very advanced case where the musculature of the colon has atrophied

Chronic Constipation—There are many cases of chronic constipation which prove very resistant to the usual medical measures These cases are worth investigation as to the likelihood of benefit by sympathectomy This operation should never be performed without the preliminary barium enema spinal anæsthetic test described above Operations at random discredit a useful procedure and give very disappointing results Sympathectomy is undoubtedly of considerable benefit in selected cases of chronic constipation

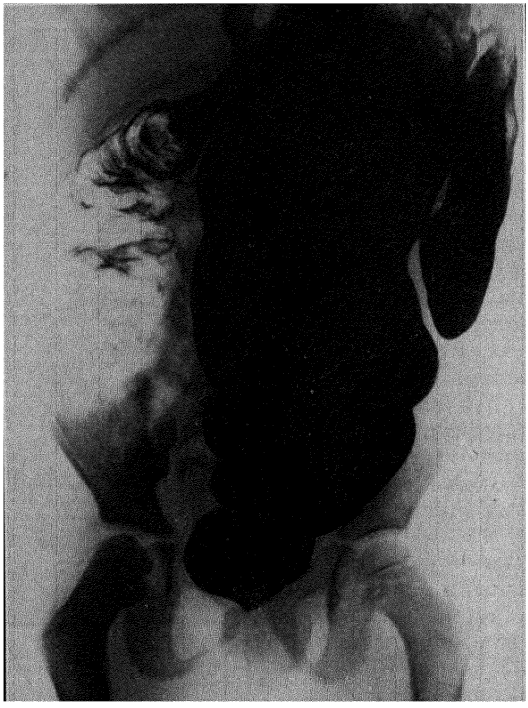


FIG 101.—BARIUM ENEMA IN A CASE OF A CHILD WITH HIRSCHSPRUNG'S DISEASE (SAME CASE AS FIG 101)

The enormous dilatation of the sigmoid colon is well seen

Cardiospasm This condition has been described under the section of 'Diseases of the Œsophagus' (Chapter XXXII), and its features need not be detailed here There is a steady accumulation of evidence to suggest that this disease is a true cardiospasm, *i e* due to tonic contraction of the cardiac sphincter the result of over-action of the sympathetic nerves Much experimental work has been done, and recently human cases have been subjected to sympathetic denervation with encouraging results The sympathetic supply to the lower œsophagus runs along the left coronary artery The usual operation of denervation consists in dividing the vessel in such manner as to include the maximum amount of connective tissue, which contains the sympathetic nerve fibres, in the ligature Of course not every case of cardiospasm should at once be subjected to operation, the simple methods of dilatation with mercury bougies,

etc , being tried first In stubborn cases a sympathectomy will frequently be palliative, if not curative The method should certainly supersede the older short-circuiting anastomoses, which were difficult and hazardous

Sympathectomy in Urinary Conditions—Renal Sympathetico-Tonus —This term has been applied to certain types of hydronephrosis without demonstrable organic cause, and to attacks of renal pain due to increased intrapelvic tension In these cases a pyelogram shows delay in emptying of the pelvis The pain in these cases comes typically in attacks, is unilateral, and is relieved by eserine It is obvious that in investigating these cases the greatest care must be taken to exclude any organic affection of the kidney or ureter These cases are definitely benefited by a sympathectomy If a hydronephrosis complicates the spasm, then plastic operations upon the renal pelvis may also have to be performed The operation of renal denervation is performed by delivering the kidney through the loin and exposing the pedicle as far as practicable in a medial direction The pedicle is then systematically stripped of fat and connective tissue, working from the mid-line towards the kidney An injection of eserine at this stage should show powerful contractions of the pelvis and ureter

Hydro-ureter —Presacral neurectomy has been practised in cases of hydro-ureter Some successes have been reported

Cord Bladder —Spinal cord injuries are especially liable to be followed by the condition termed 'cord bladder' Immediately following the injury there is retention of urine, followed by 'retention with overflow' if treatment has not been instituted In a favourable case at a later date an automatic bladder develops These cases can be potentially benefited by a presacral neurectomy The sympathetic outflow acts as the inhibitor to the detrusor urinæ muscle and as motor to the vesical sphincter Sympathetic denervation can, therefore, remove the brake, though it cannot supply additional motor power If reasonable motor power exists, then it is justifiable to consider a presacral neurectomy

III **Sympathectomy in Painful States** —The existence of a sympathetic afferent pathway has long been suspected, but has been, and still is, difficult to prove Evidence is, however, steadily accumulating to suggest the presence of afferent fibres It is certain that many painful conditions are improved by sympathetic denervation operations, though the manner in which benefit is obtained is not always obvious Thus it is impossible to draw up a definite category of conditions where sympathectomy is performed for pain In some of the conditions previously noted the relief of pain (*e g* in Raynaud's disease, angina pectoris) has been almost as marked as the clinical improvement in other respects There are, however, certain diseases where sympathectomy may be indicated, not so much as a curative measure, but to relieve the pain First among such conditions may be mentioned painful pelvic states

Dysmenorrhœa.—Certain cases of dysmenorrhœa which show no major gynæcological organic lesion, but which are usually associated

with a small uterus and an elongated cervix, are relieved by a presacral neurectomy These cases generally are hypoplastic as regards ovarian and uterine function Case selection is difficult, and the usual gynæcological measures should be tried first If these prove unsatisfactory, a presacral neurectomy frequently procures relief and certainly provides the opportunity for a thorough intra-abdominal investigation of the pelvic viscera

Inoperable Bladder States.—The later stages of tuberculous cystitis and carcinoma of the prostate or bladder are pitiable in the extreme Bladder cramps, frequency and strangury deprive the patient of sleep and completely exhaust him If the case is too advanced for the radical forms of treatment, then a presacral neurectomy may often be beneficial The operation is at least worth trying It is, of course, considerably safer than cordotomy

It is customary to perform a presacral neurectomy in the preliminary stages of the various operations of excision of the rectum in the hope that local recurrence may be relatively painless The efficacy of such a step is doubtful

Causalgia.—Causalgia literally means a burning pain, and this is a very apt description of the type of peripheral pain to which the term is usually applied Causalgia usually affects the extremities after minor injuries or minor amputations of digits It is most commonly found in the distribution of the median nerve The condition with its marked hyperæsthesia and intense subjective burning pain becomes manifest as a rule during the healing period, rather than during the active stage of the wound or injury Trophic changes appear in the part affected The finger becomes tapered, the skin red and shiny, the nails curved and brittle The skin is warmer than the rest of the hand The incapacity is extreme

This condition in the past has proved extremely resistant to treatment Nerve injections and nerve sections, and even root sections, have often failed to procure relief The painful stimuli do not appear to pass along the ordinary sensory pathway Either this is true or else the pain is central in origin Cervico-thoracic ganglionectomy has proved of great benefit in treating these cases In all but the minor cases which recover spontaneously this operation would now appear to be the standard form of treatment for a previously intractable condition

Trigeminal Neuralgia.—The standard form of treatment for this very distressing disease is by obliteration of the sensory pathway of the affected area This can be done either by injection or by section of the sensory root of the fifth cranial nerve In skilled hands these forms of treatment give very satisfactory results in the majority of cases In a few cases, however, no improvement results and the patient's condition is just as pitiable as before It is then worth while trying the effect of a cervico-thoracic ganglionectomy In some few cases dramatic improvement has occurred

Painful Ulcers—The Pain of Gangrene.—Many ulcers of the extremities, *e g* the sole of the foot and the digits, are very slow in healing and are exquisitely painful They are often pregangrenous mani-

festations The pain and associated manifestations are similar to that described under Causalgia The pain of gangrene is very severe and exhausting to the patient An amputation may be necessary in a case of gangrene of the extremity to relieve the pain when otherwise the surgeon would have preferred to wait for a natural separation

These cases are often strikingly relieved by the appropriate sympathectomy The relief of pain is dramatic, and the patient is able to obtain some much-needed rest Associated with this there is frequently rapid healing of the ulcer or in a gangrenous limb the formation of a clear line of demarcation

IV **Symptomatic Group.**—Sympathetic denervation operations find a rôle in various unrelated conditions This heterogeneous group will now be considered

Scleroderma —This is a rare condition as a separate entity, though it may be associated with Raynaud's disease Changes occur in patches of the skin These patches become hard and white and painful The underlying connective tissues are later infiltrated and contractures occur The condition may be widespread all over the body No form of treatment previous to sympathectomy was of any real benefit Definite improvement has been observed after sympathetic denervation, at any rate in the more localized forms

Chronic Arthritis —In certain forms of chronic degenerative arthritis pain may be more severe than even the crippling deformity These are the cases where bony change, apart from atrophy, is slight The arthritis is mainly periarticular These cases are sometimes benefited by sympathetic denervation The method is still experimental and the results are not yet clear The benefit may accrue by relief of pain, or it may be due to increased vascular supply to the part This acts as a sort of permanent internal radiant heat

Retinitis Pigmentosa —In this condition blindness results from retinal degeneration Vision from the onset becomes steadily impaired The retinal vessels become constricted and pigment migrates from the choroid to the perivascular lymphatics This condition has been treated by sympathectomy, the stellate ganglion being removed The results have been rather conflicting, many claiming successes while others report no benefit It would appear that allowing for variations in technique, etc , early cases may be benefited by stellatectomy, and that at any rate this operation should be tried

Anterior Poliomyelitis —Trophic changes in cases of severe paralysis cause serious disability The orthopædic measures necessary for the re-educative exercises in progress may have to be suspended owing to painful chilblains or even ulcers The child may have to go to bed and splintage become difficult This is more common in the lower limb and in cases of widespread paralysis These cases should be subjected to lumbar ganglionectomy It may be true that the benefit obtained may only last a few years These years may, however, be vital years of treatment when the orthopædic surgeon will not wish to be hampered by sores

Hyperidrosis.—Excessive sweating is a well-known manifestation of vaso-motor instability This sweat may literally drip from such

patients even at room temperature The condition may be generalized or localized to one area Sympathetic denervation operations, when properly performed, always lead to paralysis of the sweat glands in the area denervated In fact, the area denervated can best be estimated by observing the area of loss of sweating In certain cases of hyperidrosis which do not respond to medical measures, sympathetic operations may be considered In the rare cases of unilateral excessive sweating sympathectomy is of great value

Periarterial Sympathectomy

Sympathetic denervation operations were being performed long before the exact anatomical pathways had been worked out This was one of the factors which led to confusing results in the earlier investigations Many surgeons believed that the sympathetic control of the vessels of a limb passed into the limb with the main vessels, and was distributed along the branches of the main vessels to the all-important smaller vessels Actually this is incorrect The main vessels entering the limb do have a perivascular sympathetic network which constitutes their own nerve supply, but this does not pass down the limb, branching and subdividing with the smaller vessels Thus in the lower limb the perivascular sympathetic control ends at about the bifurcation of the common femoral artery Below this level the sympathetics enter the vessels by twigs from the somatic nerves which have non-medullated sympathetic fibres in them Hence it is impossible to denervate a limb of sympathetic fibres by performing a periarterial denervation The discovery of these anatomical facts led to the temporary abandonment of the pioneer operations of periarterial sympathectomy While it is undoubtedly true that this is a very incomplete procedure and should not be used in, *e g*, Raynaud's disease or Buerger's disease, in some other conditions the periarterial operation has its merits The basis is empirical rather than anatomical The supreme advantage of the periarterial operation is the ease with which it may be performed and the fact that it can be performed under a local anæsthetic Elderly patients on whom one would hesitate to perform a ganglionectomy may readily be submitted to the periarterial operation While the benefit may be only transitory—five weeks to three months—yet this period may be sufficiently long to allow healing of an ulcer or demarcation of a gangrenous area Again, the periarterial operation relieves pain, though the manner of this relief is not understood Further, the relief of pain is less transitory than any of the other beneficial effects of the operation, *e g* improving the blood-supply The periarterial operation thus finds its best application in cases of senile gangrene and painful pregangrenous conditions The periarterial operation may be applied to cases of causalgia, but in this exceedingly stubborn condition the major denervation of cervico-thoracic ganglionectomy is probably preferable

The Technique of Sympathetic Operations.

The Periarterial Operation —The vessel (common femoral or axillary) is exposed under local anæsthesia for the maximum convenient length The arterial sheath and tunica adventitia are then carefully peeled off for a distance of 2 inches or more The artery will contract under the mechanical stimulus, but later will dilate The stripping must be very thorough, as most of the nerve-fibres are on the deep aspect of the outer coat Any small strands of tissue must be removed The coat of the vessel is then painted with 90 per cent alcohol to destroy any remaining fibres The only danger of the operation is, of course, removal of too much covering with the production of rupture of the vessel, or the production of an aneurism On the other hand, if too little tissue is removed the patient will not benefit

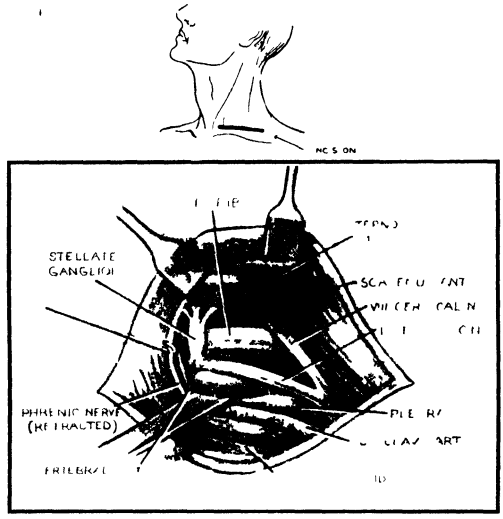


FIG 193 —THE ANTERIOR APPROACH TO THE STELLATE GANGLION

Note the relationship to the first rib Insert shows the skin incision

Cervico-thoracic Ganglionectomy —There are two standard methods of approach to the stellate ganglion the posterior approach (associated with the name of Adson) and the anterior approach The latter is gaining in popularity, and is the only one to be described here It will be remembered that to denervate the upper limb the second thoracic ganglion must be removed, together with the stellate ganglion A collar incision is made just above the clavicle over its inner two-thirds (Fig 193) The external jugular vein is divided and the clavicular head of the sterno-mastoid divided until the internal jugular vein is visible The posterior belly of the omo-hyoid is sough and divided and the scalenus anticus and phrenic nerve defined The phrenic nerve is then retracted inwards and the scalenus anticus divided at its insertion This exposes the subclavian artery, which is dissected to free its upper border The thyroid axis artery is now divided between ligatures near its origin The subclavian artery is drawn downwards and forwards, and Sibson's fascia is divided along the inner border of the first rib, exposing the pleura By gauze dissection the pleura is stripped, in a forward and outward manner, off the first three ribs and adjacent vertebræ The inferior cervical

ganglion should then be seen lying on the neck of the first rib with the trunk of the sympathetic running down on the heads of the ribs away from it The trunk is hooked up at the level of the third rib and cut across between clips It is convenient to use silver clips in the deep wound The trunk is gradually freed upwards by cutting its branches The trunk is cut across just above the inferior cervical ganglion The criterion of successful removal is the absence of sweating and the presence of a Horner's syndrome (ptosis of the upper lid, myosis and enophthalmos) It may take some hours for the syndrome to develop The wound is closed with a small drain left in for forty-eight hours

Lumbar Ganglionectomy —There are two alternative methods of performing this operation, *viz* the extraperitoneal operation and the

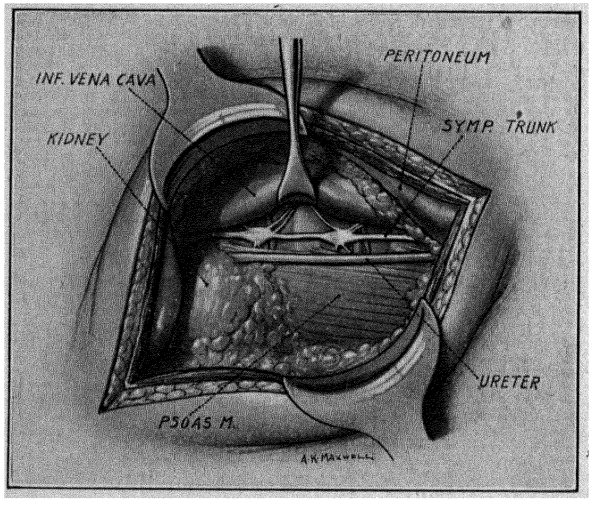


FIG 194 —THE EXTRAPERITONEAL APPROACH TO THE RIGHT LUMBAR GANGLIONATED CHAIN

transperitoneal operation The former is indicated when only one side requires denervation If both sides require denervation the transperitoneal route is usually employed, unless there is some contraindication to opening the peritoneum, when the extraperitoneal route may be used as two operations usually done in two stages

(*a*) *The Transperitoneal Approach* —A full 6-inch left paramedian incision is made from 2 inches above the umbilicus and the abdomen opened The peritoneum of the posterior wall is incised on the left side lateral to the descending colon and upper part of the sigmoid The colon is mobilized over to the right Its blood-supply is carried with it, and also the ureter, which adheres to the peritoneum The fact should be verified, as on rare occasions the ureter does not come up with the peritoneum The inner border of the psoas muscle is sought and the lumbar chain is found lying between it and the bodies

of the vertebræ At the upper end the duodenum may have to be retracted gently to allow access to the second lumbar ganglion The chain is divided just above the second lumbar ganglion and gradually dissected downwards Hæmorrhage may be troublesome from small veins, and it is again advisable to make free use of Cushing's clips The downward dissection ceases at the level at which the ganglionated cord passes behind the iliac vessels The colon is allowed to fall back into place and the peritoneum sutured A similar route can then be used on the right side by incising the peritoneum to the outer side of the cæcum and ascending colon, with mobilization of the gut inwards Then proceeding as on the left side, the ganglionated chain is found lying between the inferior vena cava and the vertebral bodies To save displacing so much gut a more direct approach may be used on the right side (Fig 194) The root of the mesentery is identified and an incision made just to the right of it over the vena cava Care has to be taken to avoid the spermatic vessels, the ureter, the vessels in the mesentery, and the duodenum The inferior vena cava is identified and retracted, and the operation proceeds in the usual manner

(*b*) *The Extraperitoneal Route* —A Mayo incision similar to that used for nephrectomy is made and the incision deepened until the psoas muscle is reached The peritoneum is stripped inwards and forwards, carrying the ureter with it (Fig 195) The inner border of the psoas is defined, and on the right side the inferior vena cava The sympathetic trunk is searched for lying on the lateral aspect of the vertebræ

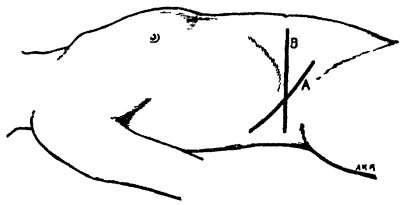


FIG 195 —INCISIONS WHICH MAY BE USED IN THE EXTRAPERITONEAL EXPOSURE OF THE LUMBAR GANGLIA

A, Unilateral approach, B, bilateral approach

Presacral Neurectomy —A right paramedian incision is made centred on the umbilicus The abdomen is opened and the viscera examined The patient is tilted into a high Trendelenburg position and the intestines packed off upwards and leftwards The interiliac triangle made by the two common iliac arteries, the bifurcation of the aorta, and a horizontal base at the level of the sacral promontory is defined The peritoneum over the centre of the triangle is picked up, incised vertically, and the bifurcation of the aorta exposed Starting in the mid-line at the level of the sacral promontory, the dense connective tissue about 1 inch wide is dissected off the anterior aspect of the fifth lumbar vertebra up to the bifurcation of the aorta The dissection is strictly mid-line, and on no account must it diverge to the left, as this would include the parasympathetic motor supply to the colon and rectum The strip of connective tissue removed contains the presacral nerve The posterior peritoneal incision is closed, and then the packs removed and the abdomen closed in layers

CHAPTER XVII

SURGICAL DISEASES OF THE SKIN AND OF THE CUTANEOUS APPENDAGES.

A **Boil** or **Furuncle** is a localized inflammation of the skin, usually terminating in suppuration, due to infection with staphylococci of a hair follicle or sebaceous gland Experimentally, a plentiful crop of boils can be produced by rubbing a culture of staphylococci into the skin, and clinically a similar infection is the most common cause of this condition The secondary or satellite boils which form around a primary one are due to the friction upon the healthy integument of dressings, covered with pus and microbes

People with coarse skins and a tendency to comedones are specially liable to the occurrence of boils, but some depressing constitutional condition, such as chronic Bright's disease or diabetes, is often present in patients who suffer from recurrent crops of boils A gangrenous inflammation ensues after infection, resulting in the death of the hair follicle, or of the sweat or sebaceous gland involved, and of the surrounding connective tissue, and the slough thus formed is cast off by a process of suppuration A matured or ripe boil, therefore, consists of a central slough or core, a zone of pus around it, and external to this granulation tissue merging into healthy skin and connective tissue

Signs—A boil commences as a small red irritable pimple, from which a hair may often be seen to protrude, it increases gradually in size, becoming more and more painful, until it forms a conical tumour, deep red in colour and exquisitely tender A small whitish spot appears in the centre, and around this so-called core yellow pus can be seen Finally it bursts, discharging the pus, and subsequently the core or slough comes away The process is then at an end, and the wound rapidly heals by granulation Occasionally the inflammation extends more deeply into the subcutaneous tissues, constituting a 'carbuncular boil' Lymphangitis sometimes follows, and the neighbouring lymphatic glands may become enlarged and painful, but rarely suppurate A boil sometimes subsides without suppuration, leaving the parts thickened and infiltrated, the condition then being known as a 'blind boil'

Treatment.—Many boils may be left to burst naturally, though possibly the process may be checked by painting them twice daily with iodine (2 per cent) and applying Klapp's suction-glass two or three times a day Where pus has formed an incision is made, and the suction-ball persisted in till the slough has come away In the later stages the skin around should be thoroughly purified, and the pus

and core received on portions of wool soaked in carbolic lotion (1 in 20), and the cavity lightly swabbed out with pure carbolic acid A small collodion dressing is then applied Tonics, such as iron and quinine, are usually required, except in plethoric individuals, in whom a spare diet and abstinence from stimulants may be recommended A change of air to a bracing seaside place is often advisable, especially when a succession of boils has appeared In the more persistent cases a staphylococcal vaccine may be employed with advantage, and the boils will in some cases be cured or aborted (p 9) In others the vaccine seems to do but little good and then stannyoxyl may be employed, or injections of collosol manganese ($\frac{1}{2}$ to 2 c c) every three or four days, excellent results have been reported in many cases, but it is not infallible

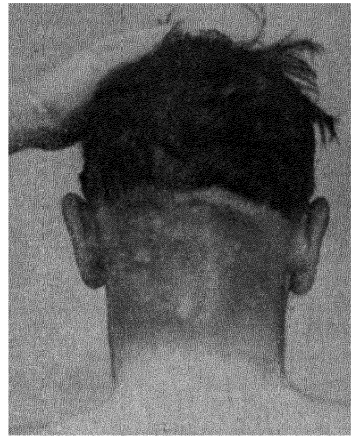


Fig 196 —Large Carbuncle at the Back of the Neck

A **Carbuncle** is a more extensive infective gangrene of the subcutaneous tissues, due to a local invasion with pyogenic microbes, the commonest being the *Staphylococcus pyogenes aureus* It occurs in individuals run down by any general debilitating condition, such as albuminuria or diabetes, in whom the germicidal powers of the tissues are much depreciated, it is also occasionally met with as a sequela of acute fevers The exciting cause may be some blow or squeeze, resulting in extravasation of blood or some local diminution of vitality, into this area cocci are implanted either by auto-infection, or more usually through the sweat glands or hair follicles, or through some slight superficial abrasion

Signs —A carbuncle commences as a hard, painful infiltration of the subcutaneous tissues, the skin over which becomes red and dusky The swelling gradually increases in size in all directions, until a diameter of many inches may be reached As it extends peripherally the central parts, which were formerly brawny, become soft and boggy, and the overlying skin shows evidences of yielding to the pressure within Vesicles form on the surface, and finally pustules, these in turn burst, and allow a tardy exit to the ashy-grey sloughs and purulent discharge accumulated below (Fig 196) Fresh openings gradually develop, leading to a cribriform condition of the cutis, some of these apertures enlarge and run into one another, producing a central irregular crateriform opening, at the bottom of which lies the necrotic tissue As the violence of the inflammation subsides the sloughs gradually separate, leaving a clean granulating wound Carbuncles most frequently occur on the back, the nape of the neck, the shoulders,

and nates, where the vitality of the tissues is never very active, when they form on more vascular parts, such as the face and lips, the consequences may be even more serious, since infective thrombosis of the large veins may follow, and this may quickly spread up to the cavernous sinus The soft and spongy tissue of the cheek is a very favourable place for the extension of the necrotic process, and there may be a wide area of mischief under an apparently insignificant superficial lesion A carbuncle is usually single, and may be accompanied by lymphangitis and a painful enlargement of the nearest lymphatic glands

There is often considerable constitutional disturbance of an asthenic type, although the temperature is not necessarily much raised A temporary glycosuria of toxic origin is sometimes present, and disappears as the condition improves, but occasionally pyæmia or septicæmia may supervene

Treatment.—In the early stages Bier's treatment by induced hyperæmia may be successful in preventing suppuration, but where the organisms are at all virulent or the focus large it will probably fail Attention should always be directed to the possible presence of coexisting disease A thorough physical examination is made with a view to finding any debilitating condition contributing to the lowered resistance of the patient The heart, lungs, and alimentary tract should receive careful attention, the urine should always be tested, particularly for sugar, acetone, and albumen Local relief is obtained to some extent by applying hot fomentations every two hours A magnesium sulphate paste* applied over the carbuncle often gives relief, increases the flow of lymph, and facilitates the liquefaction of the slough

Operative treatment may be required in some cases An incision is made through the whole length of the diseased area, cutting to the limit of its depth, a second incision is made through its breadth, crossing the first at a right angle in the centre of the carbuncle The points of the four flaps so defined are cut with sharp scissors near their base, and as much as possible of the necrotic tissue is dissected away Hæmorrhage may be considerable at this stage, but it may be controlled by firm pressure and packing with gauze The base and the walls of the cavity are lightly touched with a pledget of wool soaked in pure carbolic acid The cauterizing effect of the acid is shown by the manner in which it arrests oozing from the cut vessels, it also has the merit of destroying any active organisms which may have survived curetting with the knife or spoon It has been observed, however, that it sometimes increases the amount of subsequent sloughing The cavity is packed tightly with cyanide gauze, care being taken not to invert what remains of the flaps An abundant dressing of sterile gauze and soft wool is applied, and the operation completed by a tight bandage, which should be ample enough to immobilize the affected part Good food, iron, and quinine must be administered,

Mag sulph	45 ounces
Glycerin	55 ,,
Phenol	0 5 ,,

whilst appropriate treatment by insulin and limitation of diet are necessary in diabetic patients

A **Corn** (*clavus*) is a localized outgrowth of the epidermic layer of the skin, together with a central ingrowth of a hard, horny plug, which compresses and causes atrophy of the underlying papillæ, constituting a cup-shaped hollow, whilst the surrounding papillæ are hypertrophied The presence of this central plug constitutes the difference between a true corn and a simple callosity or diffuse overgrowth of the epidermis Any abnormal pressure is capable of producing either condition, granting that it is not sufficiently severe or intense to lead to ulceration, but corns seldom occur except on the feet, and the chief cause is badly-fitting boots Two varieties are described, *viz* the hard and the soft

The **hard corn** usually occurs on the little toe, or over the head of the metatarsal bone of the great toe, or over the heads of the first phalanges of the other toes, especially if there is any tendency to hammer-toe They form more or less conical swellings, with a dark, dry, central plug, and are often very painful, especially when pain is threatening Suppuration sometimes occurs beneath a corn, and the pain then becomes acute If it is not attended to early, the pus may burrow and cause necrosis of deeper parts or a destructive arthritis **Treatment** consists in paring the corn, after softening with hot water, or treating with salicylic acid plaster (10 or 20 per cent), or painting with a solution of salicylic acid in collodion A ring of felt plaster may subsequently be worn, but attention must be directed to the boots, and the cause of the trouble removed Occasionally, where the toe is deformed, or disease of the bones or joints has developed, it is necessary to perform amputation

A **soft corn** occurs between the toes, and owing to the absorption of sweat the surface looks white and sodden, it is often extremely painful **Treatment** consists in removing the thickened cuticle after the use of salicylic acid The parts are very carefully cleansed night and morning, and spirit of camphor painted on at night, whilst cotton-wool is worn between the toes during the day Failing this, the corn must be removed by operation The toes are held widely apart, and the incisions run transversely between them, so as to include the corn The wound can be readily closed by sutures

Tulip Fingers —Although this condition has been known in Holland for centuries, it is only of recent years that it has occurred in England The ætiology is unknown, but trauma plays a part and probably a bacterial infection follows Tulip fingers occur in women who handle, cut and grade the bulbs An infection of the nail-bed occurs, and the nail separates At times subungual abscesses form

Treatment is difficult, but the application of a spirit solution of hydrarg biniod (1 in 1,000) is useful as a prophylactic when the condition has occurred It should be applied each day on wool before starting work

Perforating Ulcer of the Foot forms on some parts of the sole, and progresses deeply so as to involve sooner or later the bones and joints,

It is usually due to two main factors, *viz* *anæsthesia* of the sole, and more or less persistent *traumatism*, such as arises from wearing a tight boot or from the presence of a nail, which is not noticed owing to the concurrent anæsthesia It is therefore likely to be met with (1) In certain central nervous diseases, *e g* tabes dorsalis, syringomyelia, spina bifida, etc , (2) in diseases such as diabetes, syphilis, alcoholism, etc , which lead to peripheral neuritis, and (3) as a sequence of traumatic lesions of the nerves affecting any portion of their course from the spinal cord downwards (4) Perforating ulcer is occasionally due to pure plantar lesions, apart from any nervous influence—*e g* a suppurating wart or corn, or even a chronic epithelioma The skin under the head of the first metatarsal is the part most frequently affected, but any spot to which undue pressure is directed may become involved, and not uncommonly several such sores may be seen on the same foot A corn or callosity first forms, and under this a bursa, in which suppuration takes place, the pus, finding a difficulty in coming to the surface owing to the thickness of the cuticle, spreads deeply into the soft structures of the sole, and the suppuration may even involve bones and joints A typical perforating ulcer presents the appearance of a sinus passing down to the deeper parts of the foot, and even extending through to the dorsum, the orifice is surrounded by heaped-up and thickened cuticle (Fig 197) There is sometimes but little discharge and often no pain, but when bones or joints are affected free suppuration may occur If allowed to progress without treatment, the bones and joints of the foot may be destroyed extensively, or may be welded together into a solid painful mass, in either case necessitating amputation A cure can sometimes be determined in the early stages by removing the thickened mass of cuticle and purifying or excising the sinus, the cavity thereby formed is packed with gauze and allowed to heal by granulation Periarterial sympathectomy is useful in many cases, but should it fail, or if bones or joints are involved, amputation will be required

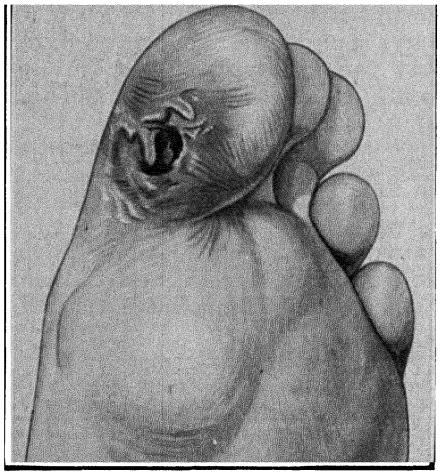


FIG 197.—PERFORATING ULCER OF GREAT-TOE PENETRATING TO BONES AND CAUSING NECROSIS

A **Wart** (*verruca*) is a papillary overgrowth of the skin, appearing as a horny projection about the size of a split pea, and usually seen on the hands of young people, its surface may be smooth or irregularly filiform, and its colour varies with the amount of dirt ingrained on

the surface When smooth-topped they are sometimes extremely numerous, and may be a little difficult to distinguish from lichen planus In parts where there is a certain amount of moisture warts become soft in character (Fig 198), and form large vascular masses, *e g* venereal warts The best method of treating ordinary warts is to paint them with glacial acetic acid, or some other caustic, every two or three days, after softening and removing the horny crust with salicylic acid Ionic treatment with salicylates is also of value

Verruca Necrogenica (see p 244)



FIG 198 —LARGE WART OF THE FOOT OF SIX YEARS DURATION

A **Chilblain** (*pernio*) is an inflammatory hyperæmia, usually involving the fingers, toes, or ears, and determined by exposure to cold It is generally seen in young people with defective circulation, whose fingers and toes easily 'go dead' They are very apt to occur on paralyzed limbs After the period of anæmia and pallor the part begins to itch or burn, and becomes red, swollen, and shiny Exudation occurs into and beneath the skin, and in bad cases a blister with blood-stained contents forms, when this bursts, troublesome ulceration ensues To prevent the formation of chilblains the patient's circulation must be improved, and exposed parts kept warm A course of lactate of calcium is helpful, 5 grains t d s are administered the first week, 10 grains during the second week, and 15 grains during the third, followed by a suitable tonic In the earlier stages treatment by induced hyperæmia is most valuable, an elastic bandage may be worn for six hours or so daily, whilst locally the parts may be painted with tincture of iodine or a solution of ichthyol When the chilblain breaks, simple antiseptic precautions may suffice, but a more stimulating application is usually required, and Peruvian balsam or resin ointment will be found useful In paralyzed limbs, or cases otherwise intractable, galvanic baths will usually prevent the development of these troublesome lesions

Tuberculous Affections of the Skin —Lupus Vulgaris is a chronic inflammation of the skin of tuberculous origin It is met with in children and young adults, rarely commencing after the age of thirty Its most usual situation is the face, generally starting on the nose or cheek (Figs 199 and 200) It is rare on the scalp, but fairly common on the trunk and extremities The mucous membrane of the nose and mouth is also attacked, but usually by extension from the skin It is not often symmetrical, except when commencing on the nose

Clinical Features —The earliest manifestation of lupus consists in the formation of one or more shot-like nodules in the deeper layers of

the skin, which are surrounded by a zone of hyperæmia and infiltration These nodules are not particularly hard to the touch, but when of any size can be demonstrated to be of a brownish-orange tint, especially if they are devascularized by the pressure of a glass slide, and then the colour somewhat resembles that of apple-jelly Gradually the process extends, and usually more rapidly in one special direction, following the course of the vessels At the same time the integument becomes infiltrated and transformed into granulation or cicatricial tissue, covered by a layer or two of epithelium (Fig 199), and owing either to degeneration of the tuberculous nodules or to a lack of vitality, arising from compression of the vessels by the contraction of this new formation, ulceration is very liable to follow (Fig 200) In the extremities the lupoid growth not unfrequently takes on a warty aspect, somewhat similar to the 'anatomical wart' occasionally seen on the knuckles of post-mortem porters (p 244)



Fig 199.—Non-ulcerating Lupus of Cheek

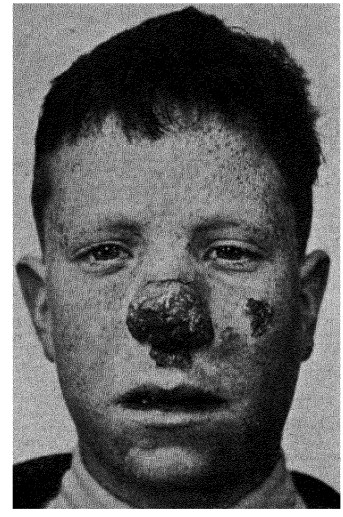


Fig 200.—Ulcerating Lupus of Nose and Cheek

A *Lupoid Ulcer* usually spreads at one margin as it heals at the other, and hence under typical circumstances is more or less crescentic in shape The surface is covered with granulations, often of a protuberant nature The edges are raised and infiltrated, and scattered lupoid tubercles are readily distinguishable extending into the healthy tissues, which are usually red and congested A considerable amount of sero-pus is often secreted, and this by drying forms thick scabs Any cicatrix which results from natural processes of cure is thin and vascular, easily breaking down from slight irritation The process extends gradually, with or without intermissions, from the seat of its first appearance, it is as a rule limited to the cutaneous tissues, but when it attacks the nose, the cartilages are often involved and destroyed, whilst if it involves the palate or septum nasi, perforation is very likely to follow The disease is almost painless, and does not at

first affect the general health Neighbouring lymphatic glands may become inflamed, and in a few instances are the seat of a tuberculous deposit Left to itself, it usually comes to an end sooner or later, the ulcerated parts cicatrizing, but leaving indelible traces of its ravages in the shape of obvious scars, with often considerable loss of substance Occasionally it persists in spite of treatment, and then an epithelioma may in time develop on the site of the mischief, running a rapid course owing to the vascularity of the part

Pathological Anatomy.—The characteristic microscopical feature of lupus lies in the formation of nodules around the smaller vessels of the skin, consisting chiefly of a mass of round cells, within which may perhaps be observed a giant cell and endothelioid cells, arranged in the same way as in tubercle

The **Diagnosis** of lupus from syphilitic and other destructive affections of the skin turns on the presence of outlying nodules beyond the spreading edge of the lesion, together with the apple-jelly-like granulations, and the thin, congested character of any cicatricial tissue present, whilst the slow, though continuous, progress and the tendency to heal at one part as it spreads at another are also suggestive of its presence The age and constitution of the individual, the absence of the Wassermann reaction, and the persistence of the disease in spite of treatment, must also be taken into account

In the **Treatment** of lupus reliance is now placed almost entirely on *heliotherapy* (p 299), both local and general, or on exposure to the ultra-violet rays of a *carbon-arc light* The *Finsen light* (p 299) similarly has curative powers In the latter each sitting lasts for one and a quarter hours, and an attendant whose eyes are shielded by dark glasses controls the crystal water-chamber, keeping it firmly against the skin, and slightly shifting it from time to time, so that an area as large as a shilling may be acted upon at each séance Slight inflammatory phenomena follow, and a local leucocytosis supervenes, as a result of which the disease disappears, and a soft supple scar is produced, which is often very little obvious This type of treatment has been found of most value where ulceration is absent and the patch of no great size *X-ray treatment* plays its part in the treatment of lupus The same precautions as to the protection of healthy tissues must be taken as for cancer (p 305) The best results have been observed by using a tube of comparatively low vacuum, and by working for a definite inflammatory reaction, when this has disappeared, the treatment is repeated The length of the course necessarily varies, but as a rule three to six exposures a week of not more than ten minutes each will suffice The X-rays act best on the ulcerative and fungating forms of lupus, which clear up and heal, but after this has been secured their action must cease, partly because they have no influence upon the small nodules of disease which remain entangled in the scar-tissue, and also because their prolonged action might terminate in the appearance of epithelioma For these nodules the Finsen or arc light treatment should be employed

When treatment of this type cannot be obtained, or where in spite of improvement nodules of the lupoid material persist, the lesions

may be dealt with by scraping with a lupus spoon, and subsequently applying solid nitrate of silver, acid nitrate of mercury on a match-end, chloride of zinc as a paste, solid powdered permanganate of potash, or even the actual cautery A pointed diathermic cautery is also useful for digging out and destroying localized lupus nodules Certain drugs may also be used to cause necrosis of the nodules in the diseased tissue, of which the best is pyrogallol, applied in a 10 per cent ointment (Whitfield)

Lupus Erythematosus is a disease the nature of which is not yet satisfactorily determined The appearance of the affection is tolerably characteristic, it is usually situated on the face, and in the most typical cases symmetrical patches are formed over the root of the nose and cheeks, corresponding in appearance to a butterfly with outspread wings The condition frequently invades the forehead, ears, and scalp, and occasionally appears on the trunk, being then unilateral It appears as a smooth hyperæmic surface, covered with a branny desquamation, the scales consist of inspissated sebum, and are continuous with deep plugs, which can be traced into the mouths of enlarged sebaceous follicles As the disease spreads peripherally, the older and central portions are transformed into cicatricial tissue of a pale, thin and white type, in marked contrast to the hyperæmic condition of the advancing margin It is usually seen in adults, and more frequently in women than men Progress is exceedingly slow, and ulceration uncommon except when the ears or scalp are involved, in the latter region the hair is often lost Epithelioma has also been known to follow this affection

The **Treatment** consists in attention to the general health, together with the local application of weak tarry and mercurial preparations The X-rays and Finsen light act rapidly, but must be used with caution, since the inflammatory disturbance caused by them is considerable

Affections of the Nails

A **Paronychia** (panaritium, or 'run around') is a condition frequently seen in surgeons, nurses, or others who have to expose their hands to infective material, as a result of infection of the semilunar fold at the base of a nail It is often preceded by a 'hang-nail,' which gives entrance to the organisms, and the patient's general condition may be unsatisfactory, not uncommonly, however, it is seen in hospital nurses and others who have just returned from a holiday, suggesting that they need to become immunized to their surroundings The skin at the side of the nail is swollen and hyperæmic, and on pressure is tender to the touch, gradually the pain increases and is particularly troublesome at night, perhaps preventing sleep A certain amount of discharge may occur through the semilunar fold, but a sufficient exit is rarely given by natural processes Unless effective treatment is undertaken, the suppuration spreads around the root of the nail to the other side, and also burrows beneath the nail, separating it from the matrix Granulations spring up freely from the semilunar fold, and thereby discharge is often prevented from escaping

Treatment in the early stages is by fomentations and the induction of passive hyperæmia by the application of Martin's bandage to the limb, the skin at the side of the nail is pared down, and if pus appears, an incision parallel to the basal margin of the nail through the inflamed tissues will give exit to the pus, and often suffices to cure the case If the pus has burrowed beneath the nail, one or more incisions must be made radially through the semilunar fold so as to expose the base of the nail, and permit all the loosened portion to be cut away from the matrix by sharp scissors, in some cases all the base of the nail has thus to be sacrificed The terminal portion may, however, be left, as it is serviceable while the new nail is forming Abundant granulations spring up from the matrix, and these may need to be kept in check by nitrate of silver

Ingrowing Toenail is an ulcerated condition of the soft parts projecting over the side of one of the toenails (usually that of the great-toe), and due either to the pressure of pointed or badly-fitting boots,

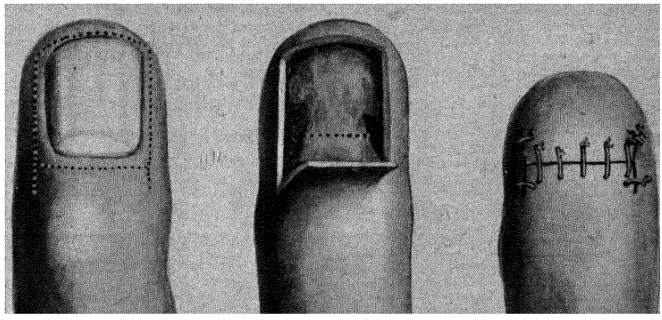


FIG 201 —OPERATION FOR INGROWING TOENAIL BY REMOVAL OF NAIL BED AND PORTION OF TERMINAL PHALANX

or to neglect in trimming the nails The fold of skin is thus pressed by the boot over and against the nail when the patient walks, and in order to diminish the pain and irritation caused thereby, he often cuts away the projecting angle of the nail, but leaves a deep corner, which still further irritates the soft parts Ulceration ensues, accompanied by an offensive discharge and so much pain as to prevent the patient from walking The matrix of the nail may also become inflamed, and onychia result In the earliest stages, further progress can often be prevented by careful attention to the nails, by the use of square-toed boots fitting easily, and by introducing small plugs of aseptic wool to press back the overhanging fold of skin A cure can sometimes be effected by excising an oval portion of skin from the side of the toe and close to the nail The edges of the incision are drawn together by horsehair, and thus the overgrowing fold of skin is drawn away from the nail It is more satisfactory, however, to excise the overhanging fold of skin completely so as to expose the side of the nail, which can also be cut away, if necessary, together with

the projecting angle This latter treatment must always be adopted when ulceration and suppuration are present In those cases where the condition tends to recur, it is advisable to remove the whole nail-bed, excise the distal portion of the terminal phalanx, and close the wound completely as in Fig 201 This always results in a permanent cure

The term **Onychogryphosis** is applied to a hypertrophic condition of the nails, which become distorted and bent, or twisted up, perhaps simulating a ram's horn It is usually limited to the great toes of elderly people, and is due to neglect The nails are very rough, and often covered with grooves or ridges, whilst beneath them is an accumulation of soft, offensive epithelium The only treatment is removal

Affections of the Sebaceous Glands.

Sebaceous Cysts occur in any part of the surface of the body, but especially the scalp, and are due to obstruction of the duct of a sebaceous gland They are rounded swellings, firm and elastic to the touch, movable on the deeper structures, and always attached at one spot to the skin On careful examination the obstructed mouth of a sebaceous follicle can usually be seen, and possibly some of the contents of the sac squeezed through this opening The cyst wall is formed by several layers of epithelium, surrounded by dense fibro-cicatricial tissue, and if exposed to irritation or pressure, as when situated on the back or shoulder, and rubbed by the braces, becomes very firmly adherent to the surrounding parts The material contained within is of a cheesy, pultaceous consistency, with a peculiar stale odour, yellowish-white in colour, and under the microscope is seen to be composed of fatty and granular débris, epithelial cells, and cholesterine Left to themselves, the cysts may attain considerable dimensions, whilst the walls and contents sometimes become calcified Occasionally the exudation oozes through the duct, and dries on the surface, with just sufficient cohesion to prevent it from falling off, layer after layer of this desiccated material is deposited from below, finally giving rise to what is known as a **Sebaceous Horn.** These become dark in colour from admixture with dirt, and are always more or less fibrillated in texture, the base, to which they are firmly adherent, is infiltrated and hyperæmic Sebaceous cysts sometimes inflame and suppurate, sooner or later they burst or are opened, and then the process subsides They may be cured in this way, but more frequently the cyst fills up again, and the same series of phenomena are repeated after an interval Should the contents only escape partially, the remainder is liable to undergo putrefactive changes, giving rise to an offensive ulcerated surface with raised edges, which may readily be mistaken for epithelioma It is sometimes known as *Cock's Peculiar Tumour* True malignant disease of an epitheliomatous nature is said occasionally to supervene

Diagnosis.—From a *dermoid cyst* it is known by the facts that the dermoid is congenital in origin, that it is limited to certain localities, whilst it is hardly ever directly attached to the skin From a *fatty*

tumour it is recognized by its rounded shape, its fixity to the skin, the absence of lobulation, and by its more solid character, whilst a lipoma is softer and more movable From a *chronic abscess* it is distinguished by the dilated orifice, by its firmer consistency, and by the history

Treatment.—A sebaceous cyst should be entirely and completely removed if giving rise to any disfigurement, inconvenience, or pain In the scalp all that is needed is to transfix the tumour, squeeze out the cheesy contents, and then the cyst wall can be readily removed by grasping it with dissecting forceps and pulling it away In other situations the cyst wall may require to be dissected out, but even then it is advisable to open it by transfixion, and to deal with the sac from within Horns and fungating ulcers should be excised with the surrounding skin

Occasionally a true **sebaceous adenoma** develops in connection with these cysts It may be slowly-growing and of a firm, solid consistency, but sometimes it is much more vascular and grows rapidly The latter has a form of semi-malignancy in that it is very liable to recurrence, and has therefore often been mistaken for a sarcoma On microscopic section it closely resembles a rodent ulcer, but its clinical history is quite distinct Its most frequent situation is the scalp, and it requires to be removed with a free hand, the defect in the scalp being made good by Thiersch-grafting

Molluscum Contagiosum —This affection shows itself in the form of a number of firm hemispherical nodules, a little larger than a split pea, usually of a yellowish-white colour, and very definitely umbilicated The depression in the centre may be occupied by dry débris, and from the larger ones a waxy mass can be expressed They are usually seen on the face, but may involve any part of the surface of the body There seems no doubt as to their contagious properties, this being perhaps best seen in the development of growths of this nature on a mother's breast, secondary to those on the face of her baby, but the cause of the contagion is by no means certain Pathologically, the tumours consist of numerous wedge-shaped lobules of polygonal, nucleated, epithelial cells, supported by a fibrous stroma The cells towards the centre undergo a waxy or hyaline degeneration, and in them are seen numerous rounded bodies, which have been supposed to resemble psorosperms *Treatment* consists in cutting or pulling them away, or in cutting them across, and squeezing the contents out from the well-defined capsule

Rodent Ulcer (basal-celled carcinoma) is a special variety of glandular cancer, commencing either in the sebaceous glands or in the basal layer of the rete Malpighii It is usually met with in elderly patients, though occasionally observed in those under forty, and is seen with special frequency on the upper two-thirds of the face, the skin below the inner and outer canthi being the chief seats of election It commences as a papule or flat-topped nodule in the skin, surrounded, perhaps, by an area of hyperæmia The infiltration extends gradually in all directions, but the ulceration usually keeps pace with the new growth The ulcer has a smooth but somewhat depressed surface, is

perhaps covered with granulations, and bounded by a slightly raised, indurated, rolled-over edge (Figs 202 and 203) In most cases one can detect evidences of the new formation beneath the skin beyond the edge If kept aseptic there is but little discharge, and imperfect attempts at cicatrization are often observed, the scar, however, readily breaking down, but when septic, the surface is covered with sloughs, and an abundant offensive discharge escapes The condition is painless, neighbouring lymphatics are not enlarged, and the general health does not suffer, except in the later stages The progress of the case is slow, but continuous, and although it spreads for a time superficially rather than deeply, sooner or later underlying structures become involved, and then nothing hinders the destructive process, even the bones of the skull being eroded and the dura mater exposed



FIG 202 —RODENT ULCER OF MANY YEARS STANDING



FIG 203 —LARGE RODENT ULCER OF FIFTEEN YEARS' STANDING

Microscopically, the growth consists of interlacing columns of epithelial cells, interspersed with fibro-cellular tissue (Fig 204) The constituent cells are small, globular, and closely packed, never of the 'prickle-cell' type, and rarely show signs of keratinization, hence 'cell-nests' are uncommon, although they are sometimes observed The cells of the peripheral layer, however, are often elongated and arranged side by side like a palisade The deep processes spread laterally rather than deeply beneath the unaffected skin, the papillæ of which are atrophied, their outline is clearly defined, and frequently angular on section There is but little infiltration of round cells around the epithelial columns

Treatment —There are only two efficient methods of dealing with rodent ulcer, *viz* excision and radio-therapy, the use of caustics has been entirely superseded Where possible, the method of choice consists in free *excision*, a margin of at least half an inch all round

being allowed, the defect is then made good by neat suturing, skin-grafting, or some plastic operation Inasmuch as the most frequent site of the trouble is the face, the ultimate æsthetic effect must be most carefully considered

Radio-therapy by means of X-rays or radium is on the whole more satisfactory in the great majority of cases Formerly observers used massive doses at long intervals, but it is beginning to be realized that



FIG 204 —RODENT ULCER

a continuous series of small doses produces better results A complete healing of the part may follow, with disappearance of all the thickening, but recurrence is not uncommon, and then a repetition of the irradiation is often unsatisfactory The influence of the rays upon the healthy cells of the part is of a depressant character, and hinders them from taking their due share in the reparative process which is essential

CHAPTER XVIII

AFFECTIONS OF MUSCLES, TENDONS, AND BURSÆ

Injuries of Muscles and Tendons.

Contusion.—Muscles are bruised as a result of blows or falls, leading to more or less extravasation, with possibly some rupture of the fibres The part becomes tender and swollen, and any active contraction gives rise to pain, passive movement, however, is tolerated if the injured fibres are not thereby put on the stretch Fomentations and rest may be needed for a few days, but regular massage, and perhaps elastic support, are subsequently necessary

Sprains and Strains, due to violent efforts or falls, result in the tearing or stretching of some of the fibres Considerable pain and stiffness follow, especially in rheumatic and gouty patients Rest and firm pressure should be used at first, to minimize effusion or to ensure its absorption The limb must be placed in such a position as to relax tension on the injured part, and often a pad or firm bandage over the tendon at a little higher level will steady it and enable it to be used without pain Elastic pressure, massage and the alternate application of hot and cold water will do much to ensure complete recovery, which is most important, especially in subjects liable to rheumatism or tubercle

Bowler's Arm.—This condition is due to a strain of the coraco-brachialis or the long head of the biceps, and often occurs after a long spell of fast bowling, manifesting itself at the end of the day when all movements of the arm appear to be painful

Absolute rest from bowling for at least two weeks is essential, during which time massage and active movements should be encouraged

Tennis Elbow falls into this category It is usually due to a strain of the pronator radii teres, induced by a sudden twist of the forearm in the effort to put ' top spin ' on the ball, and occurs most commonly in the earlier part of the tennis season, before the muscles have become habituated to the unusual exercise Aching pain is experienced in the front of the forearm, and efforts at active pronation are agonizing Complete rest from the game for a time is essential, and the pressure of a firm bandage or strapping over the painful part desirable, massage and remedial exercises are subsequently required

Tennis Leg, although an unfamiliar condition in this country, is well known in America The term is used for defining a group of injuries characterized by slight or more serious damage to the muscles, tendons, and aponeuroses forming the triceps cruris Under it are also included injuries caused by a violent strain of the plantaris tendon Early fixation in full plantar flexion is the treatment to be adopted, followed

by the use of a high-heeled boot when the patient begins to walk about

Rugby Wrist.—This is due to a bruising of the triangular fibro-cartilage which separates the lower end of the ulna from the wrist-joint, and is caused by handing off with the ulna side of the hand Movements of the wrist-joints are painful and restricted

The **Treatment** consists of deep massage combined with diathermy Recovery may be expected within three weeks

Trigger Finger—Although this condition may be congenital, it is far more often traumatic in origin, and is the result of a sprain of the finger The condition occurs chiefly in manual workers, particularly women When the patient attempts to straighten the finger from the flexed position, she finds that this can only be managed with an effort and the finger finally snaps straight The tendon sheath should be opened and the thickened portion of the sheath removed

Snap Thumb—This is an allied condition to trigger finger, in which there is an obstruction to the free movement of the long flexor tendon of the thumb, caused by a thickening of the sheath as it passes between the two sesamoid bones at the metacarpo-phalangeal joint

Treatment consists in incising the tendon sheath, which allows free movement of the tendon

Rupture of the Sheath of a muscle is an accident occasionally met with, especially in the adductors and rectus abdominis The belly of the muscle, when relaxed, protrudes through the opening as a hernia, constituting a soft semi-fluctuating swelling In treating this condition the limb must be kept at rest in such a position as to relax the muscular fibres and allow the rent in the fascial sheath to heal In old-standing cases it is justifiable to cut down upon and expose the opening in the muscular sheath, the edges of which are sutured together, or if this cannot be effected a graft of fascia lata may be stitched over the defect

Displacement of Tendons rarely occurs except in parts where these structures pass through osseo-fibrous canals, and particularly in those where the line of action is thereby changed During some violent effort the patient feels a sudden localized pain, followed by a certain amount of limitation of mobility This accident is popularly known as a 'rick' In superficial parts the displaced tendon can sometimes be distinctly felt in an abnormal position, and this becomes more evident on attempting to move it Thus the long tendon of the biceps may be dislocated from the bicipital groove, and various tendons about the wrist or ankle, especially that of the peroneus longus, may similarly suffer If left alone, the parts settle down more or less comfortably, but some permanent weakness may persist, recurrence is very likely to ensue if movement is permitted before the newly-formed connections have had time to consolidate

Treatment consists in fully relaxing the muscles and replacing the tendon, if possible, by manipulation The parts are then immobilized for six or eight weeks by a plaster of Paris splint or strapping If the displacement recurs, it is sometimes advisable to expose the tendon and stitch it back into position, using early passive movement to

prevent the formation of troublesome adhesions This is required most frequently in the case of the peroneus longus tendon, which slips forwards from its groove behind the external malleolus The external annular ligament is thereby ruptured, and the operation consists either in suturing the divided segments, or in more aggravated cases it may be necessary to turn down a flap of periosteum from the malleolus, and by stitching its apex to the outer side of the os calcis secure the tendon in place

Rupture of Muscles and Tendons is by no means uncommon, resulting from violence of an unexpected nature Most frequently the tendon gives way at its union with the muscular belly, less often

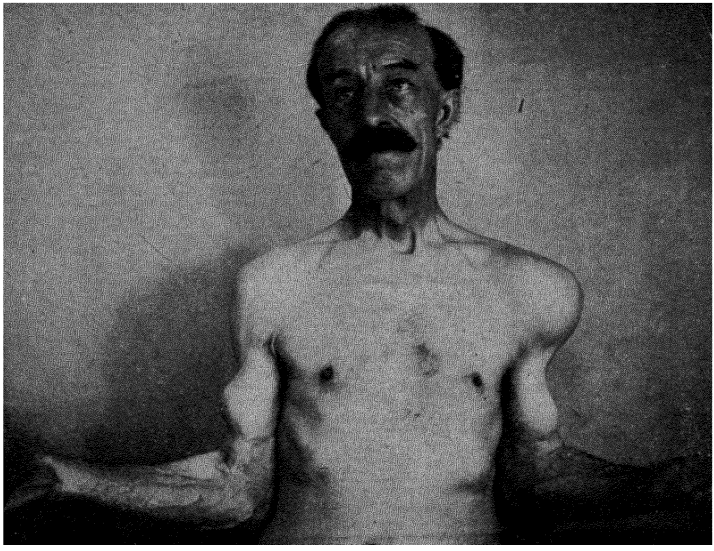


FIG 205 —BILATERAL RUPTURE OF THE LONG HEAD OF BICEPS HUMERI

the belly itself yields, whilst occasionally the tendon may snap, or the point of bone to which it is attached may be torn off

Signs —The patient at the moment of the accident experiences a sharp and severe pain, as if he had been struck with a whip, he may also feel or hear a snap Loss of function follows, together with a certain amount of pain, swelling, and bruising, which are more evident if the muscular fibres have been torn across than if the tendon alone has been lacerated On attempting to contract the affected muscle, the belly rises up as a soft, rounded, semi-fluctuating tumour (see Fig 205), drawn towards the uninjured attachment, if the union between the tendon and belly has given way, whilst if the lesion has been through the muscular substance, the divided halves of the belly become similarly prominent, and a distinct gap or sulcus can be felt between them

Repair is established by the formation of granulation, and finally

of cicatricial tissue Where a muscle is involved and the ends are much separated, a long and weak bond of union forms, but when they are closely apposed, the cicatrix is short, and may be replaced subsequently by true muscular tissue When a tendon has been divided or torn, the connecting medium is at first attached to the sheath, and if this adhesion persists, it may lead to pain and weakness It is an interesting fact to note how rapidly this tissue becomes strong, a rabbit's tendon ten days after division requires a weight of 56 lbs to break it (Paget)

Treatment.—It is essential to relax the parts fully so as to limit the separation of the divided ends and to maintain them in this position for two or three weeks Any resulting stiffness is combated by passive movements and massage, whilst, if need be, adhesions are broken down under an anæsthetic Tendons accidentally divided in open wounds should be sutured together by silk or catgut, careful antiseptic precautions being adopted to prevent suppuration along the tendon sheaths Where there has been actual loss of substance in a tendon, one may be split longitudinally in such a way as to leave a thin flap attached peripherally, so that the free end can be turned down and united to the other segment (Fig 206), or similar flaps may be provided from each end (Fig 207), or it is possible to remedy the defect by grafting a portion of tendon from another region or person, or from an animal, between the two ends Care must be exercised to prevent opposing muscles from dragging on and stretching the new bond of union, as thereby considerable functional disability may result

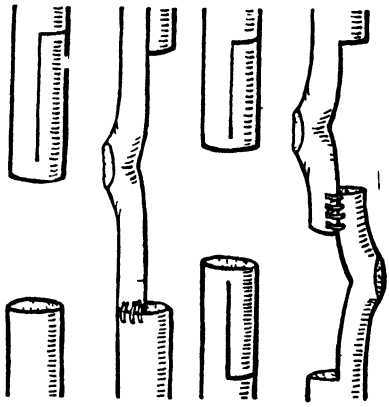


FIG 206 FIG 207

METHOD OF UNION OF TENDON AFTER LOSS OF TISSUE

In Fig 206 the flap is taken from one end only, in Fig 207 from both ends

Muscular bellies which have been divided longitudinally or obliquely are easily united by sutures, but when the section is transverse, the stitches tend to cut out, unless the sheath can also be secured In such a case it is advisable to encircle with a ligature a bundle of muscular fibres on either side of the incision, and then tie the two threads together This must be done at several spots in the cross-section

The *long tendon of the biceps* is not unfrequently torn from the muscular belly, which, on attempting to bend the arm, is drawn down towards the elbow, constituting a soft tumour, somewhat resembling a lipoma No special treatment is needed beyond keeping the forearm flexed for a time If the *tendo Achillis* is ruptured, union may be attained by keeping the knee bent and the heel raised, as by securing

a strap to the back of a slipper below, and to a dog-collar or suitable strap passed round the knee above A better result, however, would follow an aseptic incision and suture Similarly, if the *ligamentum patellæ* is torn across, suture through an open wound gives the best result The *inner head of the gastrocnemius* is sometimes torn in wrenches or slips, as at lawn tennis, and the *plantaris* is similarly affected (see p 458) The *adductor longus* may be lacerated in violent attempts to maintain a seat on horseback, and constitutes one form of rider's sprain, it is treated by rest and the application of a firm spica bandage, but in bad cases operation may be required

The *long tendons of the fingers* are not unfrequently divided accidentally, and unless they are effectively sutured considerable impairment of function will result, the finger remaining in a position of flexion or hyperextension, according to whether the extensors or flexors are involved Operation to secure the divided ends should be undertaken at the earliest possible moment, but not until suitable aseptic conditions are present (see Fig 208) Owing to the existence of a sheath the *flexor tendons* retract considerably, and a longitudinal incision in the middle line of the finger may be required to reach the proximal end Its position can be indicated by the passage of a probe up the sheath, which is *incised only opposite the retracted end of the tendon* A suture is introduced into the tendon and carried down the sheath, and thereby the retracted tendon is drawn again to the site where it was divided and secured to the distal end By this manœuvre an extensive incision of the sheath is avoided, and adhesions are minimized The finger must subsequently be kept on a splint, and active movements are not permitted for ten days

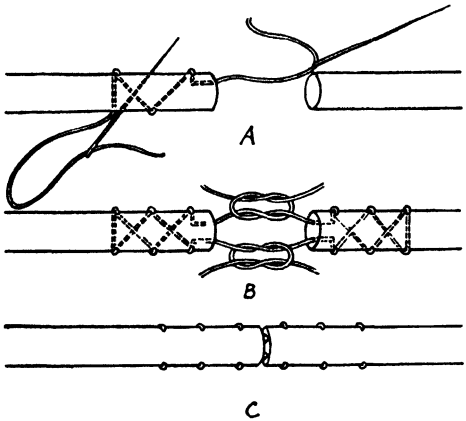


FIG 208 —THE TECHNIQUE OF TENDON SUTURE

The ends of the tendons are first trimmed First one and then the other is transfixed with silk threaded into two needles The ends of the tendon are brought into apposition and the sutures tied The knots lie between the ends of the tendon A shows the method of suturing each end, and B shows diagrammatically how the knots lie In C the appearance on completion of the operation is shown

The *extensor tendons* have no synovial sheath on the fingers, and hence there is but little difficulty in securing them by suture, except when the attachment to the terminal phalanx is torn through, a not uncommon accident The aponeurosis retracts and the thickened divided end can be felt opposite the centre of the second phalanx

the terminal phalanx is bent and constitutes the condition known as a *mallet finger* Fixation of the finger in a position of extension is useless in this condition, as approximation of the tendon to its point of attachment is not effected Open operation is often unsatisfactory, since the tendon is torn completely away from the bone, and there is nothing to which to fix it Good results are often obtained even at a comparatively late stage by putting up the finger with the metacarpo-phalangeal and first interphalangeal joints fully flexed, the second interphalangeal joint being extended—an uncomfortable position at first (see Fig 209) The extensor aponeurosis is so attached that flexion of this type drags it downwards and relaxes its terminal segment so that satisfactory union is by this means much more likely to occur

Contraction of tendons with a resulting deformity or disability will be produced by any condition which leads to destruction of muscle substance or partial loss of the tendon itself It is likely to be associated with adhesions of the muscle to skin or fascia, or of the tendon to its sheath, and in military work may be complicated by nerve lesions Occasionally it develops apart from open wounds, as in

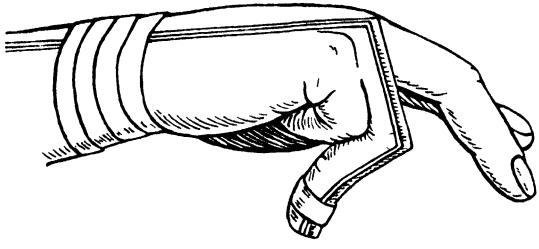


FIG 209 —SPLINT FOR MALLET FINGER

Volkmann's contracture and in certain nerve lesions The possibility of the occurrence of this trouble should ever be kept in mind by the surgeon, so that preventive measures may be early instituted When contraction has occurred, it is sometimes possible to overcome it by massage and ionization, but when a powerful muscle, such as the gastrocnemius, is involved, it is probably wiser to divide the tendo Achillis, and this should be effected, not by subcutaneous cross-section, but by open or subcutaneous division according to the **Z**-method (p 473), so that the exact degree of lengthening necessary may be secured In the case of less powerful muscles, as when the fingers are affected, treatment by splints, as described below, may be effective, but when the tendons are adherent to their sheath this is not very satisfactory, unless the adhesions can be broken down and the tendon thereby freed

Diseases of Muscles.

Inflammation of Muscles (Myositis) may arise from a variety of circumstances, but the chief results are alike, whatever the cause, *viz* a more or less painful infiltration of the muscle, with increased

discomfort on attempting movement. The part feels hard and rigid, and may be tender to the touch. If suppuration ensues, the ordinary signs of an abscess subsequently make themselves evident A certain amount of contractile tissue is thereby destroyed, and the cicatricial changes induced will possibly lead to deformity

Varieties.—1 **Simple Traumatic Myositis** results from contusion or laceration of the fibres, and is merely a plastic inflammation, with or without hæmorrhage, running on to resolution, with perhaps a little fibroid thickening of the part It is liable in some cases to become chronic, the muscle substance becoming shortened and replaced by fibrous tissue (*M fibrosa*), and this fibrosis may extend beyond the limits of the original lesion The induration of the sterno-mastoid muscle met with in children is of this type, and may lead to torticollis

A somewhat similar condition is known as Volkmann's **Ischæmic Contracture.** It is usually seen in children as a complication of fractures of the forearm or lower end of the humerus, which are treated by splints or firm bandages, but sometimes occurs due to great swelling of the arm following a fracture where no splints or bandages have been used At the end of two or three weeks the flexor muscles become hard and contracted, and the fingers flexed and clawed, the wrist being hyper-extended The deformity of the fingers disappears on flexion of the wrist, demonstrating thereby that no adhesions of tendons to sheaths are present It is recognized from a nerve lesion by the absence of sensory or trophic phenomena It is probably due to a necrobiosis of the muscular tissue from deprivation of blood owing to the pressure of a splint or bandage, and this is followed by a spreading myositis fibrosa

Treatment is somewhat tedious and painful It is best accomplished by the persistent use of splints applied so as gradually to stretch the contracted parts Thus the hand is first put up with the wrist fully flexed and the fingers straight, though bent at the metacarpo-phalangeal articulation By slow degrees the fingers are extended at this latter joint until the hand can be kept completely straight with a fully flexed wrist The next stage consists in gradually extending the wrist with the hand straight, and it is remarkable how satisfactorily this treatment can restore the mobility of the hand and fingers, thereby avoiding the serious operative measures formerly adopted, such as lengthening of all the finger tendons or shortening of bones

2 **Rheumatic Myositis,** or muscular rheumatism, is a condition often met with, especially in middle-aged men of rheumatic or gouty temperament who do not take enough exercise and live well Septic teeth are also a frequent cause The condition mainly involves the fibrous tissues, *e g* the fasciæ, aponeuroses, tendons and sheaths of muscles, or the ligamentous tissues of joints, hence the name **fibrositis** is often applied to it Some forms of neuritis result from a similar affection of nerve sheaths (p 393) Any part of the body may be involved, but in particular may be noted *lumbago*, in which the fascia lumborum is affected, the patient walking with a stiff back slightly

flexed, the pain often starts suddenly during some effort, and when present any unexpected movement elicits a sharp spasm Rheumatic wry-neck is a similar condition, and may be induced by exposure to a draught Pains in many joints—shoulders, knees, tendo Achillis, etc —are of a similar nature, and sometimes are distinctly influenced by climatic conditions

Treatment —A good dose of calomel is in many cases desirable at the start, followed by suitable dietetic or medicinal remedies, and the teeth must be put into a good state of repair Iodide of potassium is by some authorities looked on as always desirable In the more active stages the part must be kept at rest, and dry or moist heat applied to relieve pain, whilst aspirin may be given for a similar purpose Various methods of applying radiant or other forms of heat have been already alluded to (Chapter XI , p 294) Vibro-massage is in many cases valuable Hydrotherapy, when it can be utilized, is useful (p 295), and the patient must be subsequently instructed to take more exercise and to live more simply

3 **Acute Suppurative Myositis** is due to infection with pyogenic organisms, either from without, as after operation, or in penetrating injuries, etc , or from within the body, as in pyæmia, or by extension from neighbouring suppurative foci, as from subperiosteal abscesses, it may also arise from a contusion or sprain by auto-infection The local and general symptoms are severe, and pus is liable to spread widely within the sheath, or along fascial planes, great cicatricial deformity is likely to follow

Treatment consists in providing efficient drainage to the part, the wound being dressed by one of the methods already indicated This usually involves opening up the sheath freely, and the muscle may subsequently become adherent to the scar, and considerable deformity, disability and pain may result henceforth on using the part After gunshot wounds, where muscles are frequently torn and infected, these troubles are constantly met with, and the functional value of arms and legs is much diminished thereby In the treatment of these cases care must be exercised to adopt that position of limb which will leave the least contracture, as thereby deformities may be prevented When the scars have formed, ionization with sodium chloride often has a valuable influence in making them more supple, and massage assists in restoring utility to the part

4 **Chronic Tuberculous Myositis,** with the formation of a chronic abscess, is not an uncommon secondary consequence of a similar affection of neighbouring bones or joints, *e g* a psoas abscess

5 **Syphilitic Disease** is usu lly met with in the tertiary period, and takes the form either of a diffuse sclerosis or of a localized gumma Any muscle may be affected, but perhaps the tongue and sternomastoid are those most frequently involved Care is needed in order to diagnose these conditions from tumours, but the presence of a syphilitic history and a positive Wassermann reaction, the slow growth, the hardness with subsequent central softening, and the rapid disappearance after the administration of iodide of potassium, should suffice to determine their nature

Occasionally gummata appear in muscles in the shape of small, hard and shotty nodules, usually arranged more or less longitudinally, which are painless and apparently attached to the fascial sheath. They react readily to iodide of potassium

6 **Parasitic Myositis,** arising from the presence either of the *Trichina spiralis* or of hydatids, need not be described here

7 **Myositis Ossificans** is a rare disease, usually seen in young males, in which various muscles, especially those of the back, are transformed into bony plates or rods, so as to lead to extensive ankylosis The process seems to be one of ossification of the connective tissue associated with atrophy of the muscular fibres, and is sometimes extremely painful In a boy under observation the arms were immobilized by ossification of the latissimus dorsi muscles on either side, whilst the pectoralis major was also ossified on the right side (Fig 210) The erector spinæ was involved, the back being rigid, and the right trapezius was undergoing the same change This disease is often associated with a congenital deficiency of the proximal phalanx of the great-toes No treatment has proved of any value

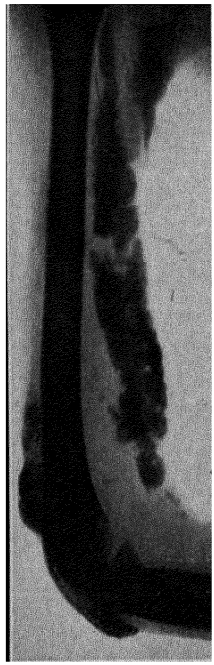


FIG 210.—SKIAGRAM OF A CASE OF MYOSITIS OSSIFICANS OF THE ARM MUSCLES

Quite distinct in nature is the *Traumatic Myositis Ossificans*, of which two varieties are described (i) The new formation results from persistent and repeated irritation of muscles or tendons, and usually starts from the periosteal attachment The 'rider's bone' developed in the tendon of the adductor longus is of this description (ii) Less commonly the affection follows a severe injury to a muscle associated with a fracture or dislocation, whereby the periosteum is torn and bone-cells (osteoblasts) are set free A certain amount of hæmorrhage follows, and in the reparative tissue developed in the muscle the bone-cells find a suitable nidus for development, and the new tissue formed undergoes ossification In about three or four weeks the presence of bone can be recognized by palpation as a deep indurated mass, usually movable on the bone and across the fibres of the muscle involved, at a later date the new bone can be seen by radiography (Fig 211) Painful limitation of movement may ensue, but if possible the condition is left alone, unless the disability is great, and then removal must be undertaken The muscles in which this change has been most commonly observed are the quadriceps femoris and the brachialis anticus

Tumours of Muscles are not very common Primary growths consist of angioma, lipoma, fibroma, chondroma, myxoma, or sarcoma,

and of these the majority start in the fibrous sheaths of the interfibrillar connective tissue Secondary deposits of both carcinoma and sarcoma also occur **Treatment** is conducted on ordinary surgical principles If sarcomatous, the whole thickness of the muscles should, when possible, be excised for some distance from the growth, since the lymphatics run in the direction of the fibres, but the sheath forms a limit not early overstepped Amputation of the limb may, however, be required

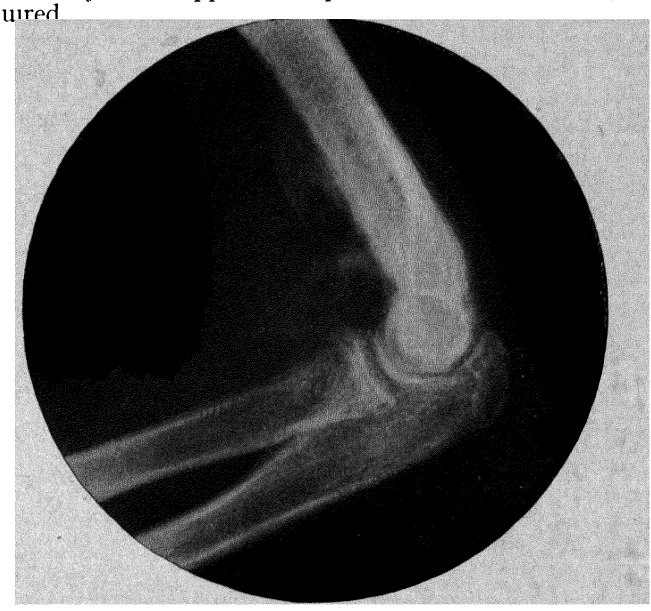


FIG 211 —MYOSITIS OSSIFICANS OF THE BRACHIALIS ANTICUS

Skiagram taken one month after injury Note the clear zone between the shadow and the shaft of the humerus The commonest sites are the brachialis anticus and the quadriceps

Diseases of Sheaths of Tendons

1 **Acute Simple Teno-Synovitis** often follows sprains and strains, and is most commonly seen in connection with the extensor muscles of the thumb A puffy swelling in the course of the tendon is produced, painful on movement and perhaps tender to the touch, giving a characteristic fine crepitus whenever the parts are moved

Treatment —Immobilize the limb for a few days, and apply fomentations As soon as the more acute symptoms have disappeared, massage is employed to hasten the absorption of the fluid, whilst active and passive movements are undertaken to prevent the formation of adhesions

2 **Acute Suppurative Teno-Synovitis** may result from a punctured wound of the synovial sheath, or the inflammation may spread to it

from neighbouring tissues The thecal variety of whitlow (p 246) is of this nature Suppuration may extend both up and down the sheath, and unless promptly treated by incision, the tendon will slough, or may contract extensive adhesions to neighbouring parts, in either case considerable impairment of function is likely to follow When the tendon survives, active and passive movements must be started very early if the formation of serious adhesions is to be prevented The suppuration may affect neighbouring articulations, leading to their disorganization, especially in the case of the tendon sheaths around the wrist-joint

3 **Chronic Simple Teno-Synovitis** is a common affection, characterized by a passive effusion into the tendon sheath of glairy synovia somewhat resembling uncooked white of egg An elastic fluctuating swelling forms in the course of a tendon, usually associated with creaking In the more limited varieties it constitutes one form of ganglion There is no pain or tenderness, but the affected part feels weak **Treatment** consists in counter-irritation and pressure, as by Scott's dressing, failing this, the part may be freely incised, the synovia removed, and, if need be, the cavity washed out In the more localized forms it may suffice to puncture the cyst-like swelling and squeeze out the contents, pressure being subsequently applied

4 **Stenosing Teno-Vaginitis** is found in relation to the short extensors of the thumb and often more commonly in women Although there is no history of trauma, yet repeated small unrecognized injuries may play their part in the causation of this condition, which has a very insidious onset Pain is the reason why the patient seeks advice, the pain is caused by active abduction of the thumb, and usually a visible swelling is present over the styloid process of the radius (Fig 212) The swelling is ovoid in shape, and is tender on pressure Pain can be elicited by abducting the thumb, and is caused by obstruction of the free movements of the tendons of abductor pollicis longus and extensor pollicis brevis as they pass beneath the dorsal carpal ligament

Operation is the only **Treatment** which is of any avail, and is nearly always successful The actual operation can be performed under local anæsthesia, an incision is made through the skin over the swelling and the superficial fibrous sheath of the tendons excised (Fig 212) The tendons can be made to move quite easily after this, and the skin is then sutured

5 **Chronic Tuberculous Teno-Synovitis** is of two types In one the sheath is lined by œdematous granulation tissue of some thickness, containing tuberculous foci, giving rise to a soft elastic swelling along the course of a tendon, which increases slowly in size, and is but slightly painful or tender Suppuration may follow, and subjacent bones or joints be involved

The other form of tuberculous disease consists in a passive effusion into the synovial space, the lining membrane of which becomes thickened by the deposit thereon of fibrinous material This is often detached, and by the movements of the part the loose fragments of fibrin are moulded into various shapes In tendon sheaths they are

often elongated, and constitute the so-called *melon-seed bodies*, but when they occur in joints, they remain somewhat flattened, whilst in bursæ they approximate more to the spherical On examination, they are found to be structureless, though sometimes laminated When numerous, they give rise to a curious and characteristic form of crepitus That they are of a tuberculous nature can be demonstrated by inoculation experiments, the bacilli contained therein are not, however, in a very active state, and the prognosis of this type is more favourable than that of the former

The **Treatment** of both these forms consists in the local application of the principles described at p 175 The patient is put under the best climatic and general conditions that are possible, and the affected part is immobilized The application of Scott's dressing may be desirable, and passive hyperæmia by means of an elastic bandage should be practised daily Suppuration, if it occurs, is dealt with

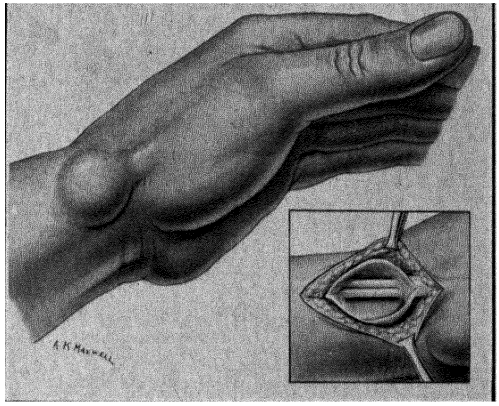


FIG 212 —OPERATION FOR STENOSING TENO-SYNOVITIS

by tapping, but if the effusion in the latter variety becomes excessive, it may be wise to incise the sheath and wash out the melon-seed bodies together with the fluid, but under no circumstances should extensive operations be undertaken for the removal of the tuberculous tissue

A **Ganglion** is the term given to a localized cyst-like swelling forming in connection with a tendon sheath or joint It is most commonly met with at the back of the wrist, arising from the tendons of the radial extensors of the carpus, and those of the thumb or index finger, but it sometimes occurs on the front of the wrist or in the foot (Fig 213) It varies in size considerably, and contains a clear, transparent, gelatinous or colloid substance A rounded, firm, elastic swelling is produced, usually somewhat movable, and neither painful nor tender at first, although some painful weakness of the part may be experienced as it increases in size It may result from a chronic localized teno-synovitis, or from a hernial protrusion of the synovial membrane

through an opening in the sheath, certainly some few arise in connection with subjacent articulations, in the same way as a Baker's cyst Another theory is that ganglia arise as a mucoid degeneration in fibrous tissue adjacent to a tendon sheath or joint Little difficulty arises in the diagnosis, although, when situated deeply and closely attached to a bone, they have been mistaken for exostoses, their connection with a tendon sheath is indicated by the possibility of moving them at right angles to the direction of the tendon, but not up and down

Treatment —A ganglion may often be ruptured by manipulation and pressure with the thumbs Failing this, a rapid cure is usually obtained by an aseptic puncture of the cavity, and the subsequent application of firm pressure In some cases it may be advisable to lay the part open and remove the cyst wall as completely as possible, such treatment requires absolute asepsis, since, if infection occurs, most serious consequences may ensue

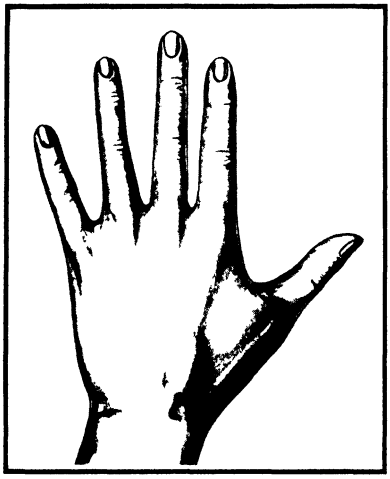


FIG 213 —GANGLION OF EXTENSOR TENDON OF THE HAND

A **Compound Palmar Ganglion** consists in a tuberculous affection of the common synovial membrane surrounding the flexor tendons of the wrist, the cavity being distended in the early stage with a glairy fluid, usually containing many melon-seed bodies, and perhaps later on with pus In the early stages all that is noted is a fulness about the front of the wrist and palm, the normal hollow being obliterated Later on a more definite swelling is observed, and this is found to extend into the thenar eminence, due to the involvement of the tendon sheath of the flexor longus pollicis The condition is painless at first, and there is but little interference with the mobility of the tendons, but in the later stages the tendons may become matted together, and the movements of the fingers hampered, or if the disease ends in suppuration, the pain and disability become more marked In all stages fluctuation can usually be detected above and below the annular ligament, being transmitted beneath it

Treatment is of the usual anti-tuberculous type The patient is sent to a sanatorium or placed in conditions approximating to it The hand is kept at rest, but one full range of movements should be allowed daily so as to guard against unnecessary adhesions Passive congestion by the use of a Martin's bandage is practised each day for an hour or two If the effusion shows no signs of absorption after a sufficient interval, it may be removed by tapping and washing out,

but there must be no handling or displacement of the tendons Suppuration is dealt with by tapping, or if the skin becomes thin and undermined, by free incision and packing with gauze soaked in iodoform and glycerine Operative treatment may be undertaken, the whole palmar bursa being removed by dissection

Myeloma may arise in connection with the tendon sheaths of the fingers A soft rounded swelling is seen on the dorsal or lateral surface of the finger (Fig 214) Excision of these small tumours is quite easy,

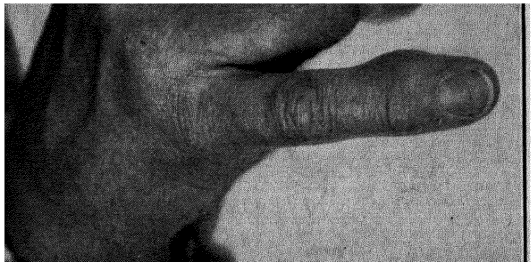


FIG 214 —MYELOMA OF EXTENSOR TENDON OF THE LITTLE FINGER

and recurrence does not take place On section the tumour mass is of an orange-yellow consistence, and microscopically giant cells are in evidence, but not as a rule so numerous as in the myelomata which are found in bones

Operations on Tendons

1 By **Tenotomy** is meant the division of a tendon through an open or subcutaneous wound with the object either of remedying some deformity, such as talipes or torticollis, or of assisting in the reduction of some displacement, as in setting a fracture It is accomplished in two ways, *viz* by subcutaneous or open incision The **subcutaneous** method is employed where there is little likelihood of injuring important structures The strictest attention to asepsis is essential, since the character of the wound, *viz* a puncture, and the entire absence of drainage, are most favourable to the development of organisms, if entrance is once given to them Moreover, the synovial tendon sheath is often, though undesignedly, wounded, and infection spreads rapidly along such a structure, and gives rise to serious consequences The operation consists in inserting a sharp-pointed tenotome through the skin down to the tendon This is then withdrawn, and a blunt-pointed knife passed along the track thus made, either superficial to or beneath the tendon The cutting edge is turned towards it, and the tendon divided by a sawing or rocking movement, whilst the structure is put on the stretch It is undesirable to operate through the synovial sheath, since even if the wound remains aseptic the tendon often retracts more than is desirable, and in healing gains adhesions to the sheath, which considerably limit the subsequent freedom of movement of the part Opinions vary as to whether it

is better to pass the knife above or below the tendon, in the former method there is no likelihood of making an unduly large wound in the skin, and there is less risk of dividing the *lax* subjacent structures if the knife is turned towards them On the other hand, if the knife is at once passed beneath the tendon, and any subjacent structures are by mistake included, their division is a matter of certainty Where, however, there is any risk of dividing important structures, such as the external popliteal nerve in tenotomy of the biceps cruris, it is wiser to adopt the **open method.** The malposition is at once corrected, and the part immobilized at the time, or in the course of forty-eight hours, in plaster of Paris Passive movements may usually commence at the end of twelve to fourteen days, and gradually be increased in vigour, until active movements are allowed

Tenotomy of the Tendo Achillis —The foot is placed on its outer side, and the tendon relaxed by pointing the toes downwards The tenotome is introduced at the inner margin of the tendon, about 1 inch above its insertion (Fig 143, F, p 353), either superficial to or beneath it, and it is readily divided when the foot is dorsiflexed If the surgeon cuts towards the skin, he must not divide the last few fibres too rapidly, otherwise a considerable external wound may be inflicted by the suddenly liberated knife

The *Tibialis Anticus* is usually divided about 1 inch above its insertion, as it crosses the scaphoid (Fig 145, p 354), and is free from a synovial sheath It is first relaxed so as to allow of the introduction from the outer side of the sharp-pointed tenotome beneath it, this is replaced by a blunt-ended instrument, and the section is accomplished when the foot is abducted

The *Tibialis Posticus* is divided, together with the flexor longus digitorum, just above the inner malleolus, about a finger's breadth from the tip of that process in an infant, and about 1½ inches from it in an adult (Fig 143, E, p 353) The knife is inserted between the tibia and the tendon, and if correctly placed, remains fixed without the support of the hand, being grasped between the tendon and the bone The blunt-ended tenotome is then introduced with its edge towards the tendon, the latter structure being divided when the foot is dorsi-flexed

The *Peronei* tendons are divided just above the base of the outer malleolus, at a spot where the synovial sheath is usually absent (Fig 144, D, p 353) The tenotome is inserted close to the fibula between the tendons and the bone

The *Biceps Cruris* tendon is best divided by an open operation, so as to avoid the external popliteal nerve, which has often been wounded in the subcutaneous method An incision is made in the direction of the tendon just above its insertion into the fibula. It is then lifted upon an aneurism needle and divided, muscular fibres will probably be found quite close to its lower end

The *Semi-membranosus* and the *Semi-tendinosus* tendons are dealt with just above the knee-joint, and the subcutaneous operation may be conveniently adopted when they are prominent and tense

For division of the *Sterno-mastoid*, see p 484

2 **Lengthening a Tendon** is sometimes required in order to overcome the deformity which results from loss of substance or contraction, where simple tenotomy does not seem desirable The most efficient method is the so-called **Z**-operation (Fig 215) The tendon is split longitudinally into two halves, which are separated one from the other by cross-cuts made on opposite sides, one at each end The two flaps are then drawn apart for a distance corresponding to the increase in length required, and sutured together, the resulting bond of union will be as represented in Fig 216 This operation is usually performed through an open wound, but for the tendo Achillis it is quite easy to undertake it as a subcutaneous procedure. The tendon is half-divided on opposite sides through two punctures 1½ inches apart, and then by forcible dorsiflexion ' the two halves of the tendon are made to slide on one another until the required lengthening is obtained ' (Robert Jones)

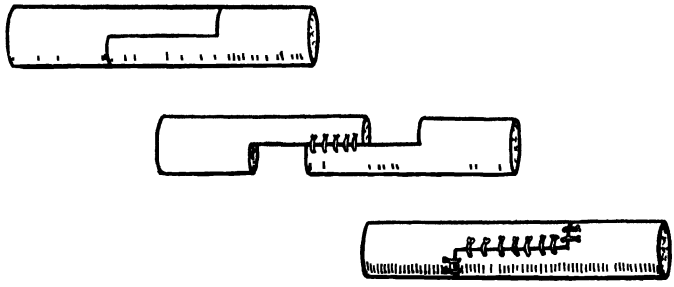


FIG 215 FIG 216 FIG 217

Z-OPERATION FOR LENGTHENING OR SHORTENING OF TENDONS

In Fig 215 the method of dividing the tendon is shown In Fig 216 the flaps are slipped downwards, one on the other, so as to lengthen the tendon In Fig 217 equal portions have been cut away from each half and the remainders sutured, so as to shorten it

3 **Shortening a Tendon** is undertaken in some forms of paralytic talipes The **Z**-method may also be employed here, the two halves, after they have been separated, being shortened to the required amount, and then stitched together (Fig 217) This operation gives a more solid bond of union than when a transverse or an oblique section is removed, in such the sutures are more likely to cut out

4 **Tenoplasty** is the term applied to any plastic operation on tendons with a view (1) to transfer the action of a healthy and strong muscle to the tendons of a weakened or paralyzed group, so as to limit deformity or disability, or (2) to displace the line of action of a muscle so as to counteract or obviate deformity, or (3) to utilize a paralyzed tendon as an accessory ligament Clearly, this operation finds its greatest use in paralytic affections It is essential to study carefully the peculiar features of each case, especially as to the electrical reaction and power of all the muscles involved, and the relative importance of each possible movement Thus, in the foot, plantar flexion is of more value than dorsiflexion, and the latter is more useful than either

adduction or abduction, whilst of the two last-mentioned movements adduction is more important than abduction Hence, although it would be mechanically correct to transplant a healthy abductor, such as the peroneus longus, into a paralyzed plantar flexor, such as the tendo Achillis, so as to improve plantar flexion at the expense of abduction, it would be unwise to reverse the proceeding It is desirable that, whenever possible, the reinforcing tendon should be derived from a synergic and not from an opposing group

Various methods of tenoplasty are available (1) *Tendon Implantation* consists in suturing the whole or part of the proximal end of the tendon of a healthy muscle to the distal end of the divided tendon of a paralyzed muscle, and for choice the latter should be divided as near its insertion as possible The actual method of union of the

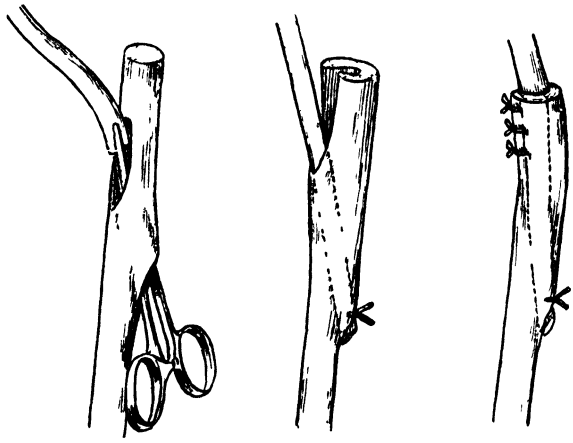


FIG 218 —TENDON IMPLANTATION

A hole is tunnelled obliquely through the healthy tendon, and the paralyzed tendon is drawn through this and fixed by sutures At the free end the receiving tendon is split longitudinally and wrapped round the paralyzed tendon, so as to improve the fixation

tendons varies with circumstances, but the best results have been obtained by tunnelling the healthy tendon and drawing the divided end of the paralyzed tendon through it, and uniting them thus by sutures (Fig 218) Direct end-to-end suture of two tendons is less satisfactory Occasionally merely a slip from the stronger tendon is employed, which is attached to the weaker one so as to fortify the latter without destroying the power of either (2) By *Tendon Transplantation* is meant the total detachment of a tendon from its point of insertion, with or without the periosteum or bone to which it is attached, and its transference and fixation to the point of insertion of the tendon of a paralyzed muscle, or to some spot where it can act more advantageously It is fixed either by sutures to the periosteum, or by drilling a hole through the bone and threading the tendon through it. (3) A somewhat similar procedure, which may be termed *Tendon*

Fixation, is sometimes employed in order to steady flail-like paralyzed parts Thus in hopeless foot-drop of paralytic origin it may be desirable to divide the extensor or peronei tendons and attach their distal segments by suitable methods to the tibia to act as accessory ligaments

The greatest care must be taken with the technique of these operations, so as to ensure complete asepsis and perfect hæmostasis Tendon sheaths must be closed by the finest catgut or silk sutures Deformities should be corrected before the tendons are united, so as to ensure accurate length of the new structure The after-treatment is in the first place directed to the avoidance of undue tension on the bond of union for fear that it may stretch The parts should be kept in an over-corrected position for six weeks by splints or plaster of Paris Subsequently a supporting instrument must be worn for six months, and the affected muscles are treated by massage, electricity, and educative exercises

Diseases of Bursæ.

Bursæ exist as normal structures in many parts of the body exposed to pressure, their object being to diminish friction and permit of a gliding movement Similar cavities, known as abnormal or **Adventitious Bursæ,** are developed in regions where exceptional pressure is brought to bear on some prominent structure, they consist of a fibrous wall lined by a serous membrane, contain a small quantity of serum, and are formed either by dilatation of lymphatic spaces, or as a result of a localized effusion into the tissues Examples of this are met with in men following special occupations, *e g* over the vertebra prominens of Covent Garden porters, and then known as a ' hummy ', Billingsgate fish-carriers occasionally have bursæ under the centre of the scalp, and deal-runners often present one on the upper part of the shoulder They occur over bony prominences arising from malformation or displacement, *e g* over the cuboid in talipes equino-varus, and over exostoses, whilst the false joint or pseudarthrosis which occurs in unreduced dislocations or ununited fractures is of a similar nature

Wounds of bursæ may be caused by penetrating injuries, or sometimes by the skin over them splitting, as, *e g* , in a fall on the point of the olecranon The escape of bursal fluid which results often prevents healing, and then it will be necessary either to excise the bursa, or to open it freely, so that it can be packed and allowed to heal from the bottom

Subcutaneous injuries are followed by hæmorrhage, constituting a hæmatoma, which may suppurate or become absorbed, in the latter case adhesions will often occur, and even polypoid fringes from the organization of the blood-clot Treatment consists in keeping the part at rest, unless suppuration is threatening, and then an incision must be made It is always well to make certain that no fracture is present beneath a hæmatoma of the olecranon or patellar bursæ

The following are the morbid conditions which arise in adventitious as well as normal bursæ

1 **Acute Simple Bursitis** results from moderate injury or prolonged irritation, especially in gouty or rheumatic individuals The part becomes swollen, painful, and tender, and if superficial the skin over it may be hyperæmic Effusion into the cavity quickly occurs, and is sometimes mixed with blood Lymph is deposited on the serous surface, and in many cases results in the formation of adhesions, and possibly obliteration of the cavity **Treatment** consists in keeping the part at rest, and applying fomentations If the effusion persists, aspiration, or removal with trocar and cannula under strict asepsis, may be employed, or even the whole cavity excised

2 **Acute Suppurative Bursitis** arises from infection occurring either from without or within, it not uncommonly follows a subcutaneous injury of a chronically inflamed bursa, leading to its distension with blood The pus, formed at first within the bursa, may travel directly to the surface, or, bursting through the capsule, is diffused through the tissues Where this occurs, the characteristic features suggesting a bursal origin of the abscess may be masked Thus, in suppuration of the bursa patellæ, the pus often finds its way to the lateral aspects of the limb, allowing the patella to be distinctly felt through the skin, the case might then be mistaken for suppuration within the knee-joint, but is easily distinguished by the absence of the more acute arthritic symptoms Implication of subjacent bones and joints sometimes occurs, thus, the patella or olecranon may become carious, or necrose **Treatment** resolves itself into an early free incision, and drainage

3 **Chronic Bursitis with Effusion** is, perhaps, the most common pathological condition met with in bursæ The cavity becomes distended with a serous effusion of varying amount, giving rise to a fluctuating swelling The walls differ in thickness according to circumstances, if the condition is one of long standing with frequent recurrences, the bursal wall is usually reticulated and dense, and adhesions, papilliform processes, or fibrous cords are often produced Subacute exacerbations are frequent **Treatment** consists in rest and counter-irritation, as by blistering or iodine paint, and if this fails, the bursa should be dissected out When the bursa communicates with a joint, such as that under the semi-membranosus tendon, the neck must be isolated, and its communication with the joint shut off by ligature

4 **Chronic Tuberculous Bursitis** is either characterized by effusion and the presence of loose fibrinous bodies (melon-seeds), or the lining membrane is transformed into granulation tissue of a tuberculous type, perhaps leading to the formation of a chronic abscess Either condition may be secondary to a tuberculous arthritis, or may give rise to it, when the bursa communicates with a joint If total removal is impracticable, **Treatment** is similar to that for chronic tuberculous teno-synovitis (p 469)

5 **Syphilitic Changes** may also occur in bursæ in the shape either of a symmetrical bursitis with effusion in the early stages, or later on as a gummatous perisynovial development In this variety, often termed *chronic fibroid bursitis*, the walls of the bursa are much

thickened, constituting a hard fibroid tumour, in the centre of which is a small cavity If the gummatous material breaks down, deep openings may develop into the swelling Anti-syphilitic treatment may assist in healing the sores, but total excision is necessary in order to cure the case

6 Occasionally **Gouty Deposits** are observed in the walls of bursæ, constituting tophi, the irritation of which may predispose to abscess formation, pus mixed with urate of soda crystals being discharged The olecranon bursa is that most frequently affected in this way

Special Bursæ

The *bursa patellæ* (Fig 219), which lies over the lower half of the bone and not over its centre, is very liable, from its exposed situation, to injury or any of the above-mentioned varieties of bursitis In its

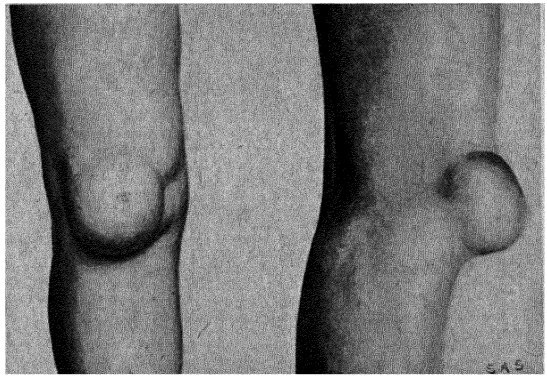


FIG 219 —ENLARGED BURSA PATELLÆ

simplest form it constitutes the condition known as 'housemaid's knee,' and is due to kneeling Caries of the patella may follow acute suppuration, and the more chronic varieties may lead to osteoplastic periostitis The knee-joint itself usually escapes

The *bursa beneath the ligamentum patellæ*, between it and the head of the tibia, when distended with fluid, gives rise to a fluctuating swelling felt on either side of the tendon, more especially when the limb is extended, when the leg is flexed, the swelling diminishes Chronic enlargement of this bursa may push the ligamenta alaria backward into the joint, so that they are nipped between the bones whenever the patient attempts to stand with the leg extended, the pain thereby induced is somewhat similar to that caused by a displaced semilunar cartilage, or by a loose foreign body in the joint The presence of the enlarged bursa, together with the inability to stand with a straight leg, should suffice to make the diagnosis clear

The *bursæ in the popliteal space* are often enlarged, especially that

between the inner head of the gastrocnemius and the semi-membranosus (Fig 220), leading to a rounded fluctuating swelling, sharply limited on its outer aspect, and more fixed and less defined towards the inner The sensation imparted to the fingers varies according to the position of the limb, the swelling being *tense in extension and flaccid in flexion*, as occurs in most of these periarticular bursæ Owing to the proximity of the popliteal vessels pulsation is occasionally detected, but is not expansile in character Enlargement of this bursa

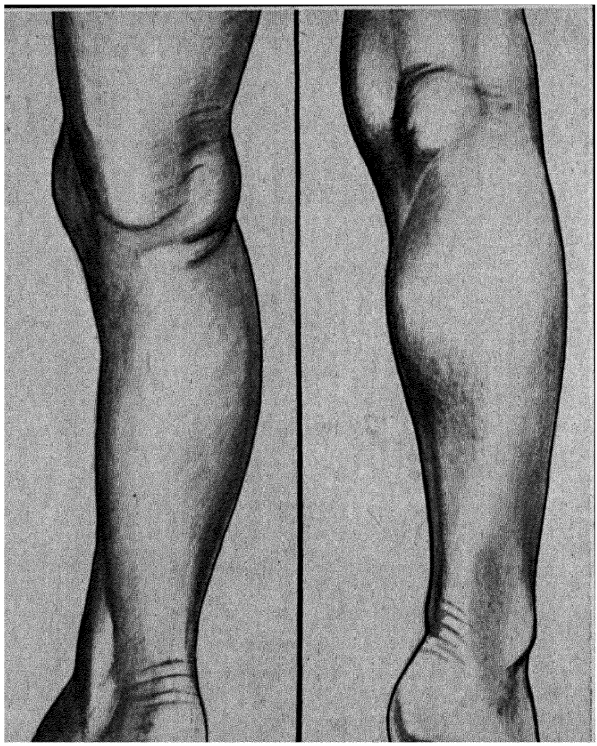


FIG 220 —ENLARGED SEMI-MEMBRANOSUS BURSA IN A BOY VIEWED FROM TWO ASPECTS

is often secondary to an articular lesion, especially tuberculous disease or osteo-arthritis, and before undertaking treatment the condition of the joint should be ascertained If the joint is healthy, the bursa may be removed by dissection, the pedicle being closed by ligature or suture

The *bursa beneath the insertion of the semi-tendinosus and gracilis* is sometimes inflamed, and is very liable to cause osteoplastic periostitis of the subjacent inner surface of the tibia

The *bursa beneath the tendo Achillis*, if enlarged, presents a fluctu-

ating swelling on either side of that structure, somewhat simulating disease of the ankle-joint, but necessarily limited to the posterior aspect of the joint Primary tuberculous disease is sometimes present

Distension of the *bursa beneath the psoas tendon* gives rise to a fluid swelling which usually projects anteriorly, presenting either on the outer or inner side of Scarpa's triangle If painful, it necessitates flexion of the thigh, and thus leads to symptoms resembling those of hip-joint disease or of a psoas abscess It must not be forgotten that this bursa often communicates with the joint

The *gluteal* bursa, situated between the insertion of the gluteus maximus and the great trochanter, is not uncommonly the seat of tuberculous disease It presents as a rounded swelling, obliterating the hollow behind the trochanter, and in its more acute manifestations may be accompanied by abduction and eversion of the limb, in order to relax as far as possible the gluteus It may thereby somewhat resemble the earlier stages of hip disease, but is recognized by the absence of flexion, and by the fact that passive movements, including even the so-called test-movement for hip disease, can be undertaken with but little or no pain Should suppuration occur, the pus may burrow widely beneath the gluteus Treatment consists of complete excision, if possible, or incision with scraping and disinfecting the interior, and allowing it to heal from the bottom Necessarily part of the insertion of the gluteus maximus will require division, and must be subsequently sutured

The *bursa over the tuber ischii*, if inflamed, gives rise to the condition known as 'weaver's bottom', it causes great discomfort in sitting, and is often solid and symmetrical If troublesome, it should be removed

Enlargement of the *bursa over the olecranon* constitutes the condition known as 'miner's elbow', suppuration within it is not uncommon, leading to necrosis of the underlying bone, the elbow-joint is but rarely affected

The large multilocular *subdeltoid bursa* is occasionally enlarged, and may be the site of a simple chronic effusion or of a tuberculous hydrops with melon-seed bodies It leads to prominence of the deltoid and expansion of the shoulder, which is liable to be mistaken for an effusion into the shoulder-joint, but is recognized without much difficulty, as the swelling is usually greater, and there is no axillary intumescence Treatment consists in tapping and irrigation, or injection of iodine, or, failing that, drainage As a final resource the deltoid can be partly detached and turned down, and the bursa dissected away

CHAPTER XIX

DEFORMITIES—ORTHOPÆDIC SURGERY

ORTHOPÆDIC Surgery has for its aim the maintenance of the normal mechanical functions of the trunk and limbs, as well as the correction of such departures from the normal as constitute deformities

Deformities may arise from many diverse causes, and it is essential to study them carefully from this point of view if correct treatment is to be secured They may be *congenital* in origin, and thus may be inherited or the result of some lesion or defect in the health of the expectant mother, *traumatism* is the cause of not a few, either directly or as the result of inflammatory phenomena caused thereby *Irregular growth* of various parts of the body from malposition or injudicious function is also an important ætiological element, especially is this the case in certain bony deformities, since the development of osseous tissue is so largely dependent on the strain to which the bone is exposed, and if this strain falls along abnormal lines, then abnormal growth will be Nature's response, and deformity will result Muscles and ligaments must, of course, accommodate themselves to the bony skeleton Quite a number of deformities are due to *static* causes of this character Finally, the *nervous* system plays a certain part in many cases and in many different ways

From the anatomical standpoint, deformities may be classed as due to the following causes

1 Contractions of the skin, subcutaneous tissues and fasciæ, as in cases of burn, cellulitis, etc Scar tissue does not grow as quickly as other tissues, and therefore deformity may sometimes become exaggerated as a child grows

2 Unbalanced action of opposing groups of muscles from whatever causes this is due—*e g*

(*a*) Simple want of tone from disuse, paralysis, etc , resulting in elongation of muscles or tendons

(*b*) Persistent spasm, either clonic or tonic

(*c*) Intrinsic contractions of the muscle substance, or adhesions of muscles or tendons to surrounding parts

3 **Ligamentous** changes may lead to articular deformities

(*a*) Simple relaxation from persistent malposition or chronic distension may lead to instability or even displacement of joints

(*b*) Contraction of ligaments of static or inflammatory origin may result in more or less limitation of movement

(*c*) Actual ossification of ligaments sometimes occurs, and causes ankylosis

4 **Osseous** causes are most variable in type, *e g*

(*a*) Irregularities of growth in the direction either of excess or effect may be congenital, static, or inflammatory in origin

(*b*) Non-union or the vicious union of fractures is a fertile source of orthopædic trouble

5 **Articular** causes are of manifold varieties, resulting from malposition, congenital or acquired, inflammatory troubles or traumatism

6 **Nervous lesions** may cause paralysis or spasm, and many types of deformity result therefrom

A careful study of the above ætiological summary will make it abundantly obvious to anyone that a large percentage of all deformities is preventable, and attention has already been drawn more than once in this work to the value of the old proverb that 'prevention is better than cure' A very large proportion of the work undertaken at the orthopædic centres in connection with the late war could easily have been prevented with a little foresight and more care on the part of attending medical officers

A few general principles which govern orthopædic treatment may be mentioned here, but it is obvious that space does not permit more than a brief note

1 **Persistent malposition results in permanent structural changes.** Thus accommodative shortening of ligaments, muscles, etc , will take place on the flexor side of a bent knee or wrist, whilst the structures on the extensor side will be stretched and in time from want of use will become atrophied Should the parts be subsequently replaced, the stretched extensors still remain weak and functionless, as the contraction of the muscles cannot 'take up the slack' in the tendons The importance of this has been emphasized in connection with nerve lesions, whether traumatic or due to poliomyelitis Joints conform to this rule, and ligamentous changes may even run on to ossification if there is much pressure or tension, the deformity thus becoming hopelessly fixed

2 **Growth of bone** is governed by the amount and direction of the forces and strain to which it is exposed Normal strain in a normal position means normal growth Abnormal strain even in a good position may result in deformity, especially if the general condition is poor, but if time be allowed for repair and improvement of the general health, the bony tissue may recover and become consolidated in the abnormal position, and the resulting bony tissue may be more solid and stronger than ever Thus in rickets the long bones often become bent, but strengthening buttresses develop in the concavity of the bent bones, and the final issue when repair has occurred is an abnormally solid bone Similarly the kyphotic spine of 'hunch-backs' may become preternaturally powerful and solid

On the other hand, want of use and loss of function are very quickly represented in bony tissue by atrophic changes

If by operation or otherwise deformed parts can be placed in a normal position once again so that normal strains are brought to bear upon them, a return to a normal structure may be expected This latter desideratum is, however, also governed by the age of the patient

and the length of time that the deformity has lasted In young people all growth tends towards the normal, but in older people the tissues do not respond so readily

3 **Exercises** in which a displaced part can be brought either gradually or from the first into the normal position will develop the muscles, etc , which have become stretched, functionless, or atrophic, and as the normal position is more easily and effectively maintained, the structures which surround it return more exactly to the normal The use of remedial exercises and re-educational methods is based on this fact It must always be remembered, however, that it is useless to develop only one group of muscles without consideration of their antagonists Muscles in the body are always balanced, and both groups must be capable of active functions if the movements of either are to be effective (Cp section on **Remedial Exercises,** etc , at p 292)

4 The cure of deformities by position and exercises is, however, often a slow process in young people, and almost impossible in those who are older Hence **Operative Treatment** is frequently required Structures which are too short, *e g* tendons, muscles, etc , may be lengthened, lengthened structures may be shortened, and displaced parts put in good position, and correct alinement of limbs thereby secured One must again emphasize, however, that the replacement of the part in good position is only the commencement of the treatment, the development of the part in its good position so as to secure normal growth of the various structures concerned is just as important an element in the treatment, and herein lies the desirability of all students and practitioners studying in themselves and in their patients the functions and methods of exercising the various muscle groups

The consideration of many orthopædic deformities has been or will be dealt with in other appropriate sections of this work, in this chapter it is proposed merely to discuss certain conditions which for convenience are grouped together

Torticollis.

Torticollis, or wry-neck, is a deformity produced primarily by contraction of the sterno-mastoid muscle, although in old-standing cases the trapezius, splenii, scaleni, and other deep muscles of the neck, as well as the deep fascia, are affected It is characterized by the affected side of the head being drawn down towards the shoulder, whilst the face is turned towards the sound side (Fig 221)

Several different types are described, in particular the acute or rheumatic, the chronic, which is usually due to cicatricial changes in the muscle, and the spasmodic

1 The **Acute** or **Rheumatic** variety is usually the result of exposure to cold or to sitting in a draught, it comes on suddenly, and is extremely painful, and the muscle or muscles affected are tender to the touch The possibility of mistaking it for other inflammatory affections, such as acute lymphadenitis or cellulitis, must not be overlooked, in them the neck is often fixed so as to protect the inflamed structures **Treatment** must be general as well as local, aspirin may be given to relieve

pain, or salicylates to counteract the rheumatic poison, whilst a dose of calomel or castor oil is always beneficial Local fomentations should be applied in the early stages, and subsequently massage

2 The **Chronic** form of torticollis is almost always due to cicatricial changes in the sterno-mastoid, which result in its intrinsic shortening (*a*) It is occasionally *congenital*, and then it is due to malformation or malposition *in utero*, whereby the muscle is imperfectly developed (*b*) Most commonly it follows the *congenital induration* of the muscle (*q v*), due to laceration of its fibres during birth, it is therefore to be looked on as a myositis fibrosa It is sometimes associated with winged scapula or other conditions due to injury of the muscular branches of the fifth and sixth cervical nerves inflicted at the same time as that to the sterno-mastoid (*c*) At a later date contraction of the muscle may result from suppuration or gummatous formation within the sheath, but the deformity is then less marked

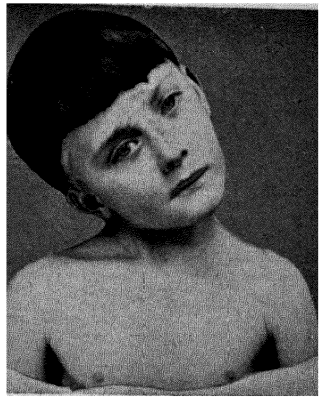


FIG 221.—CHRONIC TORTICOLLIS
The right sterno-mastoid is contracted, and the facial asymmetry is very noticeable

Either the sternal or clavicular portion may be separately contracted, or the whole muscle may be affected standing out as a hard tense band, the muscular substance being almost entirely replaced by fibrous tissue The deep fascia is always secondarily contracted and shortened, and when the deformity has lasted long the posterior cervical muscles are similarly affected, whilst changes in the shape of the cervical vertebræ are also induced, the bodies becoming wedge-shaped, and thickest towards the convexity A secondary compensatory curve is usually present in the dorsal spine, so as to maintain the horizontal position of the eyes In children the affected side of the head and face also becomes atrophic The measurement from the external canthus to the angle of the mouth is smaller, the eyebrow is less arched, the nose somewhat flattened, and the cheek less full than on the sound side These phenomena are probably due to imperfect vascular supply, resulting from the limited mobility

The **Diagnosis** of a chronic torticollis is readily made from the fact that the sterno-mastoid muscle is evidently contracted and stands out as a tense subcutaneous band It must not be confounded with cicatricial contraction of the skin of the neck following burns, or with the deformity and rigidity of the neck which results from a rheumatic inflammation of the deeper ligaments and muscles of the cervical spine (rheumatic spondylitis), or from tuberculous disease of the cervical vertebræ

Treatment—Massage and manipulation may be first tried, or even some form of mechanical apparatus directed towards stretching the

contracted muscle (*vide infra*), but in the majority of cases tenotomy or myotomy will give a more satisfactory result, and is less tedious and troublesome

Two methods of dividing the sterno-mastoid have been employed (1) The *subcutaneous* operation is a desirable proceeding, as it leaves no obvious scar, but requires great care in order to avoid damage to the important underlying structures There is but little danger or difficulty in dealing with the sternal head, a tenotome being passed down to it beneath the skin, and the incision made from before backwards, the tension to which it is exposed suffices to draw it well forward out of harm's way The clavicular portion, on the other hand, should generally be divided through an open incision (2) The *open* method obviates all danger, but leaves a noticeable scar, unless care is taken to suture the platysma separately when closing The skin, about ½ inch above the clavicle, is incised across the muscle, its anterior and posterior borders are defined, and its fibres completely divided Tense portions of the cervical fascia on its deep aspect may also be carefully cut across, keeping in view the importance of the underlying structures The position of the head is then rectified, and for a time it is kept between sand-bags, or fixed by plaster of Paris Later, a simple and satisfactory arrangement for maintaining the new position consists of a padded leather strap passed round the forehead and occiput, and another under the axillæ An elastic band is secured to the forehead strap above the mastoid process of the side which is not affected, and traction made by fixing it to the front of the lower belt on the opposite side of the body Thus, if the left sterno-mastoid is contracted and has been divided, the chain is attached above over the right mastoid process and below over the front of the left axilla, traction being thus made in the direction of the weakened right sterno-mastoid muscle Where osseous changes are present, the deformity may persist to a great extent, in spite of combined operative and mechanical treatment

3 **Spasmodic** torticollis is a condition which occurs most frequently in women about thirty years of age, in whom there is often a family history of insanity or nervous diseases, such as epilepsy, etc It is characterized by clonic spasms of the various muscles of the neck, especially the sterno-mastoid and trapezius, but the deep short rotator muscles are also affected in many cases The head is continually being twisted and jerked into a position of torticollis, but other movements are often associated The cause is some lesion of the nervous supply of the muscles, probably in most cases cortical In a few instances irritation of peripheral nerves, as by inflamed glands, teeth, etc , may exert some temporary influence, but the true spasmodic wry-neck persists in spite of the removal or cure of such causes The prognosis is always very unfavourable, since, even if the localized spasm is cured by appropriate operative treatment, other parts are likely to become affected

Treatment in these cases should be of a hygienic and tonic character, peripheral sources of irritation must be removed, and careful investigation made to ascertain that all the functions of the body are

satisfactorily performed Intestinal toxæmia, disorders of menstruation, and any other possible causes of irritation, must be relieved Local applications of electricity of various types may be employed, as also suitable hydro-therapeutic remedies Not unfrequently the spasms persist, and then it may be well to divide the posterior cervical nerves, as they lie on the semi-spinalis colli

A **Cervical Rib** is a deformity of not uncommon occurrence, generally noticed about the age of puberty It is usually bilateral, and arises most frequently from the anterior transverse process of the seventh cervical vertebra, but a similar outgrowth sometimes occurs from the sixth It is at first composed mainly of cartilage, but as age advances it becomes osseous It may be short and have a free end in the neck,

FIG 222.—BILATERAL CERVICAL RIBS

but more frequently passes down to unite with the first rib near the scalene tubercle, or to gain attachment to the sternum, occasionally, it consists of two portions, an upper and a lower, united together by a synchondrosis No symptoms are produced until the mass by its growth encroaches on the subclavian artery and lower and inner cords of the brachial plexus The vessel is pushed upwards and forwards, and becomes at times so prominent as to be mistaken for an aneurism, sometimes the pulse is impaired when the arm hangs down, and this may even determine gangrene of the finger-tips Nervous symptoms are referable to the first dorsal and eighth cervical nerve-roots, and appear in the form of neuralgia along the ulnar border of the forearm and little finger, or of weakness, mainly of the intrinsic muscles of

the thumb A cervical rib presents as a hard swelling above the clavicle, and can be readily recognized by radiography (Fig 222) Nothing should be done unless pressure symptoms are present, when removal may be required An incision is made parallel to the anterior border of the lower portion of the trapezius, the nerves and vessels are separated from the swelling and drawn aside, and the growth carefully excised by gouge, chisel, or cutting pliers

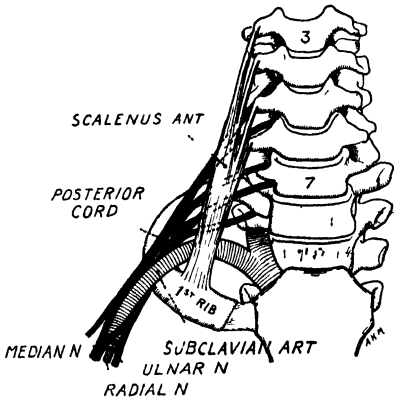


FIG 223 —THE RELATION OF THE BRACHIAL PLEXUS, SUBCLAVIAN ARTERY AND SCALENUS ANTICUS MUSCLE TO THE FIRST RIB

An alternative procedure, advocated by Adson, is that of division of the scalenus anticus muscle, close to its insertion into the first rib The operation is more simple than removal of the cervical rib, and good results are claimed (Fig 223)

Deformities of the Spine

Scoliosis —By scoliosis is meant a lateral curvature of the spine accompanied by rotation of the vertebræ Conditions are met with in which the spine becomes deflected laterally as an occasional result of Pott's disease, or in fractures, these, however, are not generally considered to be genuine scoliosis

Ætiology.—The following are the chief causes of scoliosis

(1) It occurs very rarely as a congenital deformity, owing to malformation of the vertebræ

(2) It may commence in young children as a result of *rickets*, owing partly to the softened condition of the bones, partly to their irregular growth It is probably often induced by the children being always carried on the same arm, and the primary curve is usually in the dorsi-lumbar region

(3) Any condition of asymmetry of the body may lead to what is known as *compensatory scoliosis*, *e g* congenital shortness of one leg, unilateral dislocation of the hip, contraction of the knee- or hip-joint, genu valgum, falling-in of the chest wall as a result of empyema, unilateral paralysis of spinal muscles in infantile palsy, and even old-standing torticollis If one leg is short (Fig 224), the pelvis is tilted down on that side in order to bring the foot to the ground, producing a lumbar curve with the convexity towards that side, and then a compensatory dorsal curve in the opposite direction is subsequently added in order to maintain the general axis of the body (A′) If, however, the short leg is also persistently adducted, as in old hip disease (Fig 225, B), the spine will be curved in the opposite direction in order to maintain the parallelism of the limbs (B′)

(4) The most common type, however, is the *static* (or *postural*)

scoliosis of adolescents, who are in a weak and asthenic condition, often as a result of rapid growth, combined possibly with improper or insufficient food, defective hygienic surroundings, or exposure to hard work, whereby undue muscular fatigue is induced Young women of an anæmic type who suffer from amenorrhœa, and who as housemaids or factory hands have to undertake a good deal of lifting, are liable to this condition, and especially if their work involves a maintained position of lateral deflexion of the spine It is largely due to a relaxed state of the ligaments and muscles, which have not developed *pari passu* with the weight and length of the skeleton, and is therefore not unfrequently associated with flat-foot and genu valgum Prolonged standing in a position of ease or rest, in which the weight of the body is mainly carried on one leg, may determine its occurrence School children develop this deformity readily as a result of the persistent adoption of faulty positions during reading or writing, owing to low desks and want of support to the

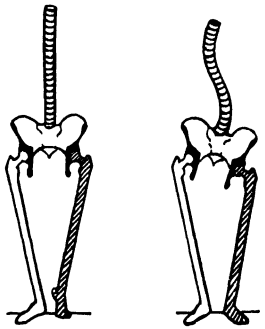


FIG 224 —SCOLIOSIS DUE TO SHORTENING OF THE LEFT LEG

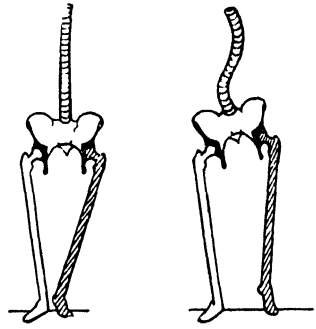


FIG 225 —SCOLIOSIS DUE TO ADDUCTION OF THE LEFT HIP

feet In addition to all these local phenomena, however, must be remembered the fact that the mental outlook of the majority of these patients is one of depression or pessimism, leading to a slouching gait with round shoulders and a prominent abdomen, the depressed state of her mind manifests itself in a relaxed habit of the body A happy, hopeful outlook on life helps to produce an upstanding frame of body with ' chest out and shoulders back '

The **Phenomena** vary considerably according to the character and extent of the lesion Sometimes the whole spine is involved in one curve (*total* scoliosis), but more usually two curves are present, one primary, the other compensatory It is by no means uncommon for this condition to be associated with kyphosis, but the absence of the latter, in what is sometimes termed the ' flat-backed ' type, is no criterion of the slightness of the case The most usual variety is that in which there is a double curve, with the dorsal convexity to the right and the lumbar to the left (Fig 226) It will be desirable to

describe this carefully, whilst for the opposite condition (Fig 227) all that is necessary is to transpose the words 'right' and 'left' or, as Hoffa has put it, one variety is the 'mirror picture' of the other

In addition to the lateral displacement, *the bodies of the vertebræ* are always *rotated* towards the convexity of the curves This also occurs to some extent in normal flexion of the spine, and is a purely mechanical act, and due to the more firm support given to, and the interlocking of, the posterior parts of the vertebræ As a result, the spinous processes are directed towards the concavity, and hence

FIG 226.—SLIGHT SCOLIOSIS (TOTAL TO LEFT SIDE)

FIG 227.—MARKED RIGHT-SIDED SCOLIOSIS

always indicate a smaller amount of distortion than really exists Occasionally there may be some backward projection of the spines at the junction of the two curves

The *thoracic walls* necessarily participate in the process, and the amount of thoracic deformity is perhaps the best measure of the degree of rotation of the vertebræ The ribs on the right side become to some extent separated from one another, and project posteriorly on account of this rotation (Fig 228), the amount of curvature at the angle is consequently increased, whilst the front of the chest on this side of the body becomes flattened On the left side the ribs are huddled together, and the curve at the angle diminished, the ribs being thereby opened out, consequently, the thorax is flattened posteriorly on that side, but projects in front, the left breast may thus be rendered prominent In fact, the thorax becomes more or less rhomboidal in shape The sternum also is somewhat displaced

towards the concavity, and twisted so that the anterior surface looks towards the right The capacity of the thorax is not as a rule affected at first, but in the later stages it is considerably diminished, and the abdominal viscera may even be displaced The *scapulæ* follow the thoracic wall, and hence the right shoulder is pushed upwards and outwards, and it is for this 'growing out of the shoulder' that the majority of cases come under observation The effect on the *waist* varies with the situation and extent of the curves, if the dorsal and lumbar curves are nearly equal, then the true waist on the right side becomes more marked than usual, corresponding to the lumbar concavity, and in advanced cases a distinct sulcus may be present between the lower ribs and the crest of the ilium On the left side the hip appears to project ('growing out'), owing to the deflection of the trunk towards the right side (Fig 227), whilst the dorsal concavity higher up may simulate a false waist The erector spinæ muscle stands out unduly on the left owing to the rotation of the vertebræ, whilst the transverse processes on this side may be unusually evident

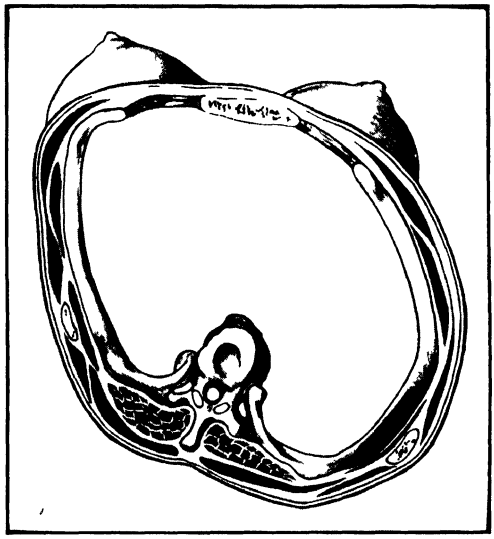


FIG 227.—SECTION OF THORAX IN SCOLIOSIS WITH DORSAL CONVEXITY TOWARDS THE RIGHT SIDE

In the early stages the characteristic deformity disappears on extension of the trunk, as by hanging from a trapeze, or on bending forwards, but as the condition progresses, the spine becomes more and more fixed, and but little alteration is produced by suspension of the patient In the worst cases, especially when associated with kyphosis, the deformity becomes so marked as to simulate the 'hump' formed in Pott's disease, and the patient's stature becomes dwarfed and stunted

Subjective symptoms, such as neuralgic pain and weakness, are also present, but usually they are not very prominent features

Anatomical Changes occur only in the later stages of the case, and conform to the general rules of such deformities At first it is merely the muscles and ligaments that become affected in the direction of shortening on the side of the concavity and lengthening and relaxation on that of the convexity, these are merely accommodative phenomena Later on, the vertebræ themselves may become misshapen, and wedge-like on section, being thicker on the convex than on the concave side The intervertebral

discs are similarly changed, whilst the articular processes are unduly pressed together on the concave side and separated from one another on the convex The transverse and spinous processes are also approximated to one another on the side of the concavity and often curved

It is most essential that a correct **Diagnosis** be made as soon as possible, since so much depends upon early treatment A thorough examination should be made with the patient standing and the clothes stripped to below the waist, so that the whole back can be seen The general appearance is first noted, and then the spinous processes are marked out one after another with a spot of ink or with a flesh pencil The shape of the thorax, the curvature of the ribs, and the position of the scapulæ are also ascertained, and the length of the legs is measured The patient is then made to hang from a bar, and to bend forwards, and the effects of these respective movements noted, by this means some idea can be obtained of the extent and nature of the deformity There can be but little risk of mistaking it for Pott's disease, since the rigidity, deformity, and localized pain of the latter are so characteristic, in bad cases of scoliosis, however, where there is a projection of the spinous processes backwards, a mistake might easily arise if only a careless examination were made

The **Prognosis** necessarily varies with the stage which the affection has reached In early days, before the deformity has become set, and when it disappears on extension of the spine, it is almost certain to be entirely cured, if suitable precautions are taken Later on it can be improved to some extent, but in bad cases all that can be expected is to prevent it from getting worse

In the **Treatment** of scoliosis, the cause of the trouble must not be overlooked, since in many cases the deformity may be remedied, or at any rate prevented from increasing, by attending to this Thus, inequality in the length of the limbs necessitates the wearing of a high-heeled boot, whilst contractions of the knee- or hip-joints should, if possible, be corrected In that variety which occurs in young people from constitutional or local debility, the general health must be improved by suitable measures Carefully-regulated rest and exercise must also be recommended, so as to improve the muscular tone of the back without unduly fatiguing the patient, for a similar reason massage and cold baths are beneficial All errors of position must be corrected, and suitable desks, forms, and chairs utilized In the slighter cases it often suffices to order the patient to rest in the supine position on an inclined board for an hour or two daily, the head being thus raised and the spine extended Remedial exercises constitute the most important element of treatment, which may be looked on as curative in early and moderate cases, and as palliative in the advanced stage Some of these are arranged so as to extend and render mobile the spine, and generally to improve the tone of the spinal muscles, others are devised so as to undo the abnormal curves present Space forbids us describing them here, and we must refer readers to special textbooks

A spinal support is occasionally useful, but should not be worn continuously, except in bad cases, as it renders the muscles of the

back weak from disuse All that is needed in the early stages is the support of a firm, carefully-fitted corset, but should the deformity increase, stronger instruments may be employed in which springs are incorporated, whereby it is hoped that correction of the curvature may be brought about In the worst cases, where the deformity is irremediable, much can be done by a skilful mechanism to hide the deformity and prevent its increase, Albee's operation (*q v*) may also be useful for this purpose

Kyphosis —By this term is meant a condition of increased dorsal convexity of the back which is often associated with loss of the lumbar concavity, so that the whole spine is arched backwards Occasionally, however, a marked lumbar lordosis is present as a compensatory condition

The chief **varieties** of kyphosis are as follows

1 Kyphosis from defective growth or habit This may occur (*a*) in children under the age of four, resulting from rickets, (*b*) in adolescents up to the age of sixteen (round shoulders), from a continuous habit of stooping, as in reading or writing, especially in those suffering from myopia, (*c*) various forms of occupation which involve the carrying of heavy weights, or stooping over work, lead to its appearance in adults, as in porters and cobblers (Fig 229), (*d*) in old men it results from senile atrophy

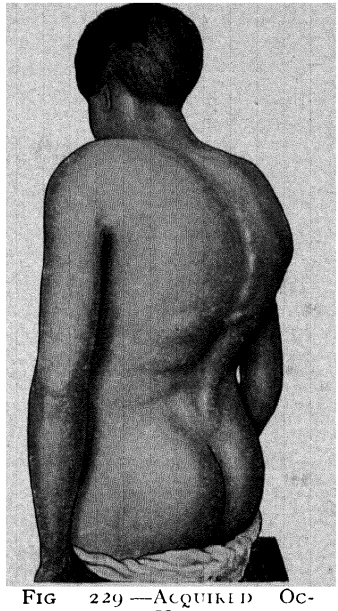


FIG 229 —ACQUIRED OCCUPATION KYPHOSIS IN A YOUNG MAN FROM EXCESSIVE WEIGHT-CARRYING

2 Kyphosis from general disease of the spine is a marked feature in spondylitis deformans, osteitis deformans, osteomalacia, hypertrophic osteo-arthropathy, and acromegaly In the latter disease the condition is limited to the dorsal region

3 Kyphosis also arises from localized injury or disease of the spine, *e g* traumatic spondylitis, fractures, Pott's disease, gumma, or cancer

Treatment is impossible in the majority of cases, but the round shoulders of young people come so commonly under observation that a little more notice of the condition is needed

Round Shoulders occur most frequently in girls who have grown rapidly, and perhaps developed precociously The condition is often due to defective habits of sitting and standing, especially at school, and may be induced by faulty desks and chairs, but other conditions, such as myopia or adenoids, may be primarily responsible The deformity can be voluntarily corrected in the earlier stages, but not so later on

Treatment.—In the first place the cause must be ascertained, and if possible removed, chairs and desks must be arranged so as to ensure that the child sits in a good position, and does not stoop when writing, reading, or playing the piano In particular, the back should be supported whilst reading, and the feet should not be allowed to dangle The muscles of the back, especially the trapezii, the erectores spinæ, the rhomboidei, and the serrati, must be strengthened by massage, electricity, and exercises, the latter necessarily directed towards extension of the back Undue fatigue must be avoided, and the girl should rest on her back two or three times a day for half an hour At night she should lie on her back, without a pillow, and with a pillow beneath the curve The general nutrition and health must also be attended to, and a course of suitable tonics prescribed In bad cases where the deformity is marked and it is feared it may be progressive, a light support may be required, but of course the exercises must be persisted in

Lordosis is almost invariably a secondary or compensatory condition, and consists in an increased anterior curvature of the spine in the lumbar region It is usually produced by continued flexion of the hip, whether due to congenital displacement, unreduced dislocation, malunited fracture, or to hip disease, and is irremediable unless the malposition of the femur can be corrected

It is seen as a temporary condition in pregnancy, and as a more persistent phenomenon in bad cases of uterine fibroids, owing to the increased weight of the uterus or its contents, necessitating backward displacement of the upper part of the spine in order to adjust correctly the centre of gravity of the body The same may be noticed in persons with large, fat, and pendulous abdomens

It is occasionally present in progressive muscular atrophy where the lumbar and abdominal muscles are weakened, and usually in pseudo-hypertrophic paralysis from loss of power in the gastrocnemii and other muscles engaged in maintaining the erect posture

Spondylo-listhesis is the term applied to a curious and somewhat uncommon deformity, in which the lumbar vertebræ slip forwards and downwards from the top of the sacrum It arises from fracture of the articular processes of the lumbo-sacral joints, or from imperfect development of the laminæ or pedicles of the lowest lumbar vertebra, as a result of which the pressure of loads carried on the shoulders or the weight of a pregnant uterus brings about the displacement In the latter instance the enforced lordosis aggravates this tendency The effects produced are shortening of the stature, together with the formation of a marked hollow above the sacrum, whilst the lumbar vertebræ are unduly prominent anteriorly The condition is accompanied by neuralgic pain and weakness

Treatment.—In suitable cases operative treatment by driving a bony peg from the fifth lumbar vertebra into the sacrum, when the deformity has been corrected by weight extension applied to the legs, is curative An Albee's bone graft is usually insufficiently strong to prevent the recurrence of the displacement In other cases prolonged rest may be tried, with possibly the application of a leather

jacket moulded to the pelvis and supplied with crutches so as to carry part of the weight downwards from the axillæ to the pelvic support without utilizing the spine

Deformities of the Upper Extremity

In **Congenital Elevation of the Scapula** (Sprengel's shoulder) the scapula may be normal in size or a little smaller than usual, but is situated above its proper position, and rotated so that its lower angle is approximated to the middle line The muscles attached to its upper border are prominent, in a few instances a cartilaginous or osseous band has replaced them, passing between the upper angle or the bone and the seventh cervical vertebra The lower third of the trapezius is often defective, as also the serratus magnus The disability, which is usually slight, depends on the condition of these

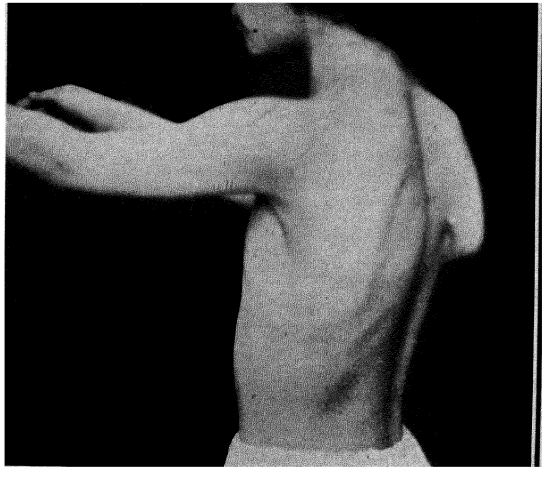


FIG 230.—WINGED SCAPULA

muscles, but the affected arm is sometimes smaller than its fellow A slight degree of scoliosis develops as a compensatory phenomenon The only active *treatment* consists in dealing with the affected muscles by removing the cartilaginous or osseous band, otherwise massage and exercises are required

A **Winged Scapula** is a condition characterized by projection backwards of the vertebral border and lower angle of that bone when the arm is thrust forwards (Fig 230) It is due to paralysis of the serratus magnus and rhomboids, which normally keep the ventei of the scapula in contact with the chest wall It may be due to injury or division of the nerve of Bell in the axilla, or to irritation and compression of the fifth and sixth cervical nerve-roots, which may be tender, weight-carrying on the shoulder may also be responsible for this lesion **Treat-**

ment consists in massage and faradism, whilst, if persistent, a suitable appliance may correct the deformity Sometimes improvement results if a part of the pectoralis major is sutured to the axillary border of the scapula

A curious **Tilting** of the **Scapula** occurs in children where the spinal accessory nerve has been divided during operations on the neck, as for tuberculous glands When the arm is raised or pushed forwards, the normal relation of the scapula to the spine is not maintained, owing to paralysis of the trapezius, but the bone is tilted upwards and outwards, so that a considerable hollow develops immediately behind the clavicle It is unsightly, but not especially detrimental, and with growth and active exercise any ill-effects usually dis-

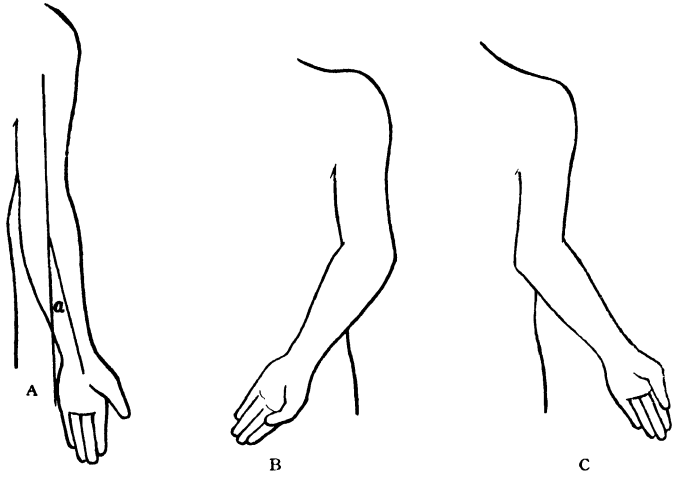


FIG 231 —OUTLINES OF UPPER EXTREMITY TO SHOW—A, NORMAL CARRYING ANGLE ($a = 15°$) B, CUBITUS VARUS, C, CUBITUS VALGUS

appear As a rule treatment is unnecessary, but if need be an attempt must be made to find and unite the divided ends of the nerve

Cubitus Valgus and Cubitus Varus —Under normal conditions the axis of the forearm does not correspond with that of the arm, the former being in a position of slight abduction (about 15°), constituting what is known as the ' carrying angle ' (Fig 231, A) This angle is often greater in women than in men, and when marked constitutes the condition of *cubitus valgus* (C) This is usually due to a fracture of the external condyle of the humerus in children The damage to the epiphysis results in impaired growth Normal growth occurring on the inner side of the joint causes gradual increase of the carrying angle Similar deformity may result from operative removal of the head of the radius Occasionally a fracture of the inner condyle of the humerus, with downward displacement of the fragment, may cause cubitus valgus The ulnar nerve is likely to become unduly exposed

beneath the skin, and thus to suffer recurring injuries of a neuritic type If the causative bony lesion cannot be repaired, the nerve should be set free and displaced in front of the condyle *Cubitus varus* (B) is due to similar lesions of the inner or outer condyle

In rare cases a supracondylar osteotomy may be required to correct the deformity

Madelung's Deformity is a condition more commonly seen in females and probably associated with injury, and consists of a deformity of the growth of the lower end of the radius whereby the carpus is pushed laterally and towards the palm without an associated movement of abduction or lateral twist It may be uni- or bi-lateral and is accom-

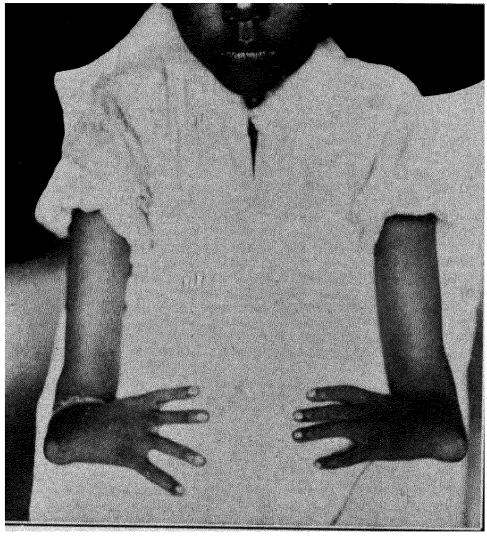


FIG 232 —BILATERAL CLUB HAND DUE TO CONGENITAL ABSENCE OF RADIUS THUMBS ENTIRELY ABSENT

panied by a limitation of movement of the wrist joint, especially as regards dorsiflexion, and a weakness of all movements Exercises and support by a moulded leather appliance extending the length of the forearm down to the metacarpo-phalangeal joints should be employed

Various types of **Club-hand** occur, in which the hand is deflected to one or the other side, or is hyper-extended or flexed Perhaps the most frequent cause is a *congenital absence of the radius* (Figs 232 and 233), under which circumstances the hand is radially abducted to a marked degree, the ulna is shortened and curved, and its lower epiphysis expanded so as to articulate with the carpal bones Where the bones are normal, the hand is usually flexed and adducted towards the ulnar side In all of these deformities radiography should be employed so as to ascertain the exact relation of the bones to each

other Congenital absence of the ulna occurs also, in which condition there is a manus varus deformity

Congenital Deformities of the Finger are much more common, and the account here given of such defects of the upper extremity applies with equal force to those which occur in the lower The following varieties may be alluded to

Polydactylism consists in the presence of supernumerary fingers and toes There may be from one to seven additional digits, and the condition is usually symmetrical The accessory digits are often stunted, and smaller in size than the normal, but may be of average dimensions Usually they are separated from the true digits, but



FIG 233 —X-RAY OF CLUB-HAND DUE TO CONGENITAL ABSENCE OF RADIUS

now and then may be blended with them The correct number of metacarpal or metatarsal bones may be present, or they also may be multiplied In one of our cases there were six digits and six metatarsal bones, but the last two digits were supported by an accessory metatarsal apparently springing from the outer side of the fourth The condition is frequently inherited The **Treatment** consists in removing the supernumerary digits, if useless, obtrusive, or troublesome Sometimes the patients are proud of their abnormality, and refuse to part with it

Ectrodactylism, or the absence of one or more of the digits, is occasionally seen, as also partial arrests of development of fingers or toes, or intra-uterine amputation at a higher level

Macrodactyly (Fig 234) consists in a congenital overgrowth of one or more fingers or toes The structures are perfectly normal in

character, and merely gigantic in size for the age of the individual Amputation or excision may be needed in these cases, as the deformed parts grow out of all proportion to the neighbouring tissues Thus, an infant with enormous overgrowth of the second toe of the right foot was successfully treated by excision of the digit, together with a V-shaped portion of the foot, which was by this means reduced to normal shape and size

Syndactylism, or webbed fingers, is a condition in which two or more fingers are joined together laterally, either by a thin web consisting mainly of skin, or by a thick fleshy bond of union In the foot no *treatment* is required, but in the hand the fingers must be separated If there is merely a thin web, this may be divided by scissors, but to prevent its re-formation from above downwards, as healing proceeds, a flap of skin must be transplanted into the angle between the fingers, or an opening in the base of the web may be made and maintained, and the edges allowed to cicatrize before the web itself is divided Where the union, however, is thick and fleshy (Fig 235), a more extensive operation is needed Two flaps of skin as long as the web, and half the width of a finger, are respectively raised from the dorsal aspect of one finger (Fig 236, A) and from the palmar aspect of the other (B) in such a manner that, after the web has been divided, the denuded surfaces can be covered by wrapping the flaps round the lateral aspects of the fingers and suturing them in position An additional flap of skin must also be fixed in the angle between the separated digits Agnew's operation consists in isolating a triangular piece of skin from the dorsum of the web, the apex of which is situated half-way up the latter and the base over the heads of the adjacent metacarpals The rest of the web is then divided, and the flap brought forward and sutured to a suitably prepared bed on the palmar aspect This flap prevents any union by granulation tissue at the bottom of the web

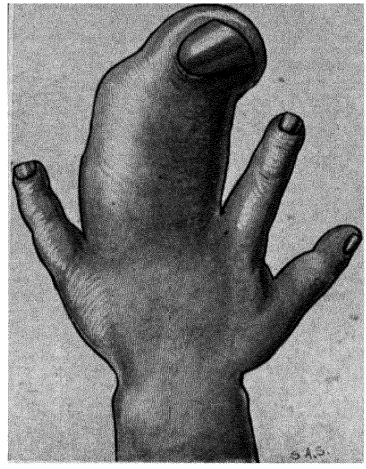


FIG 234.—MACRODACTYLY AND SYNDACTYLY

In this case a child, aged two and a half years, had the ring and middle fingers united laterally into a large mass which projected far beyond the others The middle finger was normal in size, the ring finger was hypertrophic A fruitless attempt was made to save the middle finger, but both had finally to be amputated

A similar condition is occasionally developed after burns or wounds involving the webs between the fingers It is usually preventable if the fingers are kept well apart and early skin-grafting is undertaken Otherwise the scar must be divided and the raw surface produced

thereby grafted, or operative treatment more or less similar to that described above undertaken

Congenital Contraction of the Fingers is not a very rare deformity, being frequently inherited, it is usually limited to the little finger, and may be associated with congenital hammer-toe It is due to contraction of the *central* prolongation of the palmar fascia in the finger, whereas Dupuytren's contraction involves the palmar fascia itself and its *lateral* prolongations into the fingers Moreover, in the congenital variety the first phalanx is hyper-extended, and the second and third flexed, whereas in the acquired form the first and second phalanges are flexed and the third is hyper-extended

Treatment.—It often suffices to use massage and apply a splint, but in bad cases division of the fascial bands may be needed

Acquired Deformities of the Hand.—After burns the hands may be contracted into a useless mass in which the fingers are drawn into the palm and united by cicatricial tissue to the palmar structures, so that all treatment is hopeless

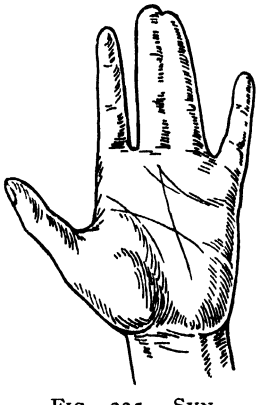


FIG 235.—SYNDACTYLY

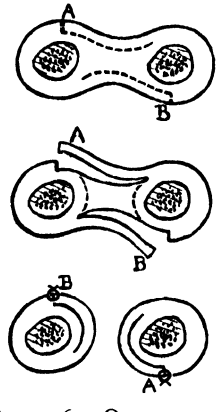


FIG 236.—OPERATION FOR SYNDACTYLY

For deformities due to damage to the tendons of the fingers, see p 463

Spring-, Jerk-, or Snap-finger is a condition in which, when the patient attempts to open his hand, one finger or the thumb remains flexed, and on extending it with the other hand it flies open with a jerk or snap Slight tenderness is usually felt near the metacarpo-phalangeal articulation, and the cause of the trouble is some obstruction to the free working of the long tendons under the transverse ligament at the root of the fingers, or between the sesamoid bones of the thumb In a few cases a ganglion has been present here, but in most instances the condition is due to an increase in size of the sesamoid bone, which radiography has taught us occurs constantly in this situation **Treatment** consists in an aseptic incision to remove the cause of the obstruction

A **Mallet Finger** ('base-ball finger') is one in which the terminal phalanx is maintained in a state of flexion owing to some damage to the extensor aponeurosis Its **treatment** in the early stage has been already alluded to (p 463), should the deformity be persistent, an incision is made on the posterior aspect of the finger, and the weak tendon isolated and stitched down in such a way as to give it a better attachment to the bone

Contraction of the Palmar Fascia (Dupuytren's Contraction).—This condition is usually met with in middle-aged individuals of a gouty

temperament, more often in men than women, and not unfrequently on both sides of the body It may or may not be associated with direct irritation of the palm, as by leaning much on a round-headed cane, or from the constant use of some instrument, such as an awl, whilst heredity is an important causative factor Pathologically, it is due to a chronic overgrowth and contraction of the fascia, inflammatory in nature, and cirrhotic or sclerosing in type It commences as an indurated subcutaneous nodule in the palm of the hand, about the situation of the most marked transverse crease, and affects most commonly the ring and little fingers first, the other fingers and thumb being less often involved The induration spreads slowly both up and down the fascial bands into the fingers, and may even extend downwards beyond the normal limits of this structure, so as to cause acute flexion of the second phalanx, as well as moderate flexion of the first The whole finger is thus gradually drawn into the palm and fixed, so

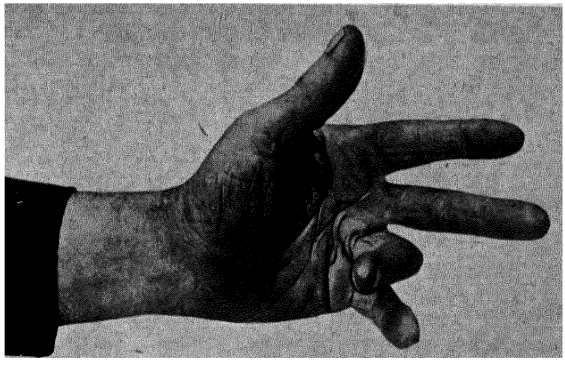


FIG 237 —DUPUYTREN S CONTRACTION

that extension becomes impossible (Fig 237) The third phalanx always remains extended, and, indeed, sometimes assumes a position of hyper-extension, owing to the injudicious application of a splint The skin over the indurated masses is sooner or later incorporated with them, and may become dimpled or creased by the traction of the subcutaneous connecting bands

The **Diagnosis** of Dupuytren's contraction is exceedingly easy, the only condition for which it is likely to be mistaken being the congenital contraction already noted, and the flexion of the finger due to contraction, division, or destruction of the long tendons In the latter case there is, as a rule, no palmar induration, but there will be a history of injury or inflammation, and some scarring

The only satisfactory **Treatment** is by operation, and the following methods are those which are most successful (*a*) Adam's subcutaneous section of the fascia and its prolongations consists in dividing the indurated bands by a tenotome in several places, where they can be felt tense One puncture and division must be made in the centre

of the palm, a second divides the same band as near the finger as possible, whilst the third and fourth deal with the lateral prolongations at the sides of the finger, if other bands still exist, they are treated similarly, the tenotome, if possible, in all cases being inserted between the skin and the fascia The improvement thus produced must be maintained and increased by the subsequent use of suitable apparatus and passive movements, but the final results are not very satisfactory (*b*) Kocher's method consists in the total extirpation of the thickened bands and their prolongations through longitudinal incisions The fingers may be subsequently straightened with ease, but not unfrequently the first interphalangeal joint remains flexed in spite of mechanical appliances and massage In old-standing cases, arthritic changes in the interphalangeal joints and tightness of the skin make correction of the deformity difficult If, therefore, the flexion persists after effective removal of the fascial bands, it is wise to excise at the same time the head of the first phalanx and shorten the extensor tendon through a transverse or semilunar dorsal incision In this way it should be possible to straighten the fingers completely when the operation is finished A splint must be applied whilst the wounds are healing, and a night splint must be worn for several months, or recurrence is likely to take place, but early movements and massage are required if a good functional result is to be secured

Deformities of the Lower Extremity.

Congenital Dislocation of the Hip is a condition in which, owing to a developmental defect in the superior acetabular rim, there is upward displacement of the head of the femur In certain cases there is a deficiency in the muscles attached to the upper end of the femur whereby they become fibrosed and pull the head out of the acetabular cavity as growth occurs, but even in these cases there is usually an associated bony aplasia The condition is occasionally bilateral Most commonly occurring in females, the disease has a definite geographic distribution, being so frequent in Italy as to be looked for in newborn babies Some cases, however, will not show themselves at birth, the head being forced out only when walking occurs, the displacement being progressive until it is well above the acetabulum In addition to the deficiency of the lip of the acetabulum, it is shallow and ill-formed, this perhaps being due to the absence of the moulding pressure of the femoral head The capsule is stretched across it and attached to it by fibrous tissue adherent to the ligamentum teres, this tissue serving as an obstruction to reduction (Fig 241) The inferior aspect of the capsule becomes very thickened, because it in great part is bearing the body weight The femoral head at first appears to be normal, but becomes flattened or even conical, the neck being anteverted with a varus deformity (Fig 240) There may be a general underdevelopment of the affected limb and a shortening of the adductor group of muscles and the hamstrings which further interfere with reduction At birth it may be noted that there is asymmetry on the two sides, the trochanter on the affected limb being

more prominent and raised slightly On account of this upward and outward displacement there is separation of the upper part of the thighs, with apparent widening of the perineum (Fig 238) Usually, however, it is not till the child starts to walk that the condition is diagnosed It is then noticed that the child walks with a curious limp If the condition is bilateral it is a waddle rather than a limp, whereas if one side only is affected there is a lurching to the affected side The raising and prominence of the trochanter will be apparent, and in bilateral cases a marked lumbar lordosis (Fig 239)

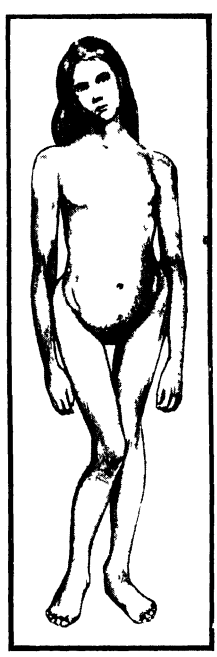


Fig 238

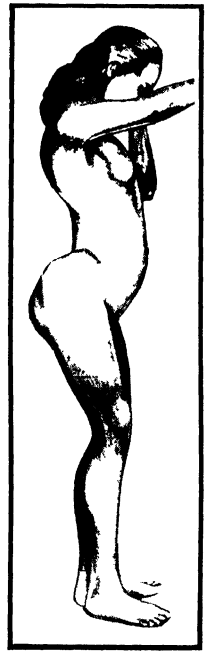


Fig 239

Congenital Dislocation of Both Hips in a Girl of Fifteen Years seen from the Front and Side

On examination the shortening of the affected limb can be determined by measurement from the umbilicus Measurement from the great trochanter will show this to be largely apparent although, as mentioned above, the under-development of the limb may give rise to true shortening If the affected leg is pulled upon, a certain amount of telescoping will be demonstrated *Trendelenburg's sign is positive* This is obtained as follows The patient is first made to stand on the sound leg, and it will be seen that a slight normal lifting of the buttock, corresponding to a tilting sideways of the pelvis, occurs When the body weight is supported by the affected limb, the buttock on the sound side drops because the gluteal muscles are working at a mechanical disadvantage and cannot tilt the pelvis normally This sign is not diagnostic for dislocation of the hip joint, but occurs in any condition where a varus deformity exists X-ray examination sometimes reveals an obvious dislocation with the shallowing of the acetabulum, but where any doubt arises the following test may be applied (Fig 240) Two lines are drawn, one through the clear area of the acetabulum, the other at right angles through the superior edge of the acetabular margin A normally placed femoral head lies below the horizontal and inside the vertical line, whereas a dislocated head lies outside the vertical and above the horizontal

Treatment —As in that of congenital deformities of the feet, treat-

ment should be instituted from the earliest possible date after birth, but this implies, of course, efficient and early diagnosis Putti, in Italy, has shown that up to the age of about twelve months cures can be effected by abducting both limbs and keeping them in a position of abduction by a suitable splint for from eight to twelve months The splint is an adjustable one allowing for gradual increases of abduction In older children the hip must be reduced manually The child is placed on her back, the knee flexed to a right angle and the thigh up towards the abdomen Medial rotation of the thigh and abduction is then performed, the trochanter at the same time being pushed forward, reduction being recognized by the click that results

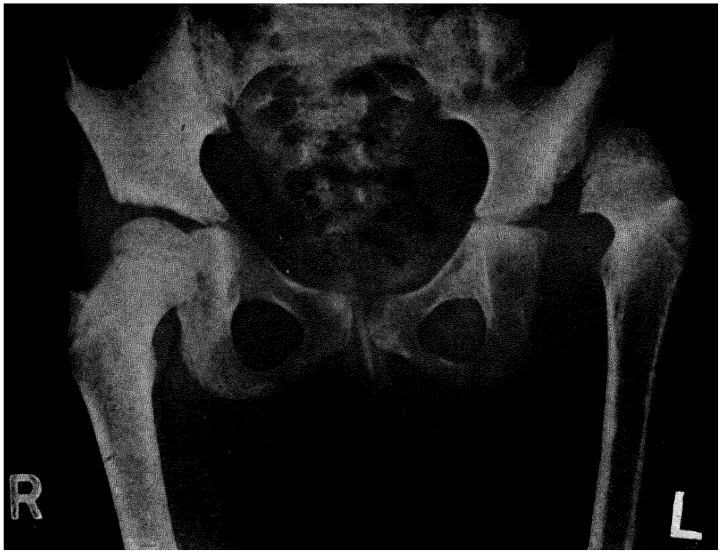


FIG 240 —CONGENITAL DISLOCATION OF LEFT HIP-JOINT

Note the shallow acetabulum and the impression on the ilium above the acetabulum, owing to pressure of the femoral head which is flattened Note also the small size of the left femur as compared with the right

as the head passes into the acetabulum, also by the fact that with reduction the full extension of the knee cannot be performed on account of the rigidity of the rather shortened hamstrings A plaster spica is then applied, with the thigh in a position of 90° of flexion and 90° of abduction, and 0° of rotation, the 'so-called' 90-90-0 position This plaster extends from the umbilicus and includes both legs down to the ankle, the knees being bent to a right angle The plaster must be effectively padded, and it is an added advantage in keeping it clean to rest the child on a metal-frame bed This plaster is maintained for about three months, when it is replaced by another in which the adduction is reduced by about 25° if all is well A further plaster is

applied, until at the end of nine months to a year a cure will have been effected This method is suitable only for children up to the age of six years In patients older than this open operation gives better results Where bilateral dislocation exists both joints may be treated at the same time where reduction is easily attained If difficulty is experienced, it is probably better to treat one hip for three to six months before an attempt is made to reduce the opposite side In the old Lorenz method of reducing this deformity the joint was forcibly manipulated if the reduction was not easy, but the danger of this method is that not only are the soft tissues damaged and the adductors probably torn, but in addition the head of the femur is permanently injured, so that a mobile hip is very unlikely to result Where reduction is not easy open operation is advised The hip joint is exposed

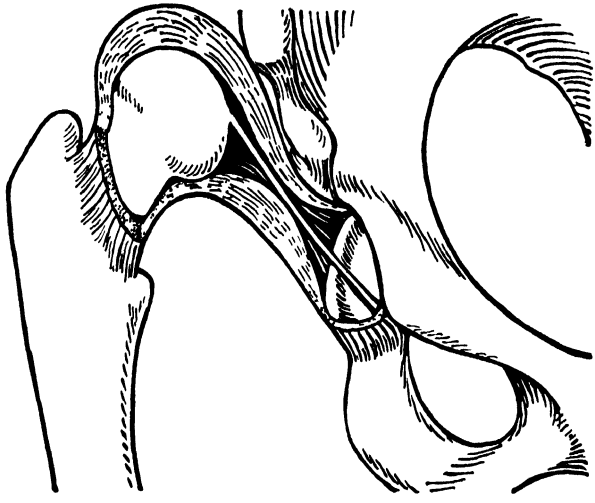


FIG 241 —DIAGRAMMATIC SECTION OF CONGENITAL DISLOCATION OF HIP, SHOWING THICKENING OF CAPSULE AND LENGTHENING OF ROUND LIGAMENT

by a Smith Petersen incision and division of an hour-glass-shaped capsule may be essential for reduction In addition the opportunity is taken to reform an adequate superior margin to the acetabulum This is effected by levering down the bone immediately above the superior acetabular margin, so that the curvature of the latter over the femoral head is approximated to normal The rather crescentic bony deficiency left following this procedure is filled with a bone graft removed from the outer table of the dorsum ilii

The limb is put up in plaster in abduction, which should be maintained for about four to six months, when weight-bearing may gradually be recommended In those who present themselves after the age of fourteen years, on account perhaps of the severe limping and pain, operative intervention should be considered, but these procedures are only palliative, and a careful consideration as to whether improve-

ment is likely must be made Of the operations, Lorenz's bifurcation operation is probably the best In this a rather oblique osteotomy is carried out just below the lesser trochanter, and by abduction and by levering the upper end of the distal femur inwards this is made to impinge on the lower acetabular rim The limb is then put up in slight abduction for three months, when union will have taken place between the two fragments Part of the weight of the body now passes directly through the acetabulum to the femur, and the pain caused by the soft parts having to take the weight is relieved In addition the limp is improved

Coxa Vara is not a specific disease, but the name given to a condition in which the normal angle that the femoral neck makes with the shaft is reduced Such a condition will eventually lead to osteo-arthritic changes in the hip-joint, because the head is displaced downwards and only the superior surface is articulating in the acetabulum (Fig 242) There is in all cases a raising of the great trochanter, which often appears more prominent, and this is associated with true shortening of the limb This is compensated by a tilting of the pelvis, with the result that the patient walks with a limp Trendelenburg's sign may be positive because of the interference with the action of the abductor muscles Coxa vara is produced by disease or trauma affecting either the epiphysis, head, neck, or the trochanteric region of the femur Thus it is associated with a slipping of the epiphysis (*vide infra*), Perthes' disease, tubercle, rickets, osteomalacia, Charcot's disease, arthritis deformans, osteitis fibrosa, fracture of the neck of the femur with malunion and other conditions

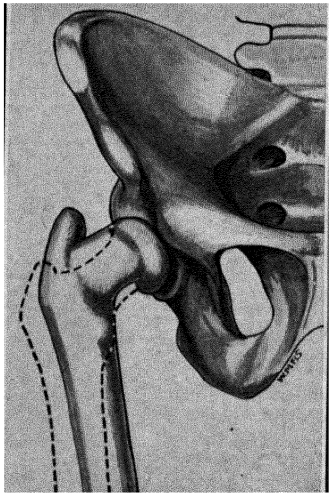


Fig 242 Coxa Vara
The dotted lines represent the normal neck of the femur

Epiphyseal Coxa Vara (Slipped Epiphysis) —In this condition there is a partial or complete downward displacement of the epiphysis of the head of the femur It occurs most commonly in males of fourteen to sixteen years of age Sometimes a history is given of previous definite trauma to the hip which may have occurred just recently or several months ago Often, however, no such history is given, and the patient's attention is drawn to his condition by the fact that he gets tired easily, may notice pain in the hip or referred down to the knee, and observes that he is developing a limp On examination of the limb true shortening will be noticed, and limitation of the movements of abduction, internal rotation, and hyper-extension are marked The cause of this condition is obscure It is observed

that most commonly the condition occurs in rather over-weight and under-sexed young adolescents This has led to the theory that the epiphysis gives way by virtue of the abnormal weight it is called upon to bear The presence of rickets or of staphylococcal infection have both been suggested as causes, the former acting by producing a coxa vara deformity of the neck, the angle at which the epiphysis lies on the shaft then being altered so that it easily slips as a result of slight trauma Injury is an undoubted factor, but an injury sufficient to produce displacement will not do so in a normal hip In the earliest stages of the disease X-rays will reveal a condensa-



FIG 243 —EPIPHYSEAL COXA VARA

Note the marked diminution of the angle between the shaft and the femoral neck on the left side as compared with the normal angle on the right side accompanied by downward displacement of the epiphysis There is no destruction or rarefaction of the bone

tion of the metaphyseal edge of the epiphysis and of the metaphysis Later the projecting lower edge of the epiphysis is seen spreading outwards apparently along the inferior aspect of the femoral neck There is separation of the normal line of continuity between the superior aspect of the metaphysis and the epiphysis (Fig 243) Occasionally in severe cases the head lies absolutely free

Treatment —Early cases should be treated by traction in a position of extension, abduction, and internal rotation, this being maintained for a month after reduction has been effected A walking caliper is then used for a year Where the symptoms have been present perhaps several months, then open reduction with similar subsequent treat-

ment is required Later cases where the epiphysis has united to the neck of the femur in a bad position will require osteotomy of the latter bone

Coxa Valga is the term applied to the opposite deformity, in which the axis of the neck of the femur approaches more to that of the shaft, and the angle of inclination between the two is greater than the normal 125° It is usually secondary to congenital dislocation or infantile paralysis, and largely due to the absence of the transmission of the body weight The limb is generally abducted and rotated outwards, and there is some limitation of adduction and internal rotation The trochanter is flattened and displaced below Nélaton's line **Treatment,** if necessary, is usually directed to the cause, but if the resulting limp is seriously noticeable, a subtrochanteric osteotomy may be desirable

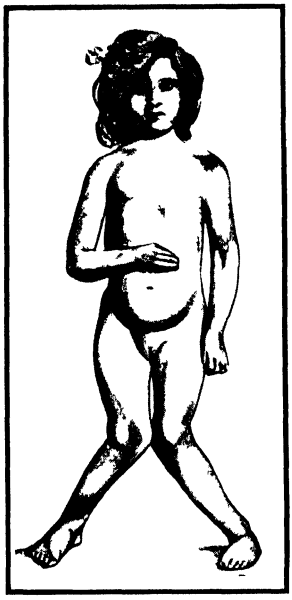


FIG 244 —GENU VALGUM OF RACHITIC ORIGIN

The patient was a child aged twelve years The femora were curved antero-posteriorly, but radiography demonstrated that the trouble in the right leg was as much tibial as femoral in origin Cuneiform osteotomy of both tibia and femur was needed on the right side, whilst simple osteotomy of the femur sufficed to correct the left side

A **Clicking Hip** is a troublesome affection in which, when the thigh is moved in certain directions (usually flexion with slight inversion), some deep structure slips over the back of the great trochanter with a snap or crack, and possibly some slight pain As a rule the structure affected is the tendon of the gluteus medius or the ilio-tibial band of fascia, and most patients are able to carry on their occupations without difficulty, unless called on to undertake heavy walking or severe exercise Where treatment is necessary, an incision may be made over this hip, for choice under a local anæsthetic, so that the patient may be able to use the joint and demonstrate the actual lesion The tendon or fascial band thus identified usually requires division and shortening, or re-fixation to the bone in a new position so as to steady it effectively

Congenital Affections of the knee are mainly connected with the patella, which is sometimes absent, and then other deformities are associated with its non-development The extensor tendon passes down the front of the knee as a thick band, and the function of the joint is not much impaired

Congenital Dislocation of the Patella may be present as a persistent lesion, the bone lying to the outer side of the joint , but more commonly the displacement occurs only at intervals (See Recurrent Dislocation of Patella, Chapter XXII)

Genu Valgum, or *knock-knee*, is a deformity in which, if the knees are allowed to touch with the patellæ looking forwards, the malleoli are separated one from the other, *i e* it is a condition of fixed abduction of the legs from the middle line, with some external rotation (Fig 244) One or both limbs may be affected, but if due to general causes the double form is more common Occasionally genu valgum occurs in one leg, whilst the other is in a condition of genu varum

There are two main **varieties** of the disease, *viz* (1) The rachitic genu valgum of young children, and (2) the static form occurring in adolescents

The genu valgum of young children arises from the irregular epiphyseal development induced by *rickets* Increased growth occurs on the inner side of the joint, and this may involve equally the femur and tibia, although most frequently the former is mainly affected When once the axis of the limb is altered, the weight of the trunk transmitted chiefly through the outer portion of the joint tends to increase the deformity In not a few cases an antero-lateral rachitic curvature of the diaphysis of the femur is an important element

The static genu valgum of adolescents occurs most commonly in young children of relaxed constitution, and particularly in those who have to carry heavy weights Thus, anæmic girls who act as nursemaids and young bricklayers, smiths, and porters, are very liable to it The method of origin is probably as follows In the erect posture the femur is normally set at an angle to the tibia (which is vertical) in such a way that the weight of the trunk passes rather through the outer than the inner condyle, whilst the latter structure is lengthened in order to keep the plane of the knee-joint horizontal This position naturally throws a certain amount of strain and tension on the internal lateral ligament, even in a healthy person (hence its insertion into the shaft and not merely into the upper epiphysis of the tibia), and this strain is increased when the natural position of rest, *i e* with the feet separated and slightly abducted, is adopted A long continuance of this posture tires those muscles on the inner side of the limb which tend to counterbalance this strain, especially if a certain amount of additional weight has to be carried, and particularly in those whose bones have rapidly increased in length and weight without any coincident increase in power of muscles or ligaments Hence the internal lateral ligament becomes more and more stretched, and not unfrequently a certain amount of lateral mobility of the knee is noticed in the early stages Subsequently the outer condyle becomes atrophied from more weight being transmitted through it, and the inner condyle becomes lengthened from overgrowth Flat-foot and lateral curvature of the spine often accompany this form of genu valgum

Occasionally genu valgum is due to *traumatic causes*, such as fracture of the tibia or femur close to the joint, or lateral dislocation of the knee, whilst, again, it may be caused by atrophy consequent on interference with the epiphysis from local injury or diseases other than rickets It is sometimes observed, as a result of riding, in those with long legs, as in cavalry soldiers, short-legged individuals, such as jockeys, are more liable to develop a condition of genu varum

The **Physical Condition** of the parts about the knee may be summarized as follows (*a*) The inner condyle of the femur is elongated and prominent, the increase in size is mainly in the vertical and transverse directions, and but very little antero-posteriorly, so that, on flexion of the joint, the deformity to a large extent disappears, (*b*) impaired growth and atrophy of the outer femoral condyle and tibial tuberosity are present owing to the weight of the body being transmitted more directly through these structures, (*c*) relaxation of the ligamentous and muscular tissues takes place on the inner side of the joint, this, however, is not constant, especially in the later stages, or in cases which are stationary, (*d*) the tendons and ligaments on the outer aspect of the joint are contracted and shortened, especially the external lateral ligament, the ilio-tibial band, and the tendon of the biceps, (*e*) the patella tends to be thrown outwards, and in bad cases recurring dislocation is sometimes observed, (*f*) in rachitic cases a localized bony outgrowth can often be detected on the inner surface of the tibia about 2 or 3 inches from the joint, and is probably due to a localized periostitis at the point of attachment of the internal lateral ligament

The feet are displaced outwards, or occasionally inwards, as best suits the convenience of the patient in obtaining as good a footing as possible, the bones of the legs and of the thighs are often bent, and, if the condition is unilateral, scoliosis may result In well-marked cases the gait of the patient is of a rolling or waddling type, and very characteristic, the legs are partially flexed, and as the condyles touch or overlap they have to be separated at each step to allow of progression

Treatment.—In *rachitic* cases, the infant requires the adoption of dietetic and therapeutic measures suitable to the condition present For the local deformity absolute rest in bed is enforced, the limbs are well rubbed daily, and such manipulation and pressure employed as will help to straighten the limb By perseverance slow but appreciable progress may be made until the deformity is corrected In older children, splints may be applied on the outer side of the limbs, reaching from the waist or axilla down to the outer malleoli, or, if they are to be kept off their feet, beyond them These are retained in position by plaster bandages, put on firmly enough to draw the knees outwards Such an arrangement is often sufficient in early cases to bring about a cure in the course of a few months

In *static* cases the administration of tonics, such as iron and arsenic, combined with rest, massage, and possibly a change of air, will frequently suffice to determine a cure in the early stages Suitable apparatus must be adopted when the patient is allowed to walk, that usually employed consists of a walking calliper, jointed at the knee, and fixed below into a slot in the heel of a well-made boot, and attached above to a pelvic band

When, however, the osseous deformity is fixed, and the patient of such an age as to preclude the hope of a cure by mechanical means, *osteotomy* will be required, and the operation devised by *Macewen*, or some modification of it, is that generally employed It consists in the division of the femur transversely about a finger's breadth above

the upper border of the external condyle, so as to be well away from the epiphyseal cartilage Macewen himself used an osteotome* for the purpose, introducing it through an incision made ½ inch in front of the tendon of the adductor magnus, and turning it so as to lie at right angles to the long axis of the shaft, the bone is divided for three-quarters of its diameter, and the remainder is broken A similar method may be employed from the outer side, the force used in breaking the inner layer of compact bone comminuting and compressing that portion, and so diminishing the deformity Many surgeons, however, prefer to divide the bone with a saw, previously making a track for it along the front of the femur, and such an operation is certainly simple and efficacious The limb, having been straightened, is put up at once in plaster of Paris Union is complete in six weeks, but an immovable apparatus should be kept on for three months

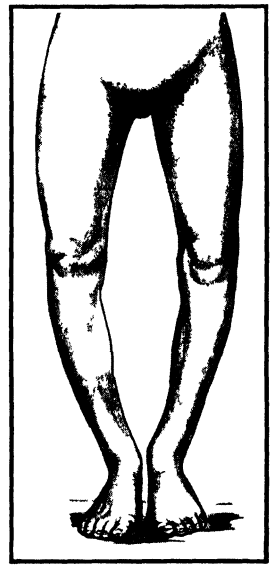


FIG 245.—BILATERAL GENU VARUM

The patient was a girl of thirteen years who had developed this condition during two years, and was the subject of adolescent rickets Enlargement of the epiphyseal ends of the radius and ulna and of the costo chondral junctions was also present

Genu Varum is a less common condition, characterized by a fixed separation of the knees when the ankles are in contact (Fig 245) It arises from three chief causes (i) Occupation, and particularly that of a jockey, the short legs being constantly apposed to the sides of the horse, (ii) traumatism, especially if directed to the femoral condyles, and (iii) rickets, the lesion usually present being a well-marked excurvation of the femoral shafts, with possibly a similar curve of the tibiæ (*bow-leg*) The condition is usually bilateral and symmetrical, but occasionally one side only is affected, whilst the other leg is in a state of genu valgum

Treatment in the early stage is by splints, in the later by operation, which consists either in simple osteotomy above the knee, or in cuneiform osteotomy of the shaft of the femur

Genu Recurvatum, or *back-knee,* is a deformity occasionally met with, in which the joint is hyper-extended, the limb describing a curve with the concavity forwards, it is necessarily associated with relaxation or stretching of the crucial ligaments, and is usually due to a congenital displacement, possibly the result of the limbs not being flexed *in utero,* but extended with the feet under the chin It is sometimes the result of paralysis of the extensor muscles, and is then due to the necessity for the patient to keep his knee slightly hyper-extended if it is to be a basis of support,

* An *osteotome* differs from a *chisel* in the fact that the former is bevelled on both sides, whilst the latter is merely bevelled on one side

in time the posterior ligaments give way, and deformity results Genu recurvatum may also arise from irregular growth along the epiphyseal line, possibly as a sequela of tuberculous or other disease of limited extent in that region, and sometimes as a result of the disorganization of the joint in Charcot's disease It has also been known to occur as an acquired accomplishment in fakirs and contortionists Treatment must be suited to the special requirements of the individual case

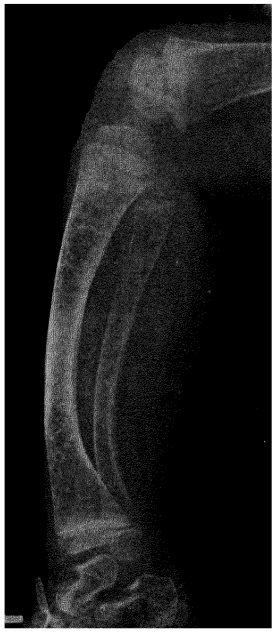


FIG 246 — RICKETS

Note the bowing of the bones the broadening of the diaphyseal extremities the line of condensation at the lower end of the femoral shaft, and the thickening of the cortex on the concave side of the curved bones Note also the transverse striations at the lower end of the tibial shaft These striations however, are not pathognomonic of healed rickets but of any disease which has at some time arrested bone growth

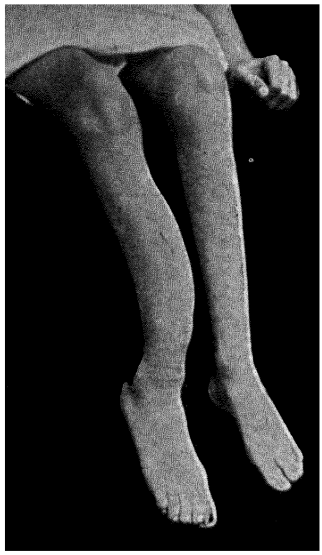


FIG 247 —RACHITIC DEFORMITY OF BONES OF RIGHT LEG

Rachitic Deformities of the Bones of the Leg are not unfrequent, if in the course of an attack of rickets a child is allowed to run about The trouble may involve both segments of the limb, and give rise to a general excurvation, constituting what is known as *bow-legs*, the knees being widely separated the one from the other, and the antero-posterior curve being exaggerated The femora are bent antero-posteriorly, with the convexity of the curve forwards and outwards, the main convexity of the curve usually occurs about the junction of the upper and middle fourths, and here it may be so marked as to be a cause of spon-

taneous fracture Cases of this nature may remain under observation for years, where both femora frequently break as a result of extreme rachitic distortion The *tibia and fibula* (Fig 246) participate in this deformity, or are separately affected, the antero-posterior curve is usually increased (Fig 247), and some amount of abduction or adduction may also be present The bones in these cases are flattened from side to side, presenting a sharp edge in front, with a buttress-like support or strut reaching along the concavity, in time they become exceedingly dense and sclerosed

Treatment in the early stages consists of rest and constitutional treatment, and in the application of suitable apparatus to reduce the deformity Where the femora are seriously affected, it may be necessary to provide the patient with an apparatus, *e g* a hinged double Thomas's knee-splint, which fits closely round the pelvis, and carries the weight to the ground by lateral metal rods which also maintain continuous extension In the worst cases operation will be required, but never until all signs of active disease have passed The bones may be divided at their most prominent parts, or, if necessary, a wedge-shaped portion may be removed (*cuneiform osteotomy*), the sections being made at right angles to the upper and lower segments of the bone respectively Careful and prolonged after-treatment, including the use of suitable splints, is required, especially where the femora have been divided, in order to prevent a reappearance of the deformity

The tibia and fibula also become distorted and curved anteroposteriorly as the result of *inherited syphilis*, this usually comes under notice at a later date than the rachitic change, and is due to a deposit of new bone under the periosteum rather than to bending The deformity is purely antero-posterior, without lateral deviation, whilst the subcutaneous margin of the tibia is rounded, and not sharp as in rickets Moreover, the curve generally involves the centre of the bone, whilst in rickets the chief deformity occurs either near the knee or a little above the ankle

Deformities of the Feet.

These cannot be understood properly unless the student grasps clearly the mechanical structure of the foot It has a twofold purpose (1) to form a solid and firm basis of support for the body, and (2) to permit of elasticity and spring in the gait The foot therefore consists of two parts (1) the solid posterior portion (astragalus and os calcis) through which the weight is transmitted from the leg to the heel, and (2) an anterior segment comprised of the front half of the astragalus and all the remaining bones, set at varying angles (to break up shock), and with movable toes controlled by muscles Elasticity is also secured by the arches of the foot, which are threefold (1) The internal longitudinal arch (arch of the instep), which reaches from the heel to the head of the first metatarsal and varies much, but in a well-formed foot is sufficiently pronounced to keep the skin clear of the ground, it is this arch which suffers most in 'flat-foot' It is maintained chiefly by the inferior calcaneo-scaphoid or 'spring'

ligament upon which rests the under side of the head of the astragalus, beneath the ligament passes the tendon of the tibialis posticus, which gives slips to most of the tarsal bones The long and short plantar ligaments and the short muscles and deep fascia of the foot also assist in maintaining the arch (2) The external longitudinal arch is of slight importance, inasmuch as the constituent elements (os calcis, cuboid, fourth and fifth metatarsal) rest almost always on the ground (3) The transverse arch is the necessary result of the arrangement of the two longitudinal arches extending from the astragalus to the heads of the metatarsal bones, and varies in its degree with the height of the instep, should this be lost, the transverse arch must obviously disappear It is chiefly maintained by the peroneus longus tendon

Talipes

By talipes, or club-foot, is meant a deformity of the foot due to muscular, ligamentous, or osseous causes, the displacement occurring mainly at the ankle and mid-tarsal joints, it may be either congenital or acquired

The *congenital* variety is often hereditary, and may be found in several members of the same family, it is sometimes associated with other deformities, such as hare-lip and spina bifida It may arise from malformation of some of the bones of the foot, or of the lower end of the tibia or fibula, but probably it is more commonly due to malposition of the feet *in utero* induced by an unusually small uterine cavity or a deficient amount of liquor amnii, as a result of which the feet are abnormally compressed and held in one position

The *acquired* varieties arise from some derangement of the equilibrium normally maintained between opposing groups of muscles, in consequence of which the more powerful group draws the foot into an abnormal position Thus it may be due to (*a*) *Paralysis*, the result of infantile palsy, or of peripheral nerve lesions, (*b*) *cicatricial* contraction of muscles from diffuse suppuration Thus penetrating wounds, followed by suppuration of the gastrocnemius or soleus, often cause such a degree of cicatricial contraction as to constitute a talipes equinus, whilst necrosis or caries of the tibia may lead to such changes in the tibialis anticus or posticus as to determine a position of talipes varus (*c*) Essential muscular shrinking, resulting from a chronic myositis fibrosa, is occasionally met with in elderly people (*d*) It also occurs in *spastic* paralysis (p 531) (*e*) Shortening of the leg from hip or knee mischief often induces a *compensatory* talipes equinus, whilst injuries or diseases of one of the epiphyses of the leg bones may stop its growth, and then the continued development of the other bone forces the foot to one side or the other (*f*) Finally, prolonged maintenance of the foot in a bad position may lead to permanent deformity, as in the variety known as talipes decubitus

Four primary forms of talipes are described, *viz* **T. Equinus,** in which the heel is drawn up, the patient walking on the toes (plantar flexion), **T. Calcaneus,** in which the toes are raised from the ground (dorsiflexion), **T. Varus,** in which the anterior half of the foot is adducted and inverted, and the inner side of the foot is raised, the patient

walking on the outer, and **T Valgus,** due to abduction and eversion of the anterior half of the foot, or to yielding of the longitudinal arch on the inner side Not unfrequently mixed forms occur, due to the association of two of the above, *e g* T equino-varus, or T equino-valgus, or T calcaneo-valgus

As to the *relative frequency* of these different forms, there is not the slightest question that T equino-varus is by far the commonest If, however, we exclude congenital cases and flat-foot, T equinus is in all probability the variety most frequently observed

Talipes Equinus (Fig 248, A, B, and C) is almost always acquired, as a congenital lesion it is very uncommon It is a very frequent sequela of gunshot wounds of the muscles of the calf, which have been followed by suppuration or required partial excision for gas gangrene, cicatrization naturally draws up the heel and brings about this deformity It also occurs as a compensatory manifestation where the limb has been shortened, as after hip disease, and may follow the prolonged pressure of bed-clothes on the dorsum of the foot of a bed-ridden patient (T decubitus) The paralytic form is the result of any lesion of the nerve-fibres which control the anterior tibial group of muscles, and if these are divided above the anterior tibial nerve the peronei muscles are also likely to be involved, and the deformity has an element of varus added to the 'drop-foot' which follows When resulting from poliomyelitis, the muscular involvement may be a little less regular in its distribution In both of these conditions the equinus deformity is of the flaccid type

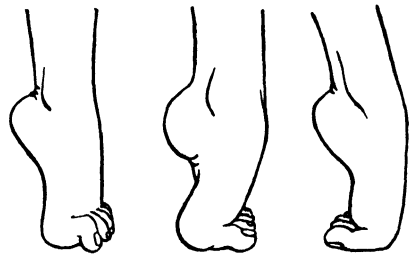


FIG 248.—VARIOUS FORMS OF TALIPES EQUINUS

In the slightest cases all that is noticed is that the foot cannot be dorsiflexed beyond a right angle (right-angled contraction of the ankle) When more marked, the heel is drawn up, and the patient walks on the heads of the metatarsal bones and on the toes, which are usually hyper-extended, but may occasionally become flexed (Fig 248, C), so that in time the whole dorsum of the foot may even be turned downwards

Secondary changes occur in old-standing cases The astragalus is displaced forwards from under the malleolar arch, only the posterior part of the articular surface being in contact with the tibia In the paralytic type the anterior segment of the foot drops at the mid-tarsal joint, so that the head of the astragalus and scaphoid constitute a marked prominence beneath the skin In all cases the sole of the foot is liable to be shortened by contraction of the plantar fascia and of the short plantar muscles (pes cavus), and a certain amount of varus is frequently present In this, as in all forms of talipes, callosities, and perhaps bursæ beneath them, form over points of pressure, *viz* under the heads of *all* the metatarsal bones

Talipes Varus, or, as it is most frequently termed, **Equino-varus,**

is the commonest variety of congenital club-foot, and is then often bilateral, and may be accompanied by other congenital defects, *e g* hare-lip or spina bifida As an acquired deformity, T varus is not a very unusual result of infantile palsy affecting the extensor and peroneal muscles, although the equinus element usually predominates, other cases are due to a spastic contraction of these muscles

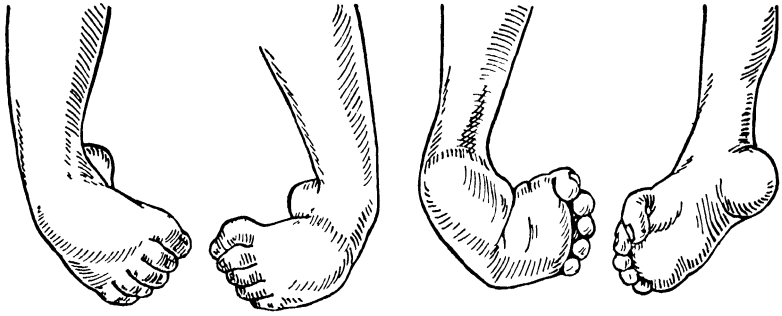


FIG 249.—DOUBLE TALIPES EQUINO-VARUS OF CONGENITAL ORIGIN SEEN FROM IN FRONT AND BFHIND

The heel is drawn up, and the anterior half of the foot adducted and drawn inwards (Fig 249) The inner border of the foot is concave, and a well-marked transverse crease crosses the sole on a level with the mid-tarsal joint, the outer border is convex, and in adults

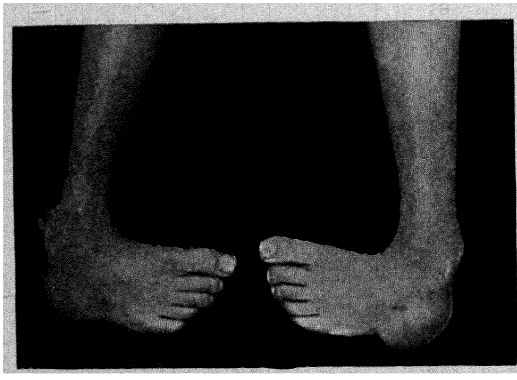


FIG 250.—CONGENITAL TALIPES VARUS OF MANY YEARS' DURATION

The large bursæ on the outer sides of the feet induced by walking are very noticeable

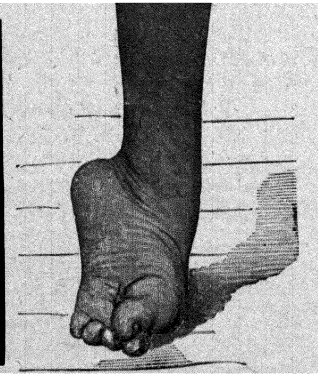


FIG 251.—VERY NEGLECTED CASE OF TALIPES VARUS

who have walked a thick bursal formation is usually present over the cuboid (Fig 250) In neglected cases the patient may even stand on the dorsal aspect of the latter bone (Fig 251) The sole of the foot is arched from secondary contraction of the plantar fascia and short muscles of the sole, and a longitudinal crease may run down the centre of the sole, owing to doubling over of the outer metatarsal bones

The most marked *anatomical changes* in the congenital type are found in the astragalus, the neck of which is elongated and inclined inwards, the bone also projects forwards from under the tibio-fibular arch, the posterior portion of the upper articular facet alone remaining in contact with it The scaphoid is displaced to the inner side of the head of the astragalus, and its tubercle is usually in close proximity to, or may even touch, the inner malleolus The os calcis and other tarsal bones are also modified in position and shape to correspond with these changes The dorsal tendons are displaced inwards, usually occupying the centre of the concavity between the foot and the leg The ligaments on the inner side of the foot are contracted, especially the anterior portion of the deltoid, the inferior calcaneo-scaphoid, and to a less extent the long and short plantar ligaments

The following table indicates the chief diagnostic points between congenital and paralytic T equino-varus

	Congenital	*Paralytic*
HISTORY	Affection has existed from birth	Affection not developed till the second or third year, and ushered in by convulsions, fever, etc
FEET AFFECTED	Usually bilateral	More often unilateral
CIRCULATION	Good	Feeble, limb is sometimes cold, blue, and clammy
MUSCLES	But little wasting	Extreme wasting
ELECTRICAL REACTIONS	Not much impaired	Almost entirely absent in paralyzed muscles
GROWTH OF BONES	Much as usual	Considerably diminished
CREASES IN SOLE	Present	Absent

Talipes Calcaneus is an unfrequent variety of the deformity, and may be either congenital or acquired In the *congenital* form (Fig 252) the toes are drawn upwards so that the heel alone comes into contact with the ground, the sole pointing forwards The extensor tendons are contracted, but the toes may be flexed owing to the tension of the flexor longus digitorum It is sometimes associated with deviation of the foot inwards or outwards, constituting a condition of T calcaneo-varus or valgus The *acquired* variety (Fig 253) is generally due to infantile palsy of the calf muscles, or occasionally to overstretching of the tendo Achillis after tenotomy The longitudinal arch of the foot is increased (pes cavus), partly from the development of a large pad of fat over the calcaneal tuberosities, but mainly from the dropping of the anterior half of the foot from the mid-tarsal joint

Talipes Valgus is a condition seldom met with as a *congenital* deformity, except in association with T equinus In it the foot is abducted and everted, owing to contraction of the peronei muscles The sole becomes flattened, and the inner border of the foot comes in contact with the ground (Fig 254) Considerable pain is usually experienced after walking a short distance This deformity is occasionally due to absence of the fibula The *acquired* variety, which is not uncommon (Fig 255), results from paralysis of the tibial muscles, or from spastic contraction of the peronei, the condition in these cases closely simulating flat-foot

The **Diagnosis** of the different varieties of talipes is, as a rule, easily ade, although the cause of the deformity is not always so readily certained In *paralytic* cases the limb is generally atrophied, bluish colour, and feels cold and clammy Trophic lesions are not unmmon in the form of recurrent ulceration, and even ulcers of the rforating type may develop, especially in cases due to peripheral

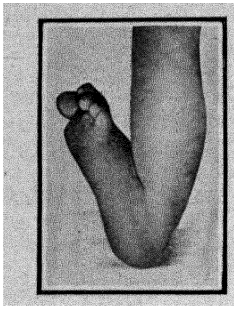


FIG 252.—CONGENITAL TALIPES CALCANEUS

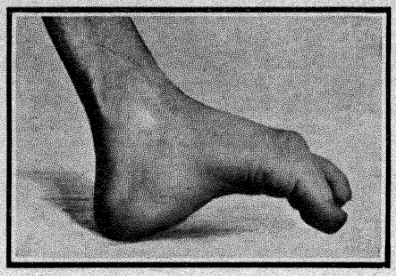


FIG 253.—PARALYTIC TALIPES CALCANEUS WITH WELL-MARKED HALLUX FLEXUS

rve lesions The trouble is often unilateral, and the muscles are asted and flabby In *congenital* cases the condition is usually symetrical, and of course present from birth, considerable resistance is lt on any attempt being made to correct the deformity, and the nbs look healthy, are well nourished, at any rate at first, and free om trophic lesions In *spastic* cases (most frequently T equinus)

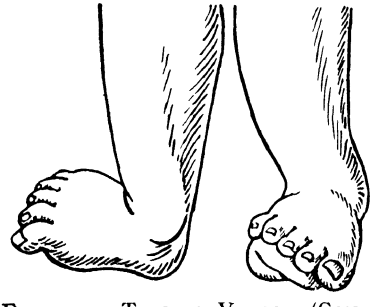


FIG 254.—TALIPES VALGUS (CONGENITAL), WITH A LITTLE TENDENCY TO CALCANEUS

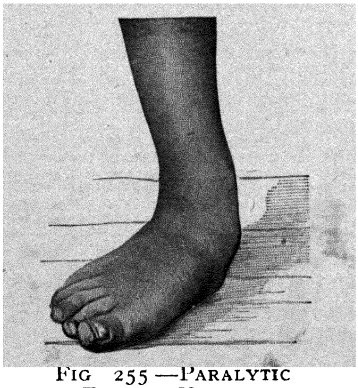


FIG 255.—PARALYTIC TALIPES VALGUS

pasm or contraction of other parts is usually present, which renders he diagnosis obvious, one or both limbs may be affected, the reflexes re exaggerated, the gait is characteristic, and the muscles, at first mply contracted, may finally atrophy

The **Treatment** of talipes is always tedious, demanding care and

patience on the part of all concerned It is important to discriminate accurately between the different varieties, and to recognize the actual anatomical lesions present in each

Talipes equinus, if secondary to hip disease, should not, as a rule, be interfered with When likely to develop as a result of intrinsic muscular contraction (post-suppurative or otherwise), it may be prevented by keeping the foot at right angles by a suitable splint, or in plaster of Paris When fully developed, tenotomy of the tendo Achillis (p 472) may be required, accompanied if necessary by division of the plantar fascia, whilst in neglected cases, or where tenotomy has failed, excision of the astragalus gives excellent results, the patient being able to walk subsequently with a plantigrade foot

In the *paralytic* variety, whether central or peripheral, every effort must be made to conserve and render more efficient all muscular tissue that is capable of functioning, and thus massage and electricity are required and the adoption of a satisfactory position In old-standing helpless cases of *drop-foot* with flaccid muscles and relaxed joints, operations to stabilize the foot must be considered, and a subastragaloid arthrodesis seems to be the most satisfactory means of securing this The ankle-joint itself is not stiffened, but the patient wears an external iron, and thereby stability is secured Other surgeons prefer Whitman's operation, which consists in removing the astragalus through an incision on the outer side of the foot The foot is then displaced slightly backwards, and the malleoli fitted into suitable beds prepared on the inner side in front of the sustentaculum tali, and on the outer by gouging out a hole in the os calcis or cuboid When healed, a considerable degree of stability is secured, and with the aid of a surgical boot walking is possible

Congenital T equino-varus —As already indicated, treatment should be commenced as soon after birth as possible, and the intelligent co-operation of both mother and nurse must be secured Two or three times a day the infant's foot must be firmly manipulated into as good a position as possible and held there for some minutes The surgeon will undertake the same once or twice a week with a little more energy The object aimed at must be clearly appreciated, *viz* firstly, to overcome the cavus element, then to abduct and evert the foot, and finally to remedy the equinus position

When the child is from three to six months old, it is possible to apply a plaster retentive dressing, and hence if by that time simple manipulation has not succeeded in overcoming the deformity, a definite attempt must be made under an anæsthetic to correct it, but only by manipulation The foot is then put up in plaster with the knee at a right angle, the plaster reaching to the mid-thigh with changes for movements once in two weeks In most children under twelve months of age this treatment is successful, though in a few division of the tendo Achillis may be required

If the case is very resistant or is not brought to the surgeon till later (one to three years), when bony growth tends to fix the deformity, it may be necessary to attempt *forcible correction* under a general anæsthetic by the employment of Thomas's wrench (Fig 259), applied

over a suitable packing of wool Failing this, subcutaneous or open division of the anterior portion of the deltoid or internal lateral ligament of the ankle may be required, as also of part of the inferior calcaneo-scaphoid ligament, the tibialis anticus and posticus tendons may also need division Subcutaneous elongation of the tendo Achillis is the final step of the corrective operative treatment, but it must be noted that this is not necessarily all undertaken at one sitting Plaster of Paris cases are applied until the foot remains in a good position without pressure, and then a metal malleable splint or tin night-shoe (Fig 256) is applied Massage and passive movements are required, and later on education in walking

When the child does not come under observation until the deformity is fixed, and still more when the foot has been used in its bad position for walking, operations directed to the bones will be required In the less severe cases, division of the neck of the astragalus may be undertaken from the dorsal aspect, and the os calcis can be divided just behind the calcaneo-cuboid joint, together with such section of tendons and ligaments as may be required In the worst cases, however, *cuneiform tarsectomy* or removal of a wedge-shaped portion of the tarsus, with its base outwards, and regardless of exact anatomical details, must be performed This is accomplished through a semilunar incision on the outer side of the foot, the thick subcutaneous structures, including the bursa, are removed, and the extensor tendons, already somewhat displaced inwards, are stripped from the bones and held aside The tarsus is divided by a chisel in two places so as to include a wedge with its base outwards, the lines of section are as far as is possible at right angles to the anterior and posterior segments of the foot, and sufficient bone is taken away to permit the foot to come into good position without difficulty After closing the wound an ordinary removable splint is applied at first until the wound is healed, and then a plaster case is employed for six or eight weeks The results are excellent, the foot, although a little shortened, being firm and plantigrade

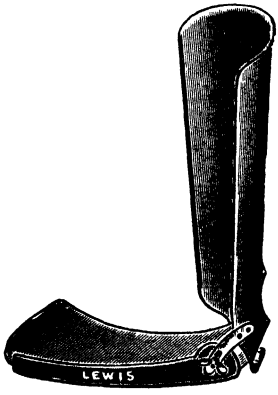


FIG 256 —TIN NIGHT-SHOE USEFUL IN CASES OF TALIPES WITH MOVEMENTS POSSIBLE IN VARIOUS DIRECTIONS

In *paralytic T varus* of central origin, with persistent paralysis of the peronei muscles, it will often suffice to transplant the healthy active tendon of the tibialis anticus from the inner side of the foot to the outer, implanting it in the cuboid, to which it is firmly sutured with the foot everted and dorsiflexed, it is maintained in this position by means of plaster of Paris for six weeks If this is not sufficient, Whitman's operation (p 517) must be used, and leg-irons provided

In congenital *Talipes calcaneus* all that may be needed is division or lengthening of the extensor tendons, but in the paralytic variety some form of apparatus must always be worn Where the tendo

Achillis is thin and attenuated, a portion of it may be excised, and the ends united by suture, or the tubercle of the os calcis into which the latter is inserted may be sawn off and re-attached by a nail or peg to the bone at a lower level, but the prognosis in all forms due to paralysis is unsatisfactory

Talipes valgus must be treated along the same lines as a flat-foot (*q v*) If unrelieved by the application of suitable boots, division of the peroneal tendons may be required, or in severer cases wrenching the foot into position, and fixation in plaster of Paris Removal of a wedge-shaped portion of bone from the inner aspect of the foot may be undertaken, but is not very successful

Flat-foot (*syn* **Splay-foot** or **Spurious Valgus**) is a condition frequently seen in young adults whose occupation exposes them to over-fatigue, or the carrying of heavy weights, *e g* in nurse-girls, shop-boys, and in young recruits It occurs as a natural condition in many of the negro races, and is more often seen in long than in short feet It is also not uncommon in women about middle life, especially if called on unexpectedly to take over heavy domestic duties

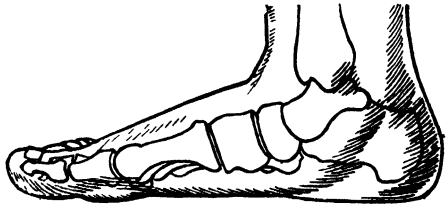


FIG 257.—FLAT-FOOT

Mechanism.—In the majority of cases it is due to relaxation of the structures which keep up the longitudinal arch of the foot, especially of the inferior calcaneo-scaphoid or 'spring' ligament, upon which rests the head of the astragalus A rapid increase in the length and weight of the skeleton apart from an equivalent increase in strength of muscles and ligaments throws undue strain upon this structure, especially if the patient is suddenly exposed to long hours of standing or weight-carrying The ligament stretches, the head of the astragalus sinks, the anterior portion of the foot becomes abducted at the mid-tarsal joint, and the typical splay-foot results The tibialis posticus is often relaxed or even paretic, and the peronei tendons are in the later stages contracted, but in some cases spasm of the peronei muscles is apparently the primary cause of the deformity Occasionally it is due to a gonorrhœal or septic inflammation of the inferior calcaneo-scaphoid ligament, which becomes relaxed and yields under the weight of the body In a few cases it results from grosser traumatism, *e g* fracture of the neck of the astragalus, or of the sustentaculum tali, or it may follow a badly treated Pott's fracture Care must be taken to differentiate flat-foot with tenderness on the inner side of the arch from Kohler's disease due to subacute osteitis of the scaphoid (p 646), radiographic examination is here helpful

However produced, the *deformity*, when fully established, is tolerably characteristic (Fig 257) The sole of the foot is flat, and in well-marked cases comes in contact with the ground throughout the whole of its extent, as indicated by a print of the sole (Fig 258) The inner

border is convex and somewhat lengthened, whilst the anterior half is everted and abducted The head of the astragalus is felt a little in front of and below the internal malleolus, whilst the sustentaculum tali, which is normally distinguishable about ¾ inch below the malleolus, is buried by this displacement The tubercle of the scaphoid is less evident than usual, being situated below and in front of the head of the astragalus

In the early stages the foot may appear to be normal or merely a little everted when the patient puts no weight on it, but when he stands, the sinking of the arch becomes evident, and increased pain is produced As the condition progresses, the front of the foot is more and more displaced outwards, and the astragalus sinks into the sole After a time inflammatory troubles are lighted up in the joints, and adhesions form in and around them, or the deformity may become fixed by bony changes In the early or first stage, therefore, the patient himself or the surgeon can easily restore the foot to a normal position, in the second stage, it may be possible for the surgeon to do so, but probably only under an anæsthetic, finally, in the third stage, when ankylosis has occurred, it is impossible to restore the arch apart from operation



FIG 258 —FOOTPRINTS OF HEALTHY (LEFT) AND FLAT FOOT

The raised arch of the instep in the healthy foot is represented by the hollow on the mesial side, when the arch is exaggerated (T cavus), this hollow becomes more distinct, and may actually divide the print into two In flat-foot it entirely disappears

The subjective symptoms are pain and a sense of weakness and fatigue, especially about the origin of the tibialis muscles, at first only experienced after or during exercise, but subsequently persistent In the more acute cases, pain is complained of in the sole, and especially below and behind the tubercle of the scaphoid in the situation of the 'spring' ligament, this may be very pronounced before the arch has actually given way Later, when the bony displacement is becoming more marked, pain across the dorsum is complained of over the astragalo-scaphoid joint, and when the displacement is still more severe, pain on the outer side of the heel may become prominent, probably owing to the outer malleolus impinging on the os calcis In not a few cases, however, there is but little pain when the arch has totally collapsed Flat-foot is not unfrequently associated with hallux rigidus (p 523), and this may be extremely painful

Treatment.—In the first stage, all that is required in the majority of cases is rest in bed for a few days if the 'spring' ligament is very tender, together with massage, by this means overstrained ligaments and muscles recover themselves Tonics may also be administered to improve the general health If the condition is of gradual onset, it may not be necessary to confine the patient to bed The most

important element in the treatment is the provision of suitable *boots*, which shall assist in keeping the foot inverted and thrown slightly over on to its outer border The boots should be low-heeled and square-toed, and the inner borders should be straight, the heel must be thickened upon the inner side ⅛ inch, tapering off to the outer side, and carried forward under the arch for ¾ inch further than is usual, a patch ⅛ inch thick should also be placed on the inner side of the sole All boots, shoes, and slippers must be similarly treated, and the patients in bad cases must *never* be allowed to put foot to ground without this support, a few minutes on his feet without support may undo the good work of weeks The patient must be taught to walk with his toes straight in front of him, and with no trace of eversion Tiptoe exercises with the feet inverted are useful in strengthening the short muscles of the sole, as also massage and electricity The latter may advisably be employed in the form of galvanic foot-baths, followed after a time by the use of the faradic current The feet are placed in a shallow bath of warm water, which should just reach the instep The electrodes are arranged so that the current passing between them

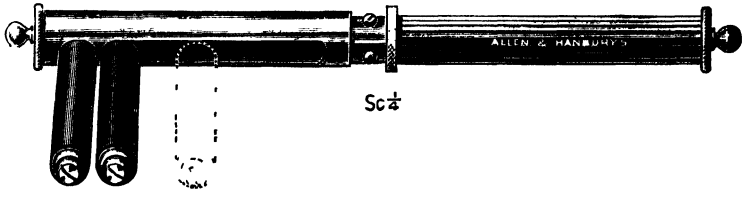


FIG 259 —THOMAS'S WRENCH

The two cross-bars are protected by thick indiarubber, and can be approximated or separated by rotation of the handle The anterior portion of the foot is firmly grasped between them, one being placed on the dorsal and one on the plantar aspect, and forcible wrenching movements can then be carried out

traverses the longitudinal muscles of the sole The anterior part of the transverse arch can also be treated by passing the current through the foot from side to side at the level of the metatarso-phalangeal joints

When the affection has reached a later stage, and the deformity cannot be remedied by ordinary manipulation, forcible rectification under an anæsthetic may be employed The foot is firmly grasped in the two hands or in a Thomas's wrench (Fig 259), and the anterior portion is forced inwards and backwards in such a way as to draw the scaphoid round the head of the astragalus as a fulcrum, and thus restore the arch Probably a number of adhesions in the astragalo-scaphoid and other joints will be felt to give way during this manipulation Tenotomy of the peronei is sometimes required before rectification of the position is possible The foot is put in plaster of Paris and kept at rest for some weeks, and then boots are supplied, and graduated exercise allowed Satisfactory results have followed

When the deformity cannot be rectified even by wrenching, and weight-bearing is still a source of pain, the patient may be advised

to wear a carefully-fitted instep pad (fitted to a plaster cast of the foot) to assist in supporting the weight, but it must be clearly understood that this contrivance should never be employed for cases where a cure can be established along the lines laid down above In mid-life these supports are sometimes extremely useful

In a few cases with a fixed deformity operative proceedings directed to the bones may be justified The removal of a wedge-shaped section from the inner side of the foot, and the production of bony ankylosis between the scaphoid and astragalus, is the only operative procedure worthy of consideration Prolonged rest and a suitable course of exercises and massage will be required subsequently, whilst an instep pad may still have to be worn

Loss of the Transverse Metatarsal Arch is a frequent cause of sore feet when walking, and may accompany either pes planus or pes cavus, and is often associated with hammer-toes and hallux valgus It is due largely to loss of power of the peroneus longus, but a good many other elements enter into its causation It is characterized by the heads of the metatarsals sinking so as to be brought into contact with the ground, and as a result callosities form under them which are extremely painful It is often possible to press up the metatarsals into a normal position and to retain them there by pressure applied transversely around the foot just above the heads, and this can be utilized in **Treatment.** A strip of chamois leather can be made to surround the foot in the position indicated and held there by strapping, or, better, an elastic band 2 inches wide can be worn around the foot with or without a pad of rubber placed centrally in the sole, with this can be combined an elastic loop which will serve to keep the big toe in correct alinement Boots with bars across the sole as in Fig 260 are also most helpful, relieving the pressure on the painful metatarsal heads Only when measures such as these fail need the operations mentioned in the section on pes cavus be considered

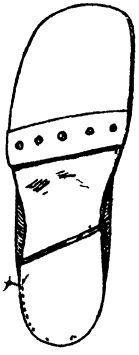


FIG 260 — BOOT WITH CROSS-BAR ON SOLE FOR USE IN PES CAVUS

Pes Cavus (Hollow or Claw Foot) is a condition characterized by increased concavity of the plantar arch, so that when the individual stands there is a greater interspace than usual, if not an absolute break, between the impressions produced by the anterior and posterior segments of the foot (Fig 248, B) Corresponding to the plantar concavity there is a marked dorsal convexity, whilst the toes are generally in a condition to be immediately described as hammer-toe, the heads of the metatarsal bones are unduly prominent below, and callosities often form beneath them, causing considerable pain The condition is almost always associated with a slight degree of talipes equinus (right-angled contraction), and its method of production from this cause is said to be as follows The weight is normally carried to the ground mainly through the heel, but also partly through the toes, in these cases it is only transmitted through the toes and front of the

foot, and since the anterior extensor muscles are probably weak, the short flexors act at an advantage, and by contracting draw the heel downwards so as to reach the ground, and thus the arch is increased

In the later stages the foot becomes inverted and assumes a varus deformity, the toes become blue, contracted and painful, and walking becomes almost impossible

Treatment.—In the early stages, when the deformity is slight and easily replaceable, the Achilles tendon should be divided or lengthened (pp 472 and 473), and the foot put up in plaster in a position of dorsiflexion When walking is permitted, the boot must have low heels, and a bar should be placed obliquely across the sole so as to rest just behind the heads of the metatarsals (Fig 260), the object of this is to maintain dorsiflexion, and throw the body weight on the heel more than on the toes

In the next stage the heads of the metatarsals begin to project in the sole and become tender If only the first metatarsal is involved, the trouble may be remedied by detaching the tendon of the extensor proprius hallucis, drilling a hole transversely through the head of the metatarsal, and threading the tendon through it, finally fixing its divided end to the tendon above so as to constitute a loop which lifts the head of the bone The plantar fascia will also need division, and perhaps the tendo Achillis, so that the foot can be put up in plaster of Paris in dorsiflexion Subsequently, boots are supplied as indicated above

Hallux Rigidus (*syn* **H. flexus**) is a painful condition of the great toe, due to a chronic arthritis of its metatarso-phalangeal articulation It usually occurs in young males with flat feet The foot is abnormally long, its circulation is defective, the toe itself may be in good position, but not unfrequently the first phalanx is flexed and the distal one hyperextended The condition is probably due to abnormal pressure owing to the valgoid position of the foot, and possibly to wearing too short a boot It sometimes arises as a result of direct trauma, *e g* a weight falling on the toe, or being 'run over' **Treatment**—In the early stages correct the flat-foot, and see that suitable boots are worn A transverse bar behind the heads of the metatarsals (Fig 260) is sometimes useful Careful strapping with Scott's dressing may also give relief In bad cases where bony changes have occurred (lipping, etc, as in osteo-arthritis), excision of the head of the metatarsal may be required

Hallux Valgus (Fig 261) consists of a displacement outwards of the great toe from the median line of the body, as a result of which the other toes are huddled together, and in extreme cases the hallux is placed over or under them It is present in the majority of people in some measure, owing to the usual shape in which boots are made, but in its severer forms it is due to a chronic arthritis of the metatarso-phalangeal joint, the greater power of the abductor group of muscles explaining the deformity The cartilaginous surface of the head of the first metatarsal bone becomes inflamed owing to the partial dislocation of the toe and the pressure of the boot, its structure and shape are thereby altered, and the joint is more or less disorganized

Two other conditions are often associated with this deformity, *viz* bunion and hammer-toe

A *bunion* consists in the formation of a bursa over the head of the first metatarsal bone, which becomes inflamed from cold or injury, and may even suppurate, the abscess often communicating with the joint, and leading to its disorganization A marked bony outgrowth is usually found under the bursa, springing from the inner side of the head of the bone, and due to a localized periostitis

The **Treatment** of hallux valgus in its earliest stages consists in the use of correctly-shaped boots, with the inner border straight from toe to heel, whilst the sock or stocking should have a separate compartment for the great toe The introduction of a toe-post between the great toe and its neighbour is sometimes effective in giving relief A boot with a cross-bar across the sole (Fig 260) is also useful by relieving pressure on the heads of the metatarsals In more severe types excision of the projecting head of the metatarsal bone gives admirable results The operation is best conducted by turning up a flap of skin and subcutaneous tissues over the inner aspect of the head of the metatarsal with its convexity forwards The bone is then exposed by splitting the internal lateral ligament and transversely divided by a chisel, the head is removed completely, allowing the toe to be easily replaced in a normal position The skin is then laid down in place and if need be shortened to meet the requirements of the case This operation is better than merely removing a wedge from the neck of the bone, or chiselling off the projecting bony overgrowth The toe should be maintained in a good position by the dressing, and massage is commenced early A good movable joint results, though the toe is slightly shortened Care must be taken subsequently to see that suitable boots are worn Very rarely ought the second toe to be removed for this condition, as the lateral support of the great toe is thus weakened, and the deformity is probably aggravated An *inflamed bunion* is treated by removing all local pressure, and applying fomentations If the joint is involved in suppurative disease, excision of the head of the bone, or amputation of the toe, may be required In less serious cases it may suffice merely to remove the thickened bursa and to chisel away the projecting portion of the bone



FIG 261.—BILATERAL HALLUX VALGUS WITH BUNIONS

Hammer-Toe.—This deformity is constituted by hyper-extension of the first phalanx, marked flexion to an acute angle of the second, and either flexion or extension of the terminal phalanx, so that the first

interphalangeal joint projects under the upper leather of the boot, whilst the patient walks on the extremity of the ungual phalanx, or even on the nail Callosities form upon the points of pressure (Fig 262 1, 2, and 3), especially on the dorsal aspect, and a subcutaneous bursa over the head of the first phalanx (4), giving rise to great pain and inconvenience The second toe is that most frequently affected, with or without the others, but it is uncommon for the hallux to be thus deformed The extensor tendons often stand out very evidently beneath the skin The flexion of the second phalanx on the first is often carried to such a degree that the former bone is semi-dislocated The prolongations of the plantar fascia on either side are much shortened, and the lower portions of the lateral ligaments of these articulations are also contracted

Causes —It is occasionally congenital, but more often acquired, and then (*a*) it may be secondary to hallux valgus, (*b*) it may result from wearing short and pointed boots, or very high heels, in either case the toes are crowded together and drawn up out of the way of pressure, (*c*) it follows contraction of the plantar fascia, and is then associated with pes cavus and talipes equinus

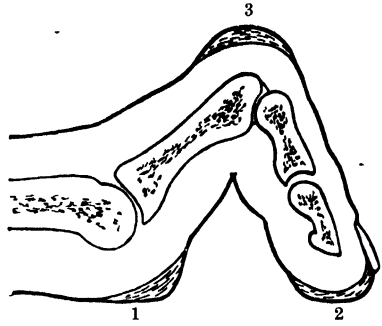


FIG 262 —HAMMER-TOE

1, Callosity over head of metatarsal bone in sole 2, callosity over end of toe, 3, callosity or corn over head of first phalanx

Treatment may be commenced by the use of correctly-shaped boots, but the case has usually progressed to such an extent when the patient is first seen that no palliative measures are of any avail Operation is then necessary, and probably the second phalanx is so much displaced that nothing short of removal of the head of the first phalanx holds out any prospect of permanent relief An incision is made longitudinally over the joint, the extensor tendon being split down the middle, the head of the bone is then cleared by the raspatory, and nipped off by cutting pliers No splint is required, as the pressure of the dressing suffices to keep the toes in good position Sometimes there is but little room between the great and third toes, so that even if one corrected the deformity of the second toe there is no space for it to lie comfortably, amputation should then be performed

Metatarsalgia, or **Morton's Disease,** is characterized by severe pain of a neuralgic type located primarily about the head of one or more of the metatarsal bones, usually the fourth, but also radiating thence up and down the limb It often occurs in gouty or rheumatic subjects, and may be attributed to some injury, a slight degree of flat-foot and the wearing of tight boots certainly predispose to it It is probably due to compression of the digital nerves between the heads of the metatarsal bones and the ground The foot is found to be broader than

usual, and the anterior transverse arch formed by the heads of the metatarsals flattened out Marked callosities, or corns, are observed on the under surface close to the heads of the bones, one or more of which may be unduly prominent below In a few cases small bony enlargements have projected from the heads of the metatarsal bones, and in some definite fibrous growths have been found in the subcutaneous tissues, in other cases a simple peripheral neuritis may explain the manifestations The pain is generally induced by walking, and comes on in characteristic paroxysms Lateral pressure over the bases of the metatarsal bones often relieves the pain, but similar pressure over the heads usually increases it Occasionally evidences of osteo-arthritis are manifested in one of the neighbouring joints

Treatment consists in resting the foot, whilst suitable diet and drugs are ordered to combat any gouty or rheumatic tendency At the end of a few weeks the patient may be allowed to walk again with boots which are low-heeled, thick-soled, and broad anteriorly, with an obliquely set bar behind the heads of the metatarsal bones (Fig 260) Associated deformities of the foot are dealt with appropriately, and the callosities on the sole by suitable chiropodical methods Morton's recommendation, *viz* excision of the head of the projecting metatarsal bones, may be reserved for the more aggravated and serious forms, it is best effected through a longitudinal dorsal incision running parallel to the extensor tendons

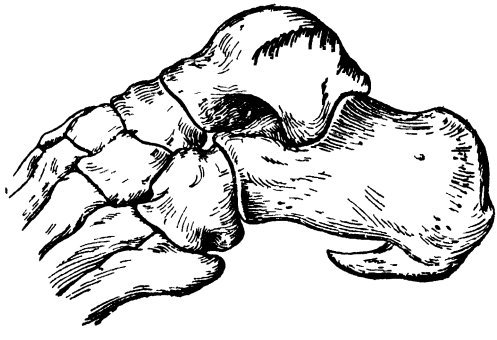


FIG 263 —BONY SPUR BENEATH OS CALCIS (DRAWN FROM SKIAGRAM)

Painful Heels —Patients are not unfrequently seen who complain of disabling pain about the heel in spite of careful attention to the fit of boots This may be the result of not a few various causes, and careful discrimination is necessary to make a correct diagnosis

1 If the pain is purely plantar, it may be due to a gouty deposit in the deep fascia or muscles, and merely requires constitutional treatment If, however, this is unlikely, an X-ray examination will sometimes reveal the existence of a bony spur (Fig 263) from the under side of the os calcis, due to ossification of the attachment of the deep fascia and resulting probably from strain Operation in these cases is essential in order to excise the spur and any adventitious bursa that may have formed over it One need hardly say that the incision should be placed posteriorly (horseshoe-shaped) or laterally, and not in the sole

2 If the pain is posterior, it is probably due to inflammation of the bursa beneath the tendo Achillis, or to periostitis beneath the insertion of that structure, resulting from strain If rest is of no

avail, igni-puncture may be useful, or the newly-formed bone may even require to be excised

3 If the pain is deeper and more central, it is possibly due to injury of the bony cancelli in the os calcis, resulting from a fall or blow on the heel and some secondary osteitis or periostitis This must be treated on general principles, but it is often very intractable

The terms 'infantile paralysis' and 'spastic paralysis' have been employed so frequently during this chapter as having important ætiological relationships to deformities that it appears desirable to add here a short description of these affections

Infantile Paralysis.

This condition, by far the most common cause of paralysis in children, is due to an acute infective inflammation of the anterior horns of the spinal cord (*acute anterior poliomyelitis*), resulting in destruction of the multipolar ganglion cells without suppuration, and followed rapidly by paralysis and degeneration of the muscles supplied from that area

The causative organisms have not yet been actually isolated, inasmuch as they are apparently ultra-microscopic and pass through a filter Portions of an infected cord inoculated into monkeys produce the disease, and the cell-free fluid obtained after crushing up such cord débris and filtering, even through coarse porcelain, is similarly effective The virus remains active in a dried cord for some weeks

Infection apparently commences in the naso-pharynx, and then spreads up the olfactory nerves, causing first a meningeal reaction, and subsequently an invasion of the nervous tissue itself, either of the brain or of the cord, but more frequently of the latter The condition of the cerebro-spinal fluid in the acute stage before paralysis has occurred is quite diagnostic it is under pressure, the albumen content is increased, there is an excess of cells (polymorphs or lymphocytes) with normal sugar and normal chlorides, and no organisms can be cultivated from it, there seems, however, no relation between the number or character of the cells and the type or gravity of the case

The disease mainly affects children between two and five years of age, but it is not uncommon throughout childhood, and even occurs in adults The incubation period varies, but in many cases does not exceed three or four days Infection commences in the naso-pharynx, and hence in schools and other institutions there should be sufficient room in the dormitories to prevent the children from coughing in one another's faces, beds may be arranged alternately head to feet with advantage The disease is often transmitted by carriers who are themselves immune

'In England and in the United States of America anterior poliomyelitis is a notifiable disease, for although it is not usually very common, yet occasionally serious outbreaks occur It is seen much more frequently in the tropics, and many grave epidemics have been reported in various parts of the world, *e g* the New England states of America and New Zealand In this country it shows a seasonal

variation, three-quarters of the cases developing between June and October

The **course** of the disease is best described in three stages

1 The inflammatory **stage of onset** often starts abruptly, and is ushered in by a short febrile attack with severe pain in the head and neck, perhaps extending to the spine, the head is retracted and fixed by muscular spasm, and there is often some hyperæsthesia of the body This stage may persist for some days and be followed by one of paralysis, or the condition may abort, possibly as the happy result of a spinal puncture for diagnostic purposes The symptoms are obviously due to the initial meningeal reaction The paralysis comes on suddenly and rapidly reaches its maximum, within perhaps a few hours, and any change thereafter lies in the direction of improvement The affected limb is helpless and relaxed, the muscles are completely paralyzed and undergo rapid atrophy, reflexes disappear, as also electric excitability, although the reaction of degeneration may often manifest itself The affected limbs are cold and bluish in colour The disease is rarely generalized, but its *distribution* is very variable, mainly involving the limbs, and that in any type of combination In the arms the deltoid is most commonly affected, less often the biceps, brachialis anticus, and supinator longus, occasionally the extensors of the wrist and fingers are paralyzed The legs are much more frequently attacked than the arms, and the lower rather than the upper halves, the tibialis anticus and extensors are involved more often than their opponents In the thigh the quadriceps and adductors bear the brunt of the trouble The spinal muscles participate in the disease occasionally, but the face and sphincters are not affected

The inflammatory condition, as indicated by pain and fever, lasts perhaps for six weeks, and is followed by—

2 The **reparative stage,** during which the mischief in the cord is being made good as far as possible by the development of cicatricial tissue, and such ganglion cells as have escaped destruction are beginning to regain their power of control over the muscles dependent on them This may occur at any time after the passing of the acute stage, and may progress slowly or rapidly, and only after the completion of this period can an assured judgment be formed as to the actual extent of the mischief A period of two years or more is often occupied in this stage, and during its course deformities are liable to develop, growth is checked, and trophic manifestations may appear Response to galvanic stimuli is the first indication of repair, and so long as the reaction of degeneration exists, one need never give up hope of improvement, then comes response to faradic excitation, and finally voluntary movement

3 The **stationary period** is at length reached, when a final opinion may be formed as to the extent of the mischief, and arrangements made for assisting the patient by operative or other treatment, which must not be considered so long as improvement in muscle tonus is occurring Henceforth, the surgeon's aim is to protect the damaged and weakened limbs from injury, to guide growth along right lines, and to assist impaired function, whilst at the same time provision

must be made for the education and amusement of the child with a view to making him ultimately an independent member of the community

Prognosis, therefore, is most difficult in the earlier stages No one can tell exactly how much damage has been done in the cord, or how that damage will influence the limbs in the direction of ultimate paralysis or cessation of growth A prolonged first stage is often a precursor of delayed repair and a protracted recovery Extensive paralysis does not necessarily connote inefficient growth, which may appear with very slight muscular impairment Fairly complete early

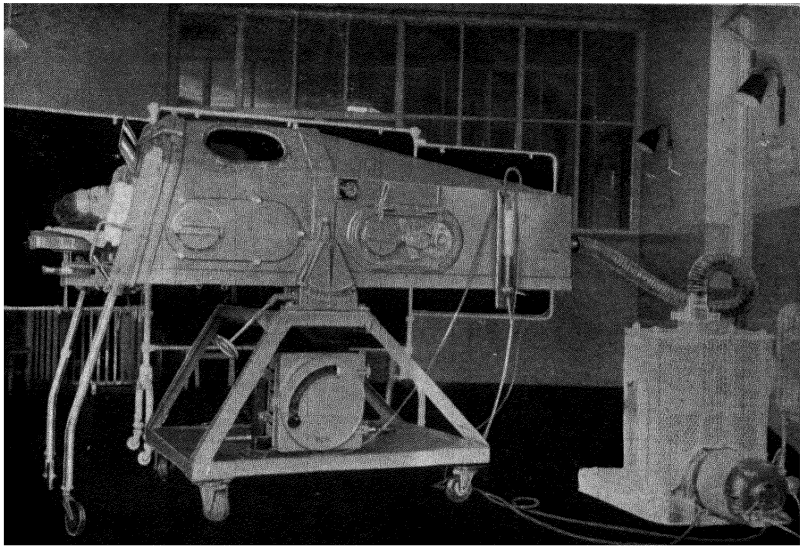


FIG 264 —DRINKER'S APPARATUS
The child had paralysis of the respiratory muscles
(Sir Henry Gauvain)

paralysis of both lower extremities usually carries with it a bad outlook, especially if persisting after three months

Treatment necessarily varies with the stage of the disease, and the practitioner must keep clearly in mind the objects to be attained in each

In the **first stage** the prime essential is rest and quiet, so that the inflamed and damaged cord may be put in the best condition for checking the destructive process and limiting the mischief caused thereby The whole body must be immobilized as far as possible in a Thomas's double spinal frame or some such contrivance, and wrapped in cotton-wool to protect it from peripheral stimuli The feet are placed at right angles to the legs, and maintained thus by

splints or plaster applied over thick cotton-wool The relative position of the thighs to the pelvis must also be watched Local applications of heat or cold, electricity or massage, are alike harmful in this stage Should the paralysis of the diaphragm occur the child can be kept alive in a Drinker's apparatus (Fig 264) and the paralysis of the diaphragm will recover

In the **second stage** the chief efforts of the practitioner must be directed towards the prevention of deformities, the correction of any that have developed, and the restoration of muscular power and function Careful study of the case is necessary, in order to determine the electrical condition of individual muscles, which should be carefully charted for future reference

The *prevention of deformity* is governed by the fact that a paralyzed muscle is always liable to become stretched under the influence of gravity or of opposing muscles, so that even if contractility is in time restored, the over-stretched muscle cannot fulfil its function All paralyzed muscles must be kept relaxed until recovery occurs, and this applies as much to times when treatment is being undertaken as to periods of rest, massage and electricity must be employed with the affected muscles in a position of relaxation Splints and postural treatment are also required during this period in order to maintain a correct position With a paralyzed deltoid, the arm must be kept abducted, for paralysis of the flexors of the forearm, the elbow must be bent to a right angle, for paralytic drop-foot, a position of dorsiflexion must be maintained All splints during this stage must be light and of a simple nature As the muscles regain tone and power, a certain limited range of movement is permitted, and gradually increased inch by inch, but the power of the muscle must not be overtaxed, or it will lose rather than gain ground

The *correction of deformities* is often required owing to neglect in the early stages, and is governed by the principles just enunciated If muscular re-education and electrical stimulation cannot effect this, appliances to maintain a correct position must be employed, or even operative treatment

Massage is of the greatest value in the restoration of muscular tone, if applied intelligently Its object is to stimulate and develop the weakened muscles, and that without undue fatigue At first gentle friction is alone required, but later the deeper parts can be kneaded When the time comes for active exercise of the muscles, they must be called into contraction at first without allowing the weight of the limb to exert its influence *Electrical treatment*, too, must be judicious, or it may be of little value The immersion of a limb in an electric bath is calculated to exercise the strong rather than the weak muscles, and the retention of the limb in the correct posture under these circumstances is difficult or impossible Interrupted galvanic stimulation to the individual muscles is the best form to employ until sufficient repair has occurred to permit of response to faradic stimuli, and then this variety may be utilized Over-fatigue of the muscles must not be permitted However, active exercises in a warm bath may be very beneficial

In the third or **chronic stage** the surgeon's chief object is to restore the patient's usefulness, so far as is possible, by correcting deformities and stabilizing weak and flail-like limbs *Mechanical appliances* are often needed, but must be carefully devised in order to assist, and not to hamper movement by unnecessary weight Celluloid, papier-mâché, or some such material may be utilized for the simpler cases, whilst for metal contrivances duralumin may sometimes take the place of steel In paralytic talipes equinus irons fixed to the boots and rising above the knees, or even sometimes running up to the pelvis, are frequently required

Operative measures are directed towards either the restoration of the muscular balance or to the fixation of a flail joint (*a*) Division of tendons or fasciæ is seldom desirable in paralytic cases, the muscles of the limbs are already sufficiently weakened However, in paralytic drop-foot, contraction of a healthy tendo Achillis is sometimes so great that the foot cannot be restored to its correct position by passive movement, and then it must be lengthened, shortening of over-stretched paralyzed muscles is seldom of much use (*b*) *Tenoplasty* (p 473), or grafting the tendon of a healthy muscle into a paralyzed one, has a certain limited scope in this affection, but requires the most precise recognition of the value and utility of the muscles employed (*c*) *Tendon fixation* (p 475) is of some value as a means of stabilizing a flail limb, *e g* in paralytic drop-foot, but unless the tendons are fixed very near to the articular surfaces, and only short lengths employed as accessory ligaments, they are extremely likely to stretch subsequently (*d*) *Arthrodesis*, or the fixation of joints, is a useful proceeding when the unnatural mobility is difficult to control, or would necessitate considerable addition to the weight of any apparatus required, or where from the poverty of the patient such apparatus cannot be obtained It is especially serviceable in cases where two joints in a limb are flail-like, one of which may be ankylosed with advantage The operation consists in a modified excision, the cartilage alone being sawn or scraped from the ends of the bones, but it must always be remembered that the reparative activity in a paralyzed limb is small It is usually unnecessary in the hip-joint, it is decidedly valuable for the flail knees of older children, where the expense of apparatus has to be considered A stiff ankle is undesirable, but arthrodesis of the astragalo-calcanean joint is useful if suitable tendon operations can be arranged to steady the ankle (*e*) Where the whole limb is hopelessly powerless and an inconvenience to the patient, *amputation* is often the best practice In the lower extremity, when the knee and ankle are both weak and flail-like, arthrodesis of the knee and removal of the foot by a Syme's amputation will often provide the patient with a serviceable limb

Spastic Paralysis (*Syn* Little's Disease, Cerebral Diplegia, etc)

Under this title are included a group of cases in which the characteristic feature is spasm of various groups of muscles, leading in time to a fixed deformity, and weakness or paralysis of other muscles,

possibly the opponents of the above The cause is always some permanent defect of the upper motor neurons, which not only impairs the passage of excito-motor impulses, but also hampers the conduction of inhibitory impulses from cortex to spinal centre The result of this is that peripheral stimuli reaching the centres from below have an undue power of producing reflex activity, and hence, in such conditions as the cerebral diplegia of children, spastic contraction of muscles is induced, and the mere placing of the foot on the ground in the attempt to walk produces such spastic contortions as to render progress difficult, if not impossible

A certain degree of spasticity occurs in various diseases of the central nervous system in *adults*, *e.g* after hemiplegia (but preceded in this case by a period of flaccid paralysis), in disseminated sclerosis, etc , but it is not necessary to discuss these

In *children* spastic paralysis may be due to localized polio-encephalitis, cortical thrombosis (post-exanthematous), or syphilitic disease, but in the great majority of cases it is a birth palsy, probably resulting from punctiform hæmorrhages in the cortex of pons, occurring during birth from undue moulding of the bones of the skull or from asphyxia, and this in spite of the story of a normal labour, which is usually forthcoming

The affection may appear as a hemiplegia, diplegia, paraplegia, or monoplegia, the two former being the more common and occurring in the proportion of 9 7 The characteristic contractures are as follows

In the lower extremity, spastic equinus, due to inefficiently controlled plantar flexion of the foot, flexion of the knee and adduction of the thigh, combined sometimes with internal rotation

In the upper extremity, pronation of the forearm and flexion of the wrist

(*a*) At first the contractions can be overcome and the limb straightened, although the mere attempt to do so often induces spasmodic action of the muscles, which, however, can be banished by deep anæsthesia In time the contracted muscles become actually shortened, and restoration to the normal position is impossible (*b*) The actual loss of muscular power in the opposing group varies much in degree, but is always present, and must be taken into account in considering operative treatment, this applies particularly to the arm lesions (*c*) Mental deficiency to a greater or less degree is commonly present in these patients, in hemiplegia 68 per cent are subnormal, and in cerebral diplegia 84 per cent The mentality of every patient should be carefully considered before undertaking a course of treatment which requires the co-operation of the patient for its successful completion (*d*) Involuntary movements of an athetotic type are often evident in these cases, and will seriously hamper all attempts at treatment

Treatment.—Massage and electricity to the muscles, however devotedly applied, are useless in effecting a cure, and can never be of much use, operative treatment can alone be expected to be of any lasting benefit

Stoffel's operation consists in division of a sufficient number of the

motor fibres leading to the spasmodic muscles to restore the balance of control, and to render them more on a level with the weakened group of opposing muscles This theory has been substantiated in practice to a great extent Spasmodic equinus is dealt with by dividing a half or two-thirds of the nerve tracts to the gastrocnemius and soleus, but this must sometimes be accompanied by local treatment to lengthen the tendo Achillis Flexion contracture of the knee requires division of a sufficiency of the nerve-fibres leading to the hamstring muscles, but older cases also need tenotomy of these muscles Adductor spasm is treated by division of branches of the obturator nerve For pronation and flexion of the forearm and wrist, the nerves to the pronators and flexors may be attacked, but the results are not very favourable, owing to the degree of weakness usually present in the opposing groups, it may be wiser in such cases to employ these muscles by transplanting them so as to strengthen the weak supinators and extensors of the wrist and fingers, in the same way as they are used in old musculo-spiral paralysis (p 414)

The actual method of division of the nerve-fibres varies somewhat, Stoffel's original suggestion was to deal with the main trunks, depending upon the knowledge now available as to the arrangement of the fibres in these trunks, other surgeons divide the peripheral nerves close to the muscles, although this involves a much more extensive dissection

Re-educational exercises must be instituted as soon after the operation as is considered safe, and here the question of the patient's mentality arises Considering the unpromising material on which the work has to be done, the results have been most encouraging, but it is obvious that unless the patients are brought under observation early, the prognosis is likely to be unfavourable

CHAPTER XX

INJURIES OF BONES—FRACTURES

Contusion of a Bone and of its periosteum is usually a matter of no great moment, although the part becomes painful and swollen Occasionally a subacute periostitis is caused in people liable to rheumatism or gout, or in the subjects of syphilis, whilst in those with low germicidal power acute infective osteomyelitis, resulting in necrosis, may supervene If the periosteum is torn, osteogenetic cells may be set free from its under-surface and escape into overlying muscles, leading to new bone formation therein (traumatic myositis ossificans, p 466) **Treatment** consists in rest and the use of cooling lotions or of a bandage, whilst if periosteal thickening results, iodide of potassium may be given, and iodine paint applied locally

Bending of Bone may or may not be associated with fracture Bending without fracture occurs mainly in children, and in adults is only the result of some local disease More commonly a partial or green-stick fracture is produced (p 536), and in this the deformity can generally be corrected without much difficulty

Fractures.

A fracture may be defined as a sudden solution of continuity in a bone, usually resulting from external violence

Predisposing Causes of Fracture—*Age* —From two to four fractures are not uncommon, owing to the unsteady gait and frequent falls to which little children are liable, from four to six the bones often bend so as to cause green-stick fractures, up to the age of eighteen years injuries near joints induce separation of epiphyses, from six years onwards fractures increase in frequency, reaching their maximum between thirty and forty years of age, old people are liable to this form of accident, owing to the bones becoming atrophic or brittle

Sex—As might be expected, fractures are more common in the male sex during boyhood and adult life, but up to the age of four or five they are equally frequent in the two sexes, whilst after forty-five they are more common in women, owing to their great liability to fracture of the cervix femoris and to Colles's fracture

Morbid Conditions of the Bones predispose in a marked manner to what is known as *Spontaneous Fracture*, in which the determining force cannot be recognized or is very slight Under this heading may be included (1) Atrophy of bone, which may be of the senile type, as manifested especially in the cervix femoris, or is due to want of use, as in a paralyzed limb or from an ankylosed joint (2) Patients afflicted with certain mental or nervous diseases, such as general

paralysis or tabes dorsalis, are unduly liable to fracture, which may occur in apparently healthy bones A man, for instance, suffering from tabes was sitting with his thigh abducted and everted in order that he might examine and dress a perforating ulcer on the sole of the foot, when the shaft of the femur, subsequently shown to be of normal dimensions, and apparently of normal density, snapped in two (3) Osteogenesis imperfecta (Chapter XXI) consists in an inherited tendency to spontaneous fracture Thus, a girl, aged twelve and a half years, had suffered from forty-one fractures since the second year of life (4) General bone diseases, such as rickets and osteomalacia, also predispose to fracture, in the latter affection the bones often bend considerably before breaking (5) Local bone disease, such as sarcoma and secondary cancer, may also be first recognized by causing a spontaneous fracture, the erosion of an aneurism and the destruction of the para-epiphyseal region in acute osteomyelitis may lead to a similar result

The **Exciting Causes of Fracture** are threefold (1) *Direct violence*, the fracture occurring at the spot struck, and being often transverse, not unfrequently comminuted, and sometimes complicated with injuries to the adjacent soft parts (2) When due to *indirect violence*, the accident is usually produced by the compression or bending of the bone with such force as to exceed the limits of its natural elasticity, so that it yields at the weakest spot Thus, when a person jumps from a height, the leg bones are compressed between the weight of the body and the resistance of the ground, and, if the violence is excessive, a fracture occurs at some point of mechanical disadvantage If the stress falls chiefly on the shaft, an oblique fracture ensues, often with much longitudinal displacement, and possibly becoming compound, if an element of torsion is present, as by forced inversion or eversion of the foot, the fracture is likely to become spiral in type If, on the other hand, the violence expends itself on a mass of cancellous tissue, such as the os calcis, astragalus, or upper end of the tibia, the bone may be fissured in various directions, comminuted, or even 'pulped', such a condition is sometimes termed a *compression fracture* (3) *Muscular action* is most commonly the cause of fracture of small bones or of osseous prominences, into which powerful muscles are inserted The patella and olecranon are not unfrequently broken in this way, the former often occurring from sudden and vigorous efforts to avert a fall Occasionally one of the long bones, such as the humerus or clavicle, has been broken by violent muscular exertion, as by throwing a cricket-ball

Intra-uterine Fractures are caused by blows upon the mother's abdomen, or by abnormal or violent uterine contractions, especially if the liquor amnii is deficient in amount or if the formation of bone is defective, as in osteogenesis imperfecta, they are usually followed by considerable deformity **Obstetric Fractures** occur during delivery, usually affecting the shaft of the femur or humerus

Varieties.—A **Closed (Simple) Fracture** is one in which the skin is unbroken, or, at any rate, where the external air has no admission to the site of injury An **Open (Compound) Fracture** is present when

the skin or mucous membrane is so lacerated that there is direct or indirect communication between the fracture and the external air. In the base of the skull, a fracture may involve one of the deeper air-sinuses, and thus becomes compound without any apparent external lesion.

Fractures are complete or incomplete, according to whether or not the continuity of the bone is entirely interrupted. Various forms of **Incomplete Fracture** are described, and indeed the introduction of radiography has shown that they are much more common than was formerly supposed. A *green-stick fracture* (Figs. 265 and 266) is one which only occurs in young children, and most often in those that are rickety, curved bones, such as the clavicle, are most frequently affected, and the fracture merely involves the convexity of the curve, whilst the concave half is bent, just as when a green bough or twig



FIG. 265.—GREEN-STICK FRACTURE OF RADIUS.



FIG. 266.—GREEN-STICK FRACTURE OF RADIUS AND ULNA.

is partially broken. *Depressions* of the skull may be similarly incomplete when the outer table is driven in without fracture and the inner table alone splintered. *Fissured fractures* also are often only partial. A *subperiosteal fracture* is one in which the periosteum remains intact, although the bone is broken, displacement does not occur, and therefore the injury is likely to be overlooked, apart from radiography.

Complete Fractures may be *transverse*, if due to direct violence, *oblique*, arising usually from indirect violence, *spiral*, when the force acts in a rotary direction as well as longitudinally, it occurs most frequently in the tibia or femur, and the lower fragment often has

a sharp triangular upper end, giving it somewhat the appearance of the mouthpiece of a clarionet (fracture *en bec de flute*) Not uncommonly a second fissure runs downwards from the main line of fracture, separating off a long narrow fragment of the shaft A *longitudinal* fracture is one due to fissuring or splitting of the bone in its long axis, it is most common as the result of gunshot injuries If it is combined with a transverse fissure, it is often termed T-shaped *Comminuted* is a term used to describe the condition when the bone is broken into more than two pieces, *impacted*, when one fragment is driven into the other, *multiple*, when more than one fracture exists, *complicated*, when important structures such as an artery, nerve, or joint, are damaged as well as the bone

The **Separation of an Epiphysis** results in young people from violence directed to the ends of the bones, but occasionally from pathological affections of the epiphysis or of the adjacent portion of the diaphysis, *e g* from inherited syphilis, rickets, scurvy, acute osteomyelitis, or tuberculous disease The femur, humerus, or radius are the bones most often affected The line of cleavage usually runs through the soft spongy tissue on the diaphyseal side of the cartilage, so that there is cartilage with spicules of bone on one side and spongy bone on the other In very young children, where the epiphysis is entirely or mainly cartilaginous, the lesion is almost always a pure separation of the epiphysis from the shaft, but at a later date it not unusually extends in part through the adjacent end of the diaphysis (Fig 267) A marked feature is the stripping up of the periosteum, which, though loosely attached to the shaft and easily separated from it in children, is firmly adherent to the epiphyseal cartilage, and hence retains its connection with it, thus frequently limiting displacement If, however, the force is sufficient, the end of the shaft penetrates the periosteum, which grasps it closely, and this periosteal 'sleeve' often hinders reduction Union usually occurs by means of bone, but arrest of the longitudinal growth may follow if the parts are not replaced in exact apposition This is a matter of importance when one of the bones of the leg or forearm is affected, since deformity of the hand or foot results if the injured bone ceases to grow and the uninjured one continues its development Suppuration sometimes follows in unhealthy children, or when the accident is compound, and may result in acute osteomyelitis

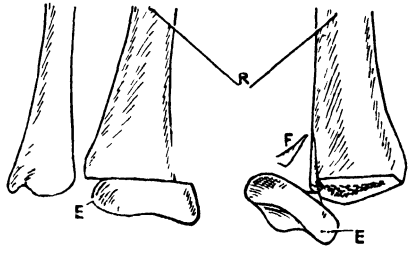


FIG 267 —SEPARATION OF LOWER EPIPHYSIS OF THE RADIUS, DRAWN FROM AN X-RAY FILM

E, Epiphysis R, radius F, small fragment of bone from diaphysis

Partial detachment of an epiphysis (the *juxta-epiphyseal strain* of Ollier) often occurs, giving rise to phenomena similar to those of a sprain, if neglected, it may interfere with the growth of the limb

The essential feature is a more or less tender, but very distinct, swelling of the bone close to the epiphysis, but the neighbouring joint remains unaffected Treatment consists in immobilization in plaster of Paris

Signs of Fracture.—The history usually given by the patient is that, as the result of some accident, he felt, or perhaps heard, something give way with a snap, and experienced sharp pain which became much intensified on attempting to move the limb On examining the injured part and contrasting it with the opposite side, the following points are usually noticed

1 The *signs of a local trauma, viz* pain, bruising, and swelling, as a result of the effusion of blood from the torn and lacerated structures The amount of this may be so great as to obliterate all the ordinary bony prominences and landmarks Blebs and bullæ sometimes appear over the surface after a day or two, and must be carefully protected from infection The discoloration may spread by gravity to parts far removed from the original mischief This infiltration often leads to considerable subsequent thickening, and possibly to adhesions and limitation of movement It is unusual for suppuration to occur after a closed fracture, unless the patient is very debilitated and with diminished germicidal powers

2 *Preternatural mobility in the continuity of the bone* may be demonstrated by manipulation, but never unnecessarily Impaction or non-separation of the fragments prevents its occurrence

3 Partial or complete *loss of function* also follows

4 *Crepitus** can only be felt when the fragments are movable and can be brought into contact, but not when there is wide separation, complete overlapping, or impaction

5 Change in shape of the limb or *deformity from displacement* results from three chief factors, *viz* the direction of the violence, the weight of the limb, and the contraction of muscles, whilst injudicious movement or rough handling may aggravate it It is always more marked in oblique than in transverse fractures, and hence is usually greater in those due to indirect violence Various types of displacement are described, *viz Angular*, generally due to the unequal action of powerful muscles, *lateral*, where the displacement is merely to one or the other side, and most common in transverse fractures, *longitudinal*, when one fragment overlaps the other or is forcibly driven into it, causing shortening of the limb, it may also occur in the form of wide separation of the fragments, as from contraction of the quadriceps in fracture of the patella, *rotatory*, when one fragment is twisted on the other, as in fractures of the femur, where the weight

* The term *Crepitus* is applied to five different conditions which may produce a creaking or grating sensation to the examining hand (1) *Bony* crepitus results from the rubbing together of the fragments in a fracture, or of the ends of bones in a joint when denuded of their articular cartilage (2) A softer variety of bony crepitus is obtained when an *epiphysis* is detached (3) An effusion of *blood* into the tissues gives rise to a soft crackling sensation on handling (4) *Effusion* into tendon sheaths, bursæ, and joints also causes a soft crepitant sensation, varying in different cases (5) *Air* in the tissues causes surgical emphysema and a characteristic form of crepitus

of the limb causes eversion of the lower end. In flat bones, *e g* the skull, deformity may exist in the shape of *depression* or *elevation*

Radiography has proved of the greatest service in connection with both the diagnosis and the treatment of fractures Many a case which would formerly have been called merely a sprain can now be demonstrated to be really a fracture (especially about the wrist and ankle), and its constant use has revolutionized our ideas as to the relative frequency and nature of many such lesions Indeed, there is at the present time too great a tendency to rely on radiography for diagnosis, to the detriment or loss of that delicate tactile sensation which surgeons of old days had to acquire The diagnosis of most fractures *can* be made without the use of radiography, its employment should be looked on as confirmatory, and only diagnostic in difficult cases It is most important, however, that the result of 'putting up' the fracture should be tested by radiography, as thereby defects of alinement may be recognized and early corrected

A satisfactory diagnosis can never be made with the screen alone, the limb must be photographed, and for choice stereoscopically, otherwise, the skiagram should be taken in two directions The importance of this is indicated by a study of Figs 298 and 299, p 592 It must also be remembered that all skiagrams are more or less exaggerations, varying with the proximity of the tube to the limb, and thus a deformity which is very obvious in the radiograph may in reality be comparatively slight Finally, one must not forget that callus is for a considerable time pervious to the X-rays, so that, although the fracture is firmly united, it may be still apparent in the skiagram

General or Constitutional Effects.—*Shock* is great or less according to the character of the violence, the seat of injury, and the amount of pain caused by the accident and its treatment

Hæmorrhage is rarely sufficient to give rise to general effects unless the fracture is open, and involves some important vessel

Fracture Fever (aseptic traumatic fever) is met with in the majority of cases, commencing twenty-four hours after the accident and lasting two or three days As a rule it is not severe, the temperature rarely rising above 100° F in uncomplicated cases In open fractures where asepsis has not been attained, any variety of wound infection may result, and even general septicæmia or pyæmia

Traumatic Delirium.—Although delirium is merely a symptom, it is occasionally of so pronounced a character as to demand special attention Three forms are described

(*a*) The *Active Delirium* which accompanies severe injuries, particularly in plethoric, and often in previously healthy individuals, whose environment has been suddenly changed from that of every-day life to a sick-bed in a hospital ward Infection of the wound is usually present, and the delirium runs a course parallel with the fever It is not usually of a violent type, although the patient may be irrational and restless, he moves the injured part without any evident appreciation of the pain which, if conscious, he must suffer, but he is easily restrained by the exhibition of firmness and tact on

the part of the attendant The symptoms are most marked at night, and commence at the end of forty-eight hours, lasting, as a rule, for two or three days There is a distaste for food, which, however, can be overcome by gentle persuasion

Treatment.—Patients in this condition must never be left, the diet should be light, but nourishing, the bowels are thoroughly opened, and an icebag to the head may be useful The wound should be freed from any purulent accumulation

(*b*) *Delirium of a Low Muttering Type* is met with in individuals of low vitality, exhausted by dissipation, drink, disease, or faulty hygienic surroundings It is commonly associated with fever of an asthenic type, such as is seen towards the end of infective diseases The patient usually lies on his back, staring vacantly upwards, is incoherent, takes no notice of surrounding objects, and is observed to pick at the bedclothes and mutter to himself unintelligently There is often, in addition, an involuntary escape of urine or fæces The mouth is generally open, the tongue dry, brown and cracked, and viscid mucus collects about the teeth (*sordes*)

The **Treatment** should be directed to careful nursing and feeding, as by that means alone can the patient be saved

(*c*) **Delirium Tremens** is observed in individuals who, previously of intemperate habits, have suffered some serious injury, such as a compound fracture The violent symptoms do not set in till about the third day, but are usually preceded by some amount of sleeplessness and wandering at night, or the patient may have short snatches of sleep, from which he awakes semi-delirious This gradually increases, and is followed by violent delirium, in which the patient is haunted by terrifying visions of reptiles, horrible insects, and the like, from which he tries in vain to escape During this stage of excitement he is with difficulty restrained from jumping out of bed, in many instances these patients are remarkably cunning, and, managing to elude the vigilance of their attendants, will succeed in escaping from the room by the door or window, and may inflict serious, and even fatal, injuries upon themselves or others There is always a tremulous condition of the extremities and of the tongue, which is white and coated, whilst the bowels are obstinately confined The pulse and temperature vary considerably, and the skin is often moist and clammy The violent stage is always followed by profound exhaustion, in which the patient may gradually sink into a state of coma and die In the case of a fractured leg, the struggles of the patient will cause considerable displacement of the limb, and necessitate constant attention to prevent further mischief The limb should never be fixed to the bed, but slung in a Thomas's splint, or immobilized in plaster of Paris

Treatment.—When fractures are treated in patients in the habit of taking alcohol regularly, it is important to see that the regular intake is not suddenly stopped Such sudden alteration in the daily routine may precipitate an attack of delirium tremens In cases where an attack is considered imminent, either from the previous history of the patient, the tremulous state of his hands and tongue, or his sleep

lessness, the best treatment to adopt is to support the strength by suitable easily digested food, combined with free purging and, if need be, soporifics, such as chloral, bromide, paraldehyde, or morphia Paraldehyde is perhaps the safest, whilst morphia must be administered cautiously, under such a regimen the symptoms usually soon disappear In the acute maniacal attacks the patient must be fully controlled and guarded, but with as little manifestation of restraint as possible, failing other drugs, hyoscin in doses of $\frac{1}{200}$ to $\frac{1}{100}$ grain will sometimes succeed in quieting the patient, but must be used with great care, as it is a severe depressant Nourishing food of a fluid type should be administered during the quiet intervals, and free purging is of course essential The patient usually recovers from a first attack, but in the later ones may die of heart failure or exhaustion

Fat embolism results from the absorption of broken-up fat globules after any injury which causes contusion or laceration of fatty tissue, when this is accompanied by tension from effusion of blood, as in fractures, this process is more likely to occur Usually the greater part of the fat absorbed is filtered off by the lungs or eliminated by the kidneys (as can be demonstrated after death by staining with osmic acid), and no harm results The pulmonary obstruction may, however, become so great as to lead to a fatal issue from dyspnœa, whilst if the cerebral vessels are blocked, syncope, or even coma, may be induced The symptoms are gradual in their onset, and usually commence about the third day, but may not be evident for a week It is a rare complication

Union of Fractures —The broken ends of the bone are left rough, spiculated, and more or less separated one from the other, the periosteum is torn, but the rupture is not always complete, a 'periosteal bridge' covered with osteoblasts perhaps persisting and playing an important part in the reparative process, especially if correct alinement is not obtained The muscles and neighbouring tissues are lacerated, and a varying amount of blood is extravasated, occupying the interstices of the wound In the course of a few hours after the parts have been immobilized, the process of repair is inaugurated by the blood-clot becoming invaded by leucocytes, and after a time it is absorbed, the hæmoglobin passing through various stages of degeneration, and thereby staining the surrounding tissues At the same time all the injured and lacerated soft parts around become hyperæmic, and the connective tissue cells therein proliferate actively The periosteum becomes thickened and more vascular, and its connection with the bone is loosened for a short distance on each side of the fracture Thus the whole area of the lesion, limited more or less by the torn and loosened periosteum, is converted into a cellular mass, in which a gradually diminishing amount of blood-clot is present This is vascularized from the tissues around, and after passing through a stage practically identical with the granulation tissue of the soft parts is converted into soft vascular bone, known as *callus* The ossification of the vascular and cellular exudate is always determined by the activity of osteoblastic cells, derived either from the exposed

and damaged bony tissue or from those always present on the under surface of the periosteum Wherever these travel they retain their bone-forming potentialities, and hence the ossification of the cellular exudate is rapid, as it can be carried on from many foci

1 On the outer aspect of the fragments beneath the torn and stripped-up periosteum the amount of the cellular exudate depends on the fixation or otherwise of the fragments, and on their vascularity The underlying bone surface becomes more vascular than usual and less dense, the entrances to the Haversian canals being enlarged Ossification is quite early in starting, and spreads from the bone towards the periosteum It is upon the ossification of this external or *ensheathing callus* (Fig 268, A) that the loss of discontinuity of the two fragments depends in the early stages When a periosteal bridge has been left between the fragments, bone formation commences on its under surface, because of the continued activity

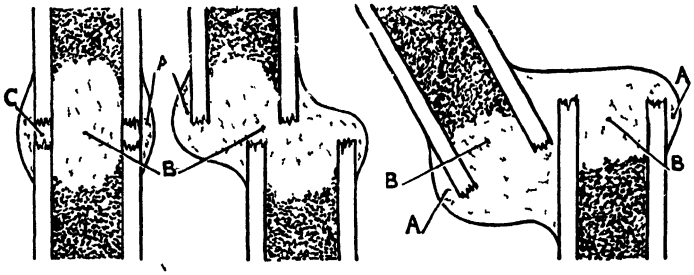


FIG 268 FIG 269 FIG 270.

DIAGRAMS TO REPRESENT UNION OF FRACTURES FIG 268, WHEN THE ENDS ARE IN CLOSE APPOSITION, FIG 269, WHEN THE ENDS ARE ONLY PARTIALLY APPOSED, AND FIG 270, WHEN THE FRACTURED SURFACES ARE NOT IN CONTACT AT ALL

A, External or ensheathing callus B, medullary plug or internal callus, C, definite or permanent callus

of the osteoblasts stripped off with it, in skiagrams a line of newly-formed bone can not unfrequently be seen passing from one fragment to another, especially on the concave side, if there is still some degree of angulation, and evidently due to this cause

2 Similarly changes occur in the medullary cavity—at first, hæmorrhage, then absorption of the blood-clot, and its replacement by a cellular exudate, then a certain degree of absorption of the bony walls, which become more vascular than previously, and finally from the bone ossification starts in the cellular exudate, which becomes thus transformed into a plug of soft bone, extending up and down the medullary cavity for a varying distance on each side, and perhaps, if apposition of the fragments is not perfect, becoming continuous with the external callus This is known as the *internal callus* or *medullary plug* (B), and assists in maintaining the continuity of the limb during the earlier stages of the process of repair

3. Naturally the compact bony tissue is the last to engage in these

changes, and the denser the bone, the longer they are in being completed The fractured ends become hyperæmic, the Haversian canals are dilated by absorption of their lining walls, and the bone cells proliferate, so that on section the bone assumes a more spongy texture than usual In time it becomes converted into a tissue which is practically identical, and becomes continuous with that of the internal and external callus Thus is developed the annular bond of union between the two layers of compact bone which used to be termed the *definitive* or *permanent callus* (C).

It will be obvious that the continuity of a bone is restored long before repair is completed, and that it mainly depends on the ossification of the ensheathing callus, the amount of which is to some extent proportional to the degree of mobility of the fragments A certain formation of cartilage often occurs in the process of bone repair, especially in young people, and where there is much mobility, it is present chiefly in the early stages, and mainly in the ensheathing callus The newly-formed osseous tissue is at first soft and spongy, but gradually becomes denser, at first it is easily detachable from the underlying bone, but later on is continuous with it As the so-called definitive callus increases in strength, the ensheathing callus is absorbed, and finally, if the ends are in good position, may vanish entirely, whilst the medullary plug may also be totally removed Thus it is possible for the bone, under these circumstances, to be restored so absolutely as to show no signs of its having been fractured

When the ends of the bones partially overlap (Fig 269), the amount of ensheathing callus is considerably increased, and fills up all the spaces left by the overlapping of the fragments The projecting edges of bone become rounded off, and the medullary cavities closed by plates or plugs The main bond of union is the ensheathing mass, a considerable portion of which persists Some deformity is certain to remain, and it is unusual for the medullary canal to be restored

If the fractured ends overlap completely, but remain in contact (Fig 270), the union is secured by a large mass of ensheathing callus (A), whilst the medullary cavity of each fragment is closed by a plate of internal callus (B)

If the fractured ends overlap, and are kept from contact by the interposition of muscular tissue, union rarely takes place, and an ununited fracture results The same occurs if the fragments are widely separated, as in the patella In these cases but little change takes place in the bone at first beyond the closure of the medullary canal or of exposed cancellous spaces by granulation, and then by fibrous tissue, at a later date the bone ends are likely to undergo a certain degree of atrophy dependent on the amount of disability

Where *comminution* has occurred, the splintered fragments are matted together by an abundant cellular exudate, which is subsequently transformed into callus Each of the fragments may become a centre of ossification, and it is astonishing in some of these cases to note the rapidity with which extensive shattering is made good in the absence of infection or great displacement. Sometimes, however, fragments of *compact* tissue may remain for a long time

unchanged and with no sign of repair, and may even constitute a cause of non-union by being wedged between two fragments, thus keeping them apart

The removal of the clot and the formation of the cellular exudate usually takes about a week or ten days, and new bone formation commences about the end of the first week By the second or third week, according to the size and vascularity of the bone and the recuperative power of the individual, the fracture will be consolidated, but, of course, cannot bear any serious strain In the leg it is often eight or ten weeks before the patient can bear any weight upon it, and three to six months must usually elapse before a patient should be allowed to walk on a fractured thigh

The soft tissues around—muscles, tendons, etc —are repaired in the usual way, but owing to their laceration and infiltration with blood the muscles may become the seat of marked fibrous changes interfering with their contractile power, or may be fixed more or less firmly to the bony surface over which they ought to play smoothly, or may be matted together and lose to some extent their power of independent movement Tendons often become adherent to their sheaths, or may be embedded in a mass of cicatrical tissue, and hence the mobility of distal parts may be impaired in spite of the union of a fracture in good position Neighbouring joints may become stiff as a result of periarticular infiltration, resulting in contraction of ligaments Nerves and vessels may be torn by the displacement of the fragments, or compressed in cicatricial tissue or callus—and hence the functional result of the union of the fracture may be very disappointing

In conclusion, one may allude to the fact that a sarcoma sometimes develops at the site of fracture within a comparatively short time of the accident It is always, however, a question whether the sarcoma was not existent beforehand, and the determining cause of the fracture

First Aid.—In moving the patient from the spot where the accident happened, it is necessary to secure the limb temporarily in as good a position as possible, splints have often to be improvised from sticks, umbrellas, newspapers, and so forth In a railway accident the splintered débris of the carriages may be employed for this purpose, and the upholstery of the seats as padding A broken leg may also be firmly tied to the other limb, which is thus converted into a temporary splint

The **Treatment** of simple fractures resolves itself into three desiderata, *viz* (1) The remedying of the deformity due to the solution of continuity in the bone, and its restoration to a true alinement, *i.e* accurate 'setting' of the fracture, as it used to be termed, (2) the fixation of the limb in such a manner as to permit the fragments to unite with a minimum of deformity, and (3) the maintenance and restoration of the function of the limb

I The **reduction of the deformity** and the restoration of the bone to correct alinement require a careful study of each lesion and the effect produced on the position of the fragments by the muscles of the part The deformity, as already stated, is due to three main

factors, *viz* the causative violence, the action of gravity, and the pull of muscles The chief methods employed to overcome these are extension of the limb by traction, relaxation of the affected muscles by position, and careful manipulation to place the fragments in apposition, the effect of gravity is overcome by supporting the limb Not unfrequently it is possible by flexion of a neighbouring joint to relax all muscular tension, and the fragments then fall into position almost without manipulation, in more troublesome cases longitudinal traction upon the distal end of a limb with the joint above the fracture fully flexed will permit of suitable coaptation of the fragments One cannot insist on this too strongly in reference to fractures below the knee, flexion of the knee relaxes the gastrocnemius and therewith the tendo Achillis, and it is often easy to reduce a fracture with a bent knee when traction with the limb straight has completely failed Care must also be taken to ensure that no abnormal rotation is present, and to this end the sound limb must be uncovered for purposes of comparison

As the manipulation is always painful and may elicit muscular spasm, it is often necessary to administer an anæsthetic, and it may be wise to make the attempt with the assistance of the radiographic screen No undue delay should occur in undertaking the putting-up of a fracture, as stiffness and infiltration soon follow and make the operation more difficult, but it is always desirable to delay it for a few hours, in order to treat shock, or to prepare the patient for an anæsthetic

The recognition for the need of **Prolonged Extension** in the treatment of certain fractures of the shafts of the long bones makes it necessary to draw special attention to the principles underlying this procedure, and the means available for securing their correct application

1 *Sufficient force must be employed to counteract muscular contraction and spasm,* which are the chief elements in maintaining the deformity Formerly the application of a weight of 7 to 10 lbs under unsuitable conditions was usually thought to be ample for a fractured femur, but the results obtained were certainly not satisfactory In the thigh of a muscular adult a weight of from 10 to 20 lbs acting freely is probably by no means too much

2 Since the object of the extension is to stretch the muscles which control the fragments, it is most important to secure a *sufficient grasp* of these structures The femur, for example, is surrounded by muscles, all of which, whether extensors, flexors, or adductors, are assisting in pulling up the lower fragment The whole muscular envelope needs to be stretched, and if this is effectively performed, the bone ends are much more likely to become satisfactorily approximated It is insufficient, therefore, to apply the adhesive plaster merely up to the line of fracture, the whole muscular envelope up to the next joint should be included

3 At the same time *joints must be left free* to allow of mobilization at an early date For the femur, the adhesive plaster may be prevented from touching the skin over the projecting femoral condyles by

bandaging over them a piece of gauze or lint, for fractures of the leg bones, the projecting malleoli must be protected

4 It is essential that *the limb should be slung clear* of the bed, so that the traction may exercise its full power without frictional resistance Long rigid splints must also be excluded from the dressing if the extension is to be effective Short splints guarding the fragments of the bone and helping to keep them in position may be of use, but must not extend beyond the neighbouring joints Skeleton splints of the Thomas or Hodgen type avoid these difficulties

5 Effective *counter-extension* must always be provided, and in the lower extremity the weight of the body is effective in this direction if the lower end of the bed is sufficiently raised, with the heavier weights now employed, the bed-end must be raised more than was formerly the custom

6 It is essential to *control treatment* of certain fractures, *e g* oblique ones of the femur or humerus, *by radiography* of the limb at intervals during the treatment to make certain that no slipping of the fragments has occurred, and this is most important during the early stages, as it is easy to correct mistakes whilst the union is still plastic *

In cases where, in spite of suitable extension combined with relaxation of muscles and manipulation, it has been impossible to secure or maintain coaptation of the fragments, operative measures will have to be considered (p 548)

7 The importance of securing union with correct alinement of the fragments cannot be exaggerated, for although one cannot promise without doubt that perfect function will be recovered, and although all surgeons can produce cases where good function is associated with defective alinement, yet statistics prove incontestably that good functional results are much more likely to occur if the restoration of the bone is as nearly perfect as possible

II The **fixation** of a fractured limb, so as to permit of suitable repair of the bone, involves (A) the application of splints and similar contrivances in order to keep the approximated fragments in correct position and alinement, or (B) the adoption of operative treatment

A **Splints** may be made of wood, leather, poroplastic, etc , according to the requisites of the case If of wood or metal, they are usually made according to some general pattern, and fitted to the patient by means of pads If formed of leather, papier-mâché, or poroplastic they can be shaped so as to meet any peculiarities of the part, softened by immersion in hot or cold water, moulded to the limb, and allowed to dry Where leather is employed, the addition of a little vinegar to the water assists in rendering it soft and supple The edges and corners are finally rounded, and the interior padded with wool or lint Splints must be sufficiently large to encase the part firmly, or, if flat, to project a little beyond it, so that the limb may be fixed by the splint, and not the splint by the limb In all cases careful attention must be given to the padding, so as to prevent irritation

* Where many fractures are likely to be treated a portable X-ray machine is essential, and hospital authorities must be urged to provide this in spite of its cost, in the long run it will prove to be an economy

of or undue pressure on the skin, which may result in splint sores (p 100) In out-patient practice, where patients are not too careful as to personal cleanliness, it is advisable to pad the splint with some antiseptic material, such as boracic lint, in order to prevent the development of vermin, but in all cases it is wise to shave and purify the limb, and to dust it over with boric acid and starch When blebs or blisters have developed, a dry aseptic dressing should first be applied The splints may often with advantage be fixed to the limb by one or two strips of adhesive plaster, and then secured by ordinary calico bandages, these must not be applied too tightly, since the limb not unfrequently swells after the accident, and undue constriction resulting in gangrene might ensue Moreover, a limb ensheathed in bandage must never be flexed, but the flexion should always be made beforehand, otherwise the bandage may cut into the soft tissues, and by compression of the vessels cause gangrene The condition of the fingers or toes is a sufficient test as to the activity or not of the circulation

In all cases where prolonged extension of the limb has to be maintained, the employment of the form of splint described above is not satisfactory, and *skeleton splints* of the type devised by Hodgen or Thomas are now generally used, suitably modified for arm and leg

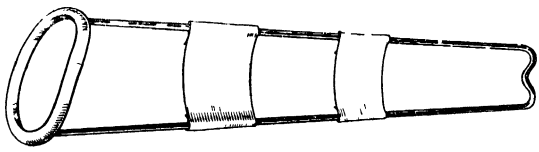


FIG 271 —THOMAS'S SPLINT AS EMPLOYED FOR FRACTURE OF THE LEG

The essential element of Thomas's splint (Fig 271) is a well-padded ring above, through which the limb is passed, it is pressed home either against the chest wall and axilla, or against the tuber ischii The skin against which it rests must be shifted from time to time and well protected, so as to prevent the development of splint sores On either side a straight or bent iron bar passes down, attached above to the ring, and terminating below in a cross-piece, the level of which is well below the sole of the foot or tips of the fingers Extension arrangements are fixed to the limb by glue or adhesive plaster, or by some form of skeletal traction apparatus (see p 614), and attached to the cross-bar of the splint or connected with a weight hanging over a pulley, this will drive the upper end firmly against the point of support Counter-extension for the leg is obtained by tilting up the lower end of the bed, so as to utilize the patient's weight for this purpose The limb itself is supported between the longitudinal bars as in a trough by securing to them bands of flannel, rubber, or metal by means of safety-pins or spring paper clips Deflection of one or both fragments to either side can be corrected by passing a broad flannel band round the limb and drawing it to the opposite bar to which it is secured, or more certainly by the application of carefully padded hollow metal

plates fixed to the sidebars and with screw adjustments, sagging downwards of the fragments is corrected by tightening the bands forming the trough, displacement forwards, by passing a band above the limb and attaching it to either bar In this way slight modifications are easily made Sometimes the additional incorporation of short splints in front or behind is of considerable importance in steadying the parts

Of great value in treating fractures of the lower end of the femur by skeletal traction is Braun's splint, because it enables movements of the knee-joint to be readily carried out It is also of great value in treating fractures of the leg

In the treatment of fractures where the tendency to displacement is slight, *e g* transverse fractures, and where in children difficulties of fixation by splints occur, various forms of **Fixed Apparatus** are used, they are also of value in the later stages when other splints are not required The materials most commonly employed are starch and plaster of Paris

The *starch* bandage is utilized only in cases where great strength and rigidity are not required After placing the fracture in good position the limb is covered with boracic lint, and over this, if necessary, are applied thin strips of cardboard soaked in starch These are firmly secured by bandages, into the meshes of which is rubbed a suitable solution of starch When this dries it produces a firm mass, sufficient to immobilize the limb Should it become loose, it can easily be readjusted by slitting up and paring away a portion of one or both sides

Plaster of Paris, though rather messy and increasing considerably the weight of the limb, is one of the best means of securing prolonged immobilization The dried plaster may be rubbed into a coarse crinoline or gauze bandage, which prior to use is soaked for a few minutes in cold water, to which a little salt or alum may be added in order to hasten its setting, it is then wound round the limb, which has been previously enswathed in boric lint or wool, and on the exterior of this fresh plaster of the consistency of cream is applied To make this cream of the right strength the dried powder is cast in spoonfuls into a bowl of cold water until it no longer sinks immediately, but remains floating on the surface The mixture is then stirred with an iron spoon, and is ready for use When the casing is sufficiently thick, the outer surface is smoothed down with wet hands, or a strip of wet bandage, the date may be advisably marked on it, and the part is slung up to dry The plaster case may, later, be cut into two halves, or 'bivalved,' by means of suitable shears, in order to facilitate massage

B The increasing success of modern aseptic surgery has given considerable impetus to the **Early Operative Treatment** of fractures in order to secure perfect alinement, complete fixation, and the early restoration of function This plan was first advocated and utilized by Lord Lister for such bones as the patella or olecranon, but its adoption for the long bones was largely due to the teaching and example of Sir W Arbuthnot Lane

The turning of a closed fracture into an open one is not to be looked on as a serious hindrance, granting that aseptic precautions are carefully observed, at the same time one cannot but recognize that an added element of risk is thereby introduced into the case Possibly, in the more recent past, surgeons were more keen on developing their operative skill than on perfecting mechanical devices which shall avoid operation One of the greatest lessons of the late war has been to emphasize once again the teachings of Hugh Thomas as to the value of the skeleton splint, and the adoption of this method of treating fractures in civilian life will limit considerably the operative activity of surgeons in this direction Of course, the great advantage of operation is that it fixes the fracture so securely as to permit of early massage and movement of neighbouring joints, atrophy of muscles and stiffness are thereby avoided, and the economical depreciation in value of a working man after, say, a fractured tibia may be to a large extent prevented One cannot but believe, however, that if similar care is given to such cases treated on appropriate lines without operation, similar good results will be obtained So long as the old-fashioned plan persists of fixing the joints above and below a fracture in apparatus troublesome to put on and take down, or in a rigid plaster of Paris case, until complete consolidation has occurred, and massage and movements are only employed to remedy stiffness already acquired, so long will bad results be turned out, and operative activity be justified

The actual *selection of cases for operation* must necessarily vary with the views of the particular surgeon, but the following may be looked on as a fair statement of the case

1 Fractures of small bones or of processes which are not easily retained in position by external appliances, and where healing apart from operation is slow and often defective, *e g* in the patella, olecranon, etc , require operation

2 Fractures involving joints, where fragments are displaced, as when the condyles of the femur or humerus are detached, may sometimes be operated on with advantage

3 Fractures of the shafts of long bones which are oblique or spiral, with much longitudinal displacement and perhaps overlapping, and with the sharp ends of the fragments impacted in muscular or other tissues, can often be placed in good position only by open operation, and even then perhaps with some difficulty In situations where extension cannot be easily applied, and reduction by manipulation fails, *e g* in some fractures of the forearm, operation is justifiable

4 Fractures of the shafts of long bones which can be brought into good position by suitable extension should, as a rule, be treated by means of Thomas's splint or of some modification thereof, rather than by operation Where effective extension can be made and maintained, an open operation may almost be looked on as a confession on the part of the surgeon of insufficient knowledge or inefficient apparatus

The *time for operation* must be carefully considered, it is usually wise to delay it for a few days, partly to allow the patient to recover

from the shock of the accident, partly to permit of effective purification of the limb and its radiographic examination, and partly to allow those early reparative changes to occur in the tissues of the part, which also assist in protecting them from infective troubles Any time between the fourth and tenth days will be satisfactory During the interval of waiting it is wise to apply effective weight extension so as to prevent any increase in the deformity and to reduce the amount of manipulation required at the operation

The **operation** itself must be conducted with the most minute care as to aseptic precautions The skin must be previously shaved and purified, but all direct handling of the wound is to be avoided, manipulations being carried out by means of instruments which have been sterilized by prolonged boiling The long-handled instruments devised by Lane are particularly suitable for this work Gloved hands are employed Spinal analgesia is often useful for the lower limb so as to secure complete muscular relaxation The incision should be planned so as to give effective exposure to the site of fracture, and allow exit to as much of the extravasated blood as possible The surrounding skin should be protected by towels clipped on the wound margins The ends of the fragments are exposed, cleared, brought into correct position with as little manipulation as possible, and held by suitable forceps, whilst their fixation is being accomplished After this has been effected, the displaced periosteum is, if possible, drawn together so as to limit the field of activity of the osteoblasts and to prevent adhesions of the muscles to the bone, divided muscles are sutured together with deep sterilized catgut stitches, provision is made for temporary drainage if thought necessary, the deep fascia of the limb is carefully sutured, as also the skin A suitable splint is then applied, and the patient returned to bed

Various *methods of bone fixation* are available, and it is not always easy to determine which to employ Much ingenuity has been exercised in the production of some of these, but most of them will be found in the near future rather in the museum than in the operating room

1 Sometimes it is sufficient to hold the fragments together by *silver wire* of appropriate thickness, *e g* for the patella or olecranon, or for some oblique fractures of long bones For the latter it is desirable to transfix the bone in two positions and introduce the wire as a mattress suture, and in a very oblique fracture two such sutures are desirable instead of one Care must always be taken to tighten the wires securely by twisting, but not to twist off the ends, the knots must be bent over and beaten down, so as not to cause irritating projections

2 When the fracture extends through masses of cancellous tissue, *e g* the condyles of the femur, or has involved fragments covered with muscular origins, the complete displacement of which would be undesirable, *e g* the condyles of the humerus, it is often possible to fix the fragment in position by *screws, nails, or pegs* of bone or ivory It is usually desirable to introduce two of these, so as to protect the fragment from displacement during the interval between withdraw-

ing the drill and introducing the peg, as also to secure the fragment, when fixed, from rotation Autogenous bone pegs, cut from the tibia by a double circular saw, *e g* Albee's, and rounded by an electrically driven dowel-shaper, are more satisfactory than metal screws or nails, they are introduced into a suitable-sized hole and driven home by a hammer, any excess being cut off, so that there is no projection

3 *Intramedullary pegs* of metal or bone have also been employed, but are not so generally applicable, in that their introduction involves a good deal of displacement of the fragments, they do not secure so

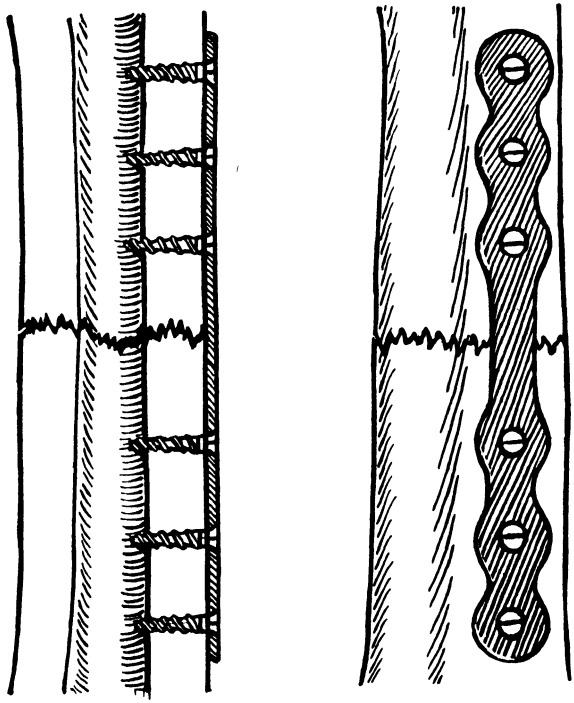


FIG 272 —LANE'S PLATE APPLIED FOR TRANSVERSE FRACTURE WITH DIAGRAMMATIC LONGITUDINAL SECTION

perfect an immobilization, and should the operation by mishap be followed by sepsis their removal is most difficult

4 For fractures through the shafts of long bones, **Lane's plates** (Fig 272) have been largely employed They consist of flat metal plates which can be bent by suitable wrenches to fit accurately to the contour of the bone They are supplied with a varying number of holes for screws, according to the type of fracture, holes are drilled through these into the bone, so as to reach the medullary cavity For a fractured tibial shaft at least four screws are required, and for a femur six or eight

Experience has, however, shown that there are many objections to their employment as a routine method of treatment, and they are now but little used (*a*) It is essential to secure a firm hold of each fragment by the use of a *long* plate, this involves considerable interference with the soft tissues, thereby interfering with the nutrition of the bone (*b*) Absolute fixity of the fragments without the possibility of the slightest movement does not conduce to rapid or effective union, the best results are secured when it is possible for the ends to rub one against the other without displacement Non-union in the ribs is unknown, delayed or non-union after 'plating' is not uncommon (*c*) The local effects of the screws on the bony tissue is to cause rarefaction, so that the firm hold is lost in a short time If splints or other retentive apparatus are removed too soon, so that powerful muscles can come into action, displacement and deformity may readily appear, especially in the shaft of the femur (*d*) Infection of the wound is almost always associated with death of the portion of bone lying under the plate, and may reach the medullary cavity through the screw holes Delayed auto-infection may also occur, arising in the small hæmatoma or from the damaged tissues around the plate (*e*) It is hardly needful to say that metallic plates or wires should never be used for an open fracture owing to the presence of sepsis, which must be assumed in every case

5 **External clamps** connected with long removable screws have been advocated by some authors, *e g* Hey Groves, but their employment is not generally recommended or feasible

6 In conclusion, one would note that all metal appliances are undesirable in the fractures of children, silver wire is the least objectionable, nails and screws, especially near joints, may light up inflammatory mischief, the screws of bone plates are early loosened by rarefying inflammation, so that this proceeding is not very reliable, catgut or silk sutures passed, through the periosteum so as to hold the fragments temporarily in position or autogenous bone pegs should be chiefly relied on Every effort must be made, however, to avoid operation for fractures in children

III **Massage and Mobilization** nowadays play an important part in the treatment of fractures The days of prolonged splinting and immobilization are over (or should be), and splints are looked upon as undesirable necessities to be discarded as soon as possible and replaced if need be by light removable plaster of Paris supports, which protect from injury and displacement a weakly united fracture between the intervals of exercise and massage Under the old régime the functional results of treatment were extremely bad in the aggregate, the limb remained for a considerable period weak and stiff, owing partly to atrophy of muscles, partly to cicatricial adhesions, and in part to contraction of ligaments in neighbouring joints, and these disabilities increased in direct ratio to the length of time that the limb had been kept at rest The modern surgeon endeavours to prevent these disabilities, but this can only be effected by persistent attention and methodical after-treatment

In the earliest stages massage may be employed in the shape of

gentle stroking movements to relieve pain and diminish muscula spasm Thus diagnosis is facilitated, since the patient permits th limb to be handled and gentle movements to be undertaken, an reposition of the fragments may become practicable

In fractures through the shafts of long bones with displacement which, apart from operation, may possibly recur, the part is necessaril immobilized by a suitable appliance, but although the joints abov and below the lesion are included in the apparatus, there is no nee to keep them immobile throughout the course of treatment Indeed it is most desirable that from a very early date they should be move regularly, and thereby stiffness prevented, and with modern appliance of the Thomas type this is perfectly feasible Massage is employe in these cases to tone up muscles, as well as to assist in the absorptio of blood, etc Possibly some pain is noticed at first, but it soo disappears if the massage is gentle and not too forcible Of course the patient is not allowed to put any strain on the part by activ movements until the consolidation of the fracture is assured Wher the tendency to displacement has been remedied by operation, th whole proceeding is necessarily easier

In fractures near joints or through the articular ends of bones i is often possible, and indeed wise, to discard splints entirely, or a any rate only to use them for a short time, steadying the part b some simple contrivance, such as a sling or strapping, massage i commenced after the first few days, and if of the gentle and sooth ing type is most comforting, and will enable the neighbouring joint t be moved passively This method of treatment is specially applicabl to such injuries as fractures of the anatomical neck of the humerus the simpler varieties of Colles's and Pott's fractures, and for man fracture dislocations in the neighbourhood of the elbow In suc cases active movements may often be permitted at quite an earl date, but if these are produced by powerful muscles, which by thei attachment to one of the fragments are liable to reproduce the de formity, then passive movements and massage must be relied on unti the fracture is consolidated, and there are conditions about th elbow where even passive movements must be refrained from fo a time In spite of all precautions, however, a certain percentag of cases under this heading are certain to develop permanent stiffnes to a varying degree

Ambulatory Treatment —Certain fractures in the lower limb, *e g* tibi and Pott's fracture, may be treated by fixation in a plaster of Pari splint, in which the patient is allowed to walk, after allowing a fe days for the preliminary swelling to subside The active muscula contractions thus obtained, together with the slight movement of th fractured surfaces, are conducive to rapid consolidation, and minimiz the need for subsequent massage

It is advisable to protect the plaster from direct contact with th ground, either by a metal stirrup of the Bohler pattern (Fig 346 p 630) or by a wooden sole-plate

Finally, a word of caution must be given against too forcible an vigorous massage and movement, which can readily induce pain

muscular spasm, and increasing stiffness This is particularly the case when the line of fracture involves a joint, and then natural movements carefully graded are often more valuable than forcible passive exercises The onset of pain as the result of massage or movement is always an indication to keep the parts at rest for a few days longer

Complications of Fractures—1 **Implication of a Joint**—When the fracture extends through the articular cartilage, the joint becomes distended with blood and synovial fluid, but this is subsequently absorbed, and the fissure in the cartilage closed by plastic lymph, which develops into scar tissue If the fragments are in perfect apposition, no permanent harm need result if treatment such as that recommended above is undertaken If, however, the apposition is imperfect, adhesions of a more serious type develop, and considerable limitation of movement may follow It is thus comprehensible that one of the chief indications for the operative treatment of fractures is when they involve joints In elderly people injuries of this type may result in a chronic traumatic arthritis, particularly in the shoulder or hip, causing pain and limitation of movement by the development of osteophytes In some of these cases massage seems to do harm rather than good

2 The same violence that causes the fracture may at the same time produce a **Dislocation** in a neighbouring joint, and particularly in connection with the elbow and shoulder Treatment should always be undertaken as soon as possible Should the fracture involve or be close to the articular end of the bone, an attempt should be made to reduce the deformity by manipulation under an anæsthetic, failing this, or if the deformity recurs, open operation should be undertaken if the conditions as to surgical cleanliness permit In most cases the dislocation can be reduced after removing the extravasated blood, and the fracture fixed, but sometimes, when the displaced articular fragment is small, it is wiser to excise it

When the fracture is further away from the joint, it is sometimes possible to command the fragments by splints, and then reduce the dislocation under an anæsthetic Should this fail, the surgeon may either fix the fracture by operation and repeat the attempt to reduce the dislocation, or he may open the joint and perform an open reduction Should immediate treatment be impracticable, the limb should be fixed in splints so as to allow union of the fracture, and at a later date the unreduced dislocation should be treated

3 The **Main Artery** may be compressed, contused, punctured, or ruptured, giving rise to thrombosis, aneurism, or hæmorrhage In the former case, dry gangrene may result if the terminal vessels are unhealthy, in the latter, moist gangrene may be produced by the pressure of the extravasated blood on the veins This is most frequently observed in fractures of the lower end of the femur, where the femoral or popliteal artery may be involved **Treatment** has been discussed elsewhere (p 102) Here it may only be mentioned that in the case of a ruptured artery operation should, if possible, involve not only the removal of the blood-clot and the securing of the artery, but also the fixation of the fracture

4 Laceration of **Veins** results in extravasation of blood, which is not so extensive as when an artery is wounded, since thrombosis occurs more easily, the distal part of the limb may become congested and œdematous, and this may require for its removal firm bandaging and massage Pulmonary embolus is an occasional sequence of venous thrombosis

5 The **Nerves** of a limb may be injured at two different periods (*a*) Immediate injury is due to laceration or rupture, either of the whole trunk, or, as is more common, of the nerve fibrillæ, without loss of continuity of the sheath (*b*) Secondary symptoms result from inclusion and compression of the nerve in the callus, or from injudicious splint pressure Irritative symptoms in the shape of neuralgia are first manifested, followed by paralysis and anæsthesia This usually occurs three or four weeks after the accident, and may disappear in a month or two, or persist **Treatment** is always for a time of the expectant type, even when the paralysis is immediate, since total rupture of a nerve is rare, and restoration of function the rule rather than the exception When, however, the symptoms persist, the parts must be laid open, the nerve freed from adhesions, or exuberant callus removed, and such measures taken as will best secure the nerve from further compression (Chapter XV , p 383)

Complications arising during Treatment—(1) If an elderly patient is kept in bed for any length of time in the recumbent posture, *hypostatic pneumonia* is likely to ensue It occurs most commonly after intracapsular fractures of the cervix femoris, and non-union often results, since the patients must be allowed to get about on crutches at an early date with the limb fixed by a suitable splint (2) *Bed-sores* (p 100) are liable to supervene in old people with fractures which need treatment in the recumbent posture (3) *Crutch palsy* is the result of compression of the brachial nerves between the head of the humerus and the pad of a crutch It may affect all the nerves of the upper extremity, or may pick out any one of them, and then most commonly the musculo-spiral It can usually be prevented by the use of spring-padded crutches with cross-pieces for the hands, so as to allow the patient partially to relieve the axillary pressure by supporting the weight of the body by means of the arms, or by the employment of the modern stick-crutch When it has occurred, the use of crutches must be discontinued, and faradism and massage employed to the affected muscles (4) *Volkmann's contracture* (p 464) sometimes develops in cases of fracture of the forearm or elbow in children (5) Another muscular complication consists in a deposit of bony tissue therein, a result of a *myositis ossificans* (p 466) (6) *Gangrene* may arise from fractures in a variety of ways (i) From the immediate effects of the injury, either by its direct action on the tissues, or by causing arterial thrombosis in a limb with atheromatous vessels, or from rupture of the artery with consequent venous thrombosis, owing to the pressure of the extravasation, (ii) by the supervention of spreading gangrene in a compound fracture, (iii) from errors in the course of treatment, as by bandaging the limb too tightly, so as to constrict the vessels, or by the bandage becoming unduly

tight, owing to the subsequent swelling of the limb, or by flexing a joint after bandaging it, the bandage cutting into the soft tissues, or by the localized pressure of a splint which has been insufficiently padded Moist gangrene is the type met with in all cases, except when the limb has been previously drained of its fluid by an atheromatous condition of its vessels

(7) *Splint sores* constitute a form of localized gangrene due to the pressure of a badly fitting or imperfectly padded splint, or possibly to bandaging on too tightly a splint which otherwise would be satisfactory The commonest situation is over the heel when the limb has been kept for a time on a back splint with a foot-piece, it is also sometimes seen on the outer or inner side of the leg when side splints have been too firmly applied When of considerable size, the parts must be purified carefully, all pressure removed, and antiseptic fomentations applied to assist in the removal of the dead tissue, the sore resulting therefrom will require stimulating applications to encourage healing When the slough is of small dimensions, it is kept aseptic and allowed to be absorbed by natural processes

Open (or Compound) Fractures.

An open fracture is one in which there is a communication between the external air and the site of injury It is caused by direct or indirect violence, the solution of continuity of the skin being produced in the former from without, and in the latter by the penetration of a bony fragment from within It is also sometimes secondary to treatment, the skin over the fracture sloughing as a result of pressure or irritation The bone may be but little displaced, or may protrude through a small opening in the skin, or the bone may be crushed and comminuted, and a large fleshy wound may be associated with it In some of the injuries produced by railway or machine accidents, gunshot wounds, or motor-cars, the skin and muscles are violently torn across, and the underlying bone may be pulped, whilst road dust, grease, and dirt of many types are ground into the tissues

The chief peculiarities of open fractures are due to the existence of the external wound, which permits of the entrance of bacteria into the depths of the limb, and perhaps interferes seriously with the application of splints and other appliances

Hæmorrhage occurs to a variable degree according to the size of the vessels involved, but inasmuch as the lesion is not usually produced by cutting, the vessels may become sealed by natural processes Secondary hæmorrhage is not uncommon in septic cases, as the result of a periarteritis, particularly if a sharp fragment lies in close contiguity to a large vessel

Infection is caused by any of the multifarious types of germs found in the skin, dirty clothes, road dirt or soil The ordinary pyococci are almost always present, together with anaerobes, coliform bacilli, and organisms of the proteus type Any or all of the parts involved may become the seat of suppurative lesions which have a considerable tendency to spread Thus cellulitis may develop in the subcutaneous

tissues, and erysipelas sometimes occurs The deeper planes of cellular tissue are also involved, and this may be followed by wide burrowing of pus The possibility of the development of tetanus must also be remembered

Muscle bellies often protrude through the opening in the deep fascia by which they suffer constriction, and present as an œdematous mass which may even become gangrenous, drainage of the deeper parts of the wound is thereby hindered Anaerobic invasion may lead to localized gas gangrene

Tendon sheaths, if opened, provide a favourable nidus for the development of pus organisms, and the suppuration may track up or down for a considerable distance, the tendons themselves slough or contract dense adhesions to the sheath

The effect on the *bone* varies If the shaft is broken cleanly, an acute osteomyelitis may follow if drainage is defective, but if there is a free exit to discharges, all that may result is a limited necrosis of the compact tissue of the end of one or both fragments If the fracture involves cancellous tissue, an acute infective osteitis follows, leading to cario-necrosis, and possibly by direct extension involving neighbouring joints and bones The existence of *fissures* extending from the main focus of the lesion does not necessarily involve a spread of the suppuration along them, unless rough handling, or injudicious movement, or tension from want of drainage, is present When *comminution* is present, infection almost invariably leads to death of all totally detached fragments, but those which retain their periosteal connection will probably live and be useful in the reparative process if satisfactory drainage is established

Neighbouring joints may become infected at the time of the original injury, or subsequently by secondary extension through living bone or along fissures In old-standing cases with necrosis and chronic sepsis, joints may become stiff by prolonged immobilization, and then forcible attempts to break down adhesions and free the joint may result in lighting up an acute suppurative arthritis

Nerves may be injured at the time of the accident, or damaged at a later date by inclusion in the callus or in cicatricial tissue The phenomena are identical with those following a simple fracture, but unfortunately nothing can be done in the operative line to repair them until the sepsis has been overcome

It will be manifest from the above brief generalization that whilst compound fractures may be followed by good results if treated early and effectively, delay or defective treatment may involve the patient in the gravest dangers of an infective nature (pyæmia, septicæmia, etc), or may lead to a most wearisome and prolonged convalescence Life and limb are alike threatened, and even if both are saved great and crippling disability may follow

The **Method of Repair** of a compound fracture is much the same in principle as that of the simple variety, but necessarily is largely influenced by the *course of the case*

If complete and immediate sterilization of the wound can be effected, it may be closed at once or by delayed primary suture, and

the fracture treated in the same way as one with no skin involvement The repair is then identical in the two types The same occurs if infection merely involves the soft tissues

If, however, bacteria invade the bony fragments, a certain amount of necrosis is almost sure to occur, and delay in healing of the wound must ensue whilst the necrosed fragments are separating

(i) If the fracture is *a clean break through the shaft*, and the necrosis limited to a small section of the compact tissue on one or both fragments, the dead bone is separated by a process of rarefying osteitis in the neighbouring compact tissue, the marrow cavity is shut off by a medullary plug of soft bone, the superficial layer of which is converted into granulation tissue Whilst this is occurring, new bone is being formed from the osteoblasts adherent to the neighbouring periosteum, and this may suffice to bridge the gap between the fragments and determine their union The bond of union thus formed constitutes an involucrum (p 638) to the dead bone, which lies within and is gradually separated If the sequestrum is small, it may find its own way to the surface, but usually the external wound has narrowed to such an extent during the interval as to prevent its escape, and sequestrotomy must be undertaken When once the sequestrum is removed, a clean granulating cavity persists, and this should heal more or less quickly according to its shape and blood-supply, the deeper part of the granulations being derived from bone is likely to develop into bone, the more superficial part into cicatrical tissue

Sometimes, however, the presence of the sequestrum maintains so much irritation that reparative changes cannot occur so long as suppuration persists, and the fracture remains ununited, removal of the sequestrum may bring about such a degree of healthy action as to determine union

(ii) *In cancellous bone* a septic fracture will be followed by a spreading osteitis until efficient drainage is provided, and then the destructive process comes to an end and repair follows

(iii) *Comminution* of compact tissue is a serious complication in an infected open fracture Fragments totally detached die, and, unless they are removed, cause persistent suppuration Fragments retaining their periosteal connections live, and undergo active changes, either destructive or reparative, according to the degree of infection present Where drainage is free, the fragments are welded together by granulations around the central cavity of the fracture, and these granulations are converted into new bone

In cancellous tissue a similar process occurs when the parts are freely opened up and drained, and all loose fragments removed Too conservative a policy results in the retention of both dead and living fragments, between which pus burrows, coming to the surface in various directions, so that the whole area of the injury may be riddled with sinuses Some degree of reparative activity occurs, and in time the site of the injury may be occupied by a swelling, which consists of a curious mixture of dead and living bone, more or less carious, between the constituent elements of which lies a mass of œdematous tissue, partly granulation, partly cicatricial, sinuses

track through this mass, and the patient may become gravely ill and anæmic from toxic absorption No repair can be expected so long as this mass persists, and cure can only be established by clearing out the whole infected area

The **Treatment** of compound fractures has two main points in view, *viz* (1) To prevent the development of infection or to limit its ravages, and (2) to fix the limb in apparatus, so that repair of the bone may occur with as little deformity as possible

The prevention of infection is really a question of time, if the case is seen early, much can be done, if there is much delay, sterilization of the wound is almost impossible The rules already given (p 66) must be followed out with the greatest care The skin of the limb is shaved and purified, the margins of the wound are excised, the cavity of the wound is laid open by suitable incisions, so that the interior may be thoroughly explored Damaged and hopelessly torn tissues are cut away so as to leave a free approach to the site of the fracture, which is appropriately dealt with If the surgeon is satisfied, he may close the wound entirely, or may wash it with alcohol and 'Bipp' it before closure If he is doubtful as to the result of his efforts, the Carrel-Dakin treatment may be instituted, or a flavine pack inserted—but in the latter case the gauze must not be entangled in the spicules of the bone A counter-opening may be necessary, but *under no circumstances must a drainage-tube be carried across the site of the fracture so as to lie between the fragments*, necrosis is certain to follow such a procedure

Winnett Orr of America has produced some astonishingly good results by thoroughly cleaning up the wound and packing it with gauze soaked in sterile vaseline, after the bone or bones have been brought into alinement by manual or skeletal traction No attempt is made to close the wound, nor is any drainage employed The limb is encased in plaster of Paris The plaster is not removed for six weeks or more, when it is found the wound will probably have healed

The treatment of the bone itself varies with circumstances When merely a sharp end of one of the fragments protrudes through a small opening in the skin, the latter is first purified thoroughly, and then after the margins have been excised and the wound, if need be, enlarged, reduction is effected, and the wound, if thought desirable, closed In clean breaks without protrusion, the fractured ends are apposed in the usual way and the limb placed on a suitable splint Skeleton splints of the Thomas type are of the greatest value in compound fractures, in that the limb need not be disturbed when the wound is dressed, the flannel bands which constitute the trough in which the limb lies must be so arranged that by the removal of one or more easy access to the wound is secured

When comminution is present, the site of the fracture should be carefully explored All totally detached fragments are removed, but the majority of fragments which retain their periosteal attachments, especially if of large size, are saved If the surgeon is fairly confident as to sterilization, no removal of bone other than of completely detached fragments is justifiable, if, however, he anticipates infection,

or if it is already present, he should remove by careful subperiosteal resection such loose fragments as are likely to hinder effective drainage, always leaving a sufficiency of bone to maintain the continuity of the limb

When suppuration persists, necrosis has probably occurred, and radiography is useful in determining when the sequestrum is free It must be remembered, however, that sequestra seldom take more than two or three months to separate, and often less As soon as separation is effected, operation to remove the sequestrum must be undertaken, delay involves thickening and condensation of the involucrum, with subsequent trouble in determining closure of the sequestral cavity (p 649)

All secondary operations required for non-union, vicious union, or nerve lesions must be postponed till the wound has been satisfactorily healed for some time

The question of *amputation* has, of course, to be considered in many cases, both immediately or as a secondary procedure, and has been discussed elsewhere It is only necessary here to remind practitioners that so much can be done nowadays by conservative means that amputation must not be decided on without the most careful consideration, at the same time it is useless to retain that which may become a source of serious danger, or even if saved remain a useless encumbrance

As a secondary operation, amputation is needed mainly for severe recurrent secondary hæmorrhage, grave infection of the soft parts extending up the limb with marked toxæmia, a heavy infection of a neighbouring joint or of surrounding bones (as in the tarsus), or chronic anæmia and toxæmia due to persisting and long-continued suppuration Gangrene from whatever cause also requires amputation, but not necessarily up to the site of fracture

Chronic necrosis has been unfortunately a sequela seen only too commonly after compound fractures due to gunshot wounds, and there can be no question that for some years these cases will require treatment The unfortunate patient retains one or more suppurating sinuses, from which perhaps small spicules of bone are discharged, this may be followed by healing which persists for a time, and then possibly, as the result of some slight injury, the wound flares up, the limb swells, and the cicatrix gives way, permitting exit to a quantity of pus. A probe is passed, and finds its way into a bony cavity along a passage which may be straight or tortuous, bare bone is touched, and the doctor not unfrequently decides to 'scrape it out' This is done more or less thoroughly, probably through a small incision, fresh bony tissue is laid bare and infected, fresh necrosis follows, and the whole gamut of trouble is repeated This goes on time after time, and operation follows operation for years perchance, and at the end of fifteen to twenty operations the patient is in a rather worse condition than previously, and frequently requests the removal of his limb

The local conditions present in these cases vary considerably, but as a rule there is a sequestrum of greater or less size lying in a cavity

which is almost surrounded by bone, which becomes increasingly dense and non-vascular as the months pass, until sometimes it is as hard as ivory It is obvious that reparative changes can only occur very slowly in such tissue, and that scraping cannot be expected to bring about healthy activity The sinuses which reach this cavity are often narrow, and may be badly placed for drainage or dressing, the constant passage of discharges and the daily introduction of gauze packing (often too tightly) suffice to determine a spreading sclerosis in the surrounding soft tissues which will impair subsequent usefulness Even if the sequestrum is taken away successfully without waking up fresh trouble, healing does not always occur, since the bone may be tunnelled, and the sides of a bony tunnel necessarily cannot fall together

The treatment of these cases is often very difficult, and usually irksome both to doctor and patient, and yet they can be cured even after many futile operations

The actual operative procedure must be governed by the following considerations (1) A careful stereoscopic skiagram of the limb must be secured, which shall enable the surgeon to visualize clearly the conditions he is called on to treat (2) The trouble in the bone must be approached by a route which shall enable him effectively to deal with it, if the existent sinuses happen to fall into the line of his incision, well and good, if not, the sinuses will probably close quickly after the essential cause of the trouble has been dealt with (3) The incisions must be sufficiently long to enable *all* the trouble in the bone to be reached and dealt with openly without recourse to a curved spoon, which can scrape round a corner and only just get into a narrow passage The ideal condition to be left after operation is a wide shallow gutter or crater with no overhanging bony lips This necessarily involves the cutting away of a good deal of bone in many cases, for which suitable chisels and gouges are required, but the dense bone often found is very unfavourable for reparative purposes Tunnels in the bone are treated, if practicable, by removing entirely one side of the tunnel so as to convert it into a trench into which the surrounding soft tissues may find an entrance

The cavity thus formed is carefully dried, hot saline solution being employed as a hæmostatic, it may be then wiped over with absolute alcohol, and packed with gauze soaked in 'Bipp,' which is retained for ten days or more unless there has previously been very free discharge If there is little discharge, frequent dressings are quite unnecessary, and indeed harmful, probably it suffices to change the 'bipped' gauze once in ten days Occasionally the surgeon may feel justified in closing the cavity entirely after 'bipping' it, but this is not often possible Other methods of closing the cavity in the bone are alluded to at p 649

Ununited Fractures.

Three varieties of ununited fracture have been described (1) *Absolute non-union*, when no attempt at repair is made, may result from fractures due to the presence of some local disease which has led to

wide destruction of bony tissue, such as sarcoma or osteomalacia, or from the resection of extensive areas of bone for sarcoma or gunshot injuries (2) *Fibrous union* consists in the development of a more or less firm mass of connective tissue as the bond of union between the ends of the bones, which are either rounded off and closed by a thin plate of bone or cartilage, or are sometimes atrophic and pointed (3) A *false joint*, or *pseudarthrosis*, is a condition in which the ends of the fragments are covered either by bone or cartilage, and more or less altered in shape, so as to form a shallow ball-and-socket joint, the capsule being represented by the surrounding fibrous tissue, and the synovial cavity by the formation of an adventitious bursa

The most common situations for ununited fractures are projecting processes of bone to which powerful muscles are attached, such as the patella, olecranon, coracoid process, posterior half of the os calcis, etc , whilst in long bones the middle of the shaft of the humerus and the upper and lower thirds of the femur are the favourite sites

Causes —(1) Want of apposition of the bony ends, owing to extensive resection, or to muscular action, *e g* in the patella, when the two fragments are widely separated, (2) the interposition of muscular or aponeurotic tissue, or detached fragments of compact bone, (3) failure of efficient reduction and maintenance of the reduction (in this respect non-union associated with too heavy traction whereby the fractured ends are artificially separated should be noted, removal of the excess weight in these cases will at once promote union), (4) defective blood-supply to one or both fragments, as by injury to the nutrient artery, or as in transcervical fracture of the cervix femoris, where the only source of supply to the upper fragment is a small twig derived from the obturator artery running along the ligamentum teres, (5) local affections of the bone, such as suppuration with necrosis in compound fractures, malignant tumours, or the undue pressure of pads upon newly-formed callus, (6) general bone disease, as osteomalacia, and (7) general constitutional weakness or debility, and diseases such as scurvy or severe syphilis

The **Signs** of an ununited fracture are usually obvious, mobility between the fragments being easily obtained in some directions, though perhaps not in all, of course, crepitus is absent It is perfectly possible, however, for a person with good muscular development to have an ununited fracture with but little functional disability, the condition may be obvious when the muscles are relaxed, but disappears when the muscles contract In doubtful cases radiography will help in diagnosis

The **Prognosis** is fairly good if suitable treatment is adopted, and the local or general conditions do not prohibit reunion In particular emphasis must be laid upon the necessity for patience in the non-union associated with infected open fractures Until all necrosed tissue has been removed, and the infection overcome, reparative processes are often slow in being established If the parts be fixed, and the vascularity of the limb increased by massage and the use of such portions of the limb as can be moved without displacing the fragments, and if the general health be improved, repair without

operation can often be established in time Operation itself is not always successful, especially if the soft parts have to be extensively interfered with in order to secure reposition of the fragments, in children, under such circumstances, the outlook is poor, the ends of the bone becoming atrophic, rounded, and covered by cartilage, in such the final resource is not unfrequently amputation

Treatment.—(1) If in good position, the parts should be refixed, and a course of passive venous congestion carried out A Bier's elastic bandage is applied to the limb above the fracture for three or four hours daily Excellent results often follow At the same time the general health is improved by a stay at the seaside or the administration of tonics, and the condition of the limb improved by massage If an external support can be arranged so as to enable the patient to use the limb, though the fracture is still ununited, so much the better, it may stimulate the bone-forming power of the fragments

(2) Failing this, operative measures must be undertaken If the bone is tolerably superficial, and the ends not very far apart, they should be exposed, sawn into shape, fitted together, and secured by catgut sutures, silver wire, or pegs To effect this a free incision in a line of safety is necessary, taking special precautions to protect not only the main nerves, but also their muscular branches The ends of the bone are carefully examined, and suitably cut into shape so as to secure effective coaptation One of the simplest and best methods is to cut 'steps' in the bone ends by a saw (Fig 273) and to fix the fragments by a catgut or wire mattress suture The limb is shortened somewhat by this means, but firm union is secured, and the delay and doubts associated with bone grafts are avoided See also below, *re* 'flail-arm'

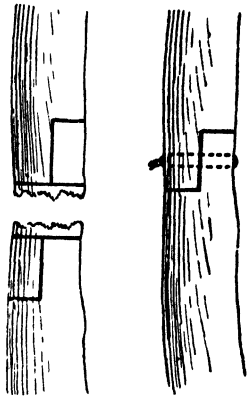


FIG 273 — 'STEPPING OPERATION FOR UNUNITED FRACTURE

Having freed the ends of the fragments a saw cut is carried across the end to make certain that bony tissue is exposed The saw (possibly a butcher's) is next carried longitudinally up the centre of the shaft to a sufficient distance, and the small fragment loosened by a Gigli saw The same process is performed on the other fragment, and the wire mattress suture is then introduced through holes previously made Exact and accurate fitting of the fragments is essential for good results

(3) If, however, the bones are deeply placed, so that it is difficult to expose the ends and fit them together, it may be wiser to leave them in their bad position, and fix them by the insertion of autogenous bone pegs, or failing this by screws or ivory pegs Thus, in the upper end of the femur non-union is usually associated with overlapping of the fragments to a considerable extent To expose and fit these together would necessitate a very extensive dissection, it may be desirable in such cases merely to cut down in front upon

the upper anterior fragment, drill two holes in different directions through both fragments, and into these insert suitable pegs or screws Two holes should always be employed to prevent slipping of the fragments during the necessary manipulations, whilst one drill is removed for the insertion of the peg, the other holds the bone steady Their presence causes the formation of a large amount of callus, and by this means the fracture is consolidated Of course, this procedure involves the persistence of shortening, and in young and healthy adults it is probable that a more extensive operation with complete reduction and fixation of the fracture is advisable, but unless the local and general conditions are good, the above procedure may suffice

(4) When there is loss of substance between the bone ends and other operative measures fail, various methods of bone-grafting may be employed (p 686)

(5) Beck has introduced a new method attended with considerable success Numerous drill-holes are made passing through the adjacent portions of the fractured bone and thus through the area of non-union Some thirty or so tracks are made with the drill, this being introduced firstly through a small skin incision just above the line of the fracture and then through one placed just below The drill-holes radiate in all directions through the sclerosed bone from the two primary points of entry Osteoclastic and osteoblastic activity are stimulated and union results

The problem as to how to treat the **flail-arm** resulting from the resection of extensive areas of bone for gunshot wounds is one that has recently exercised many surgeons The condition occurs most frequently at the upper limit of the arm due to removal of the head of the humerus and a good portion of the shaft, or in the neighbourhood of the elbow, the shattered bone ends having been widely exsected (1) It is necessary to support the limb after the original operation and during convalescence in such a manner as to encourage accommodative shortening of muscles, etc , to permit the arm to hang without support must obviously result in stretching of these muscles by the weight of the limb This support should rest on the shoulder above, to which it is carefully fitted, and should grasp the elbow or forearm below (2) During the period of waiting which must supervene before further operation is feasible, the biceps and triceps must be toned up daily by electrical treatment (sinusoidal current), and encouraged to contract, thereby diminishing the gap between the bone ends Skilful operative treatment directed towards the bones will prove to be useless unless the muscles have been previously treated in this way, they cannot contract and control distal parts if they are slack (3) The actual details of operative treatment must vary in different cases, but essentially it consists in approximating the bone ends sufficiently to permit of the introduction of silver wire or a plate, which shall hold the ends together Thus the lower end of the humerus may be pushed down and wedged into the hollow of the olecranon and there fixed, the upper end of the humerus may be attached to the lower lip of the glenoid cavity or to the acromion process which has been sawn through and turned down Occasionally

simple bone grafts will suffice to secure fixity, and sometimes these grafts may include such structures as a complete joint, but our experience is not yet sufficient to justify any dogmatic statement

Disunited Fracture is the term applied to a rare condition, in which a fracture which had been firmly united becomes separated again It is only met with when the individual develops some extremely debilitating disease, such as scurvy, and may be recovered from under suitable treatment directed to the cause, and by fixation of the parts

Vicious Union (Fig 274) of fractures results either from imperfect adjustment of the ends of the bone, or from the parts not being kept at rest, and hence becoming subsequently displaced The difficulty of managing serious compound fractures explains the frequency with which vicious union is seen after gunshot wounds Various kinds of deformity and disfigurement, accompanied or not by loss of function, may result, and, if these are serious, means must be taken to remedy matters If observed early, when the callus is not too consolidated, it is not difficult forcibly to readjust the parts by manipulation under an anæsthetic—if necessary refracturing the bone In some cases powerful mechanical appliances, or osteoclasts, are employed for this purpose, but care must be exercised not to damage unduly the soft parts The *open* method is certainly preferable, cutting down on the bone, redividing it, removing redundant callus, and fixing the fragments by silver wire, pegs, or screws Of course, after septic gunshot wounds the usual precautions as to delay and preliminary vaccine treatment to protect against infection must be observed

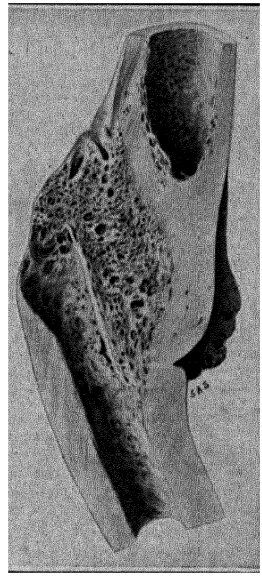


FIG 274.—VICIOUS UNION WITH MARKED DEFORMITY AFTER FRACTURE OF FEMUR

Special Fractures

Bones of the Face.—The **Nasal** bones are broken as a result of direct violence—by the fist, a cricket-ball, stick, etc The fracture is generally transverse, and situated just above their free margins, occasionally, when greater force is used, it occurs to the root of the nose, and may then be associated with fracture of the frontal bone or base of the skull (Fig 275) In young people the cartilages alone may be separated There is usually considerable deformity from depression or lateral displacement of the fragments, although it may at first be masked by the amount of bruising Severe epistaxis, surgical emphysema, and cerebral symptoms are sometimes met with as complications The fracture very readily becomes consolidated, and

the deformity is thus often irremediably fixed, unless its presence is determined at once, and suitable treatment adopted The **Septum** is sometimes broken and depressed, in association with or apart from the above injury Lateral displacement occurs, causing unilateral nasal obstruction and some amount of obvious deformity The **Treatment** of these cases consists in immediate replacement of the bones, advisably under an anæsthetic, this may be accomplished by the pressure of some blunt instrument, such as a pair of dressing forceps, the blades of which, covered with rubber, are introduced within the nostril A pad of lint or gauze soaked in carbolized oil is, if necessary, inserted to maintain the position, and a gutta-percha or zinc splint moulded to fit the bridge This dressing should be changed at least every twenty-four hours

The **Lachrymal** bone has been broken by direct violence, the fracture usually extending from the nasal bone to the lateral mass of the ethmoid Interference with the flow of tears and surgical emphysema are the two most marked symptoms

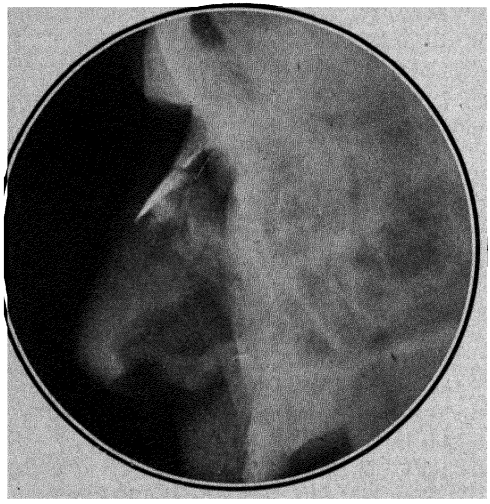


FIG 275.—FRACTURED NASAL BONES

The **Malar** bone is but rarely broken without the other bones of the face being involved, fracture is almost always associated with damage to the anterior wall of the antrum and considerable depression of the fragments An attempt should be made to replace the parts by pressure from within the mouth, but should this fail a small incision should be made in the cheek, a hook inserted, and the depressed bone pulled and levered out into position

The **Zygoma** is fractured by direct violence applied from without, the broken portion may be depressed below the surface, but vertical displacement is limited by the attachment of the masseter below and of the temporal fascia above Reposition, either by manipulation from within the mouth, or even by operation, is essential in order to prevent interference with the subsequent mobility of the jaw Perhaps the simplest plan to adopt is to encircle the zygoma subcutaneously with a loop of silver wire and drag it up to its natural level

The **Superior Maxilla** is invariably broken as a result of direct injury, such as a blow or gunshot wound, it is almost always compound, and often bilateral The alveolar portion is either partially or entirely detached, or a transverse fissure, extending as far as

the pterygoid processes on each side, may render the whole palate and lower part of the facial skeleton movable More frequently all the bones of the face are smashed and comminuted, severe hæmorrhage sometimes resulting from wounds of the terminal branches of the internal maxillary artery **Treatment** consists in merely keeping the patient quiet and applying cooling lotions, union occurs with great readiness, but is sometimes associated with suppuration and necrosis The patient must be fed by a tube, and a carefully-fitted dental plate should be applied to a broken alveolus after removal of the teeth which penetrate the affected region

The **Inferior Maxilla** is usually fractured by direct violence applied from in front, as by a fall or a 'punch' on the chin, more rarely the force acts from the side, and then the bone may break in the middle line Most frequently, however, the lesion is a little in front of the mental foramen in the neighbourhood of the canine tooth (Fig 276), this being a weak spot at the junction of two strong parts, *viz* the symphysis menti and the alveolar process carrying the molar teeth This fracture is occasionally bilateral—when great violence has been applied to the symphysis A solution of continuity sometimes occurs close to the last molar tooth (Fig 277), whilst the coronoid process and condyle have also been broken, the former only as a result of severe direct force, *e g* a gunshot wound, the latter from either direct or indirect violence Gunshot wounds of the lower jaw are often comminuted and associated with gross destruction of the soft tissues, and often with loss of considerable portions of bone

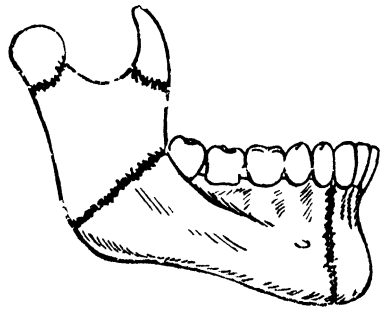


FIG 276.—LOWER JAW, INDICATING THE MOST COMMON SITES OF FRACTURE

The **Signs** of fracture are very evident if the lesion is situated anteriorly, but when behind the teeth, diagnosis may be much more difficult, apart from radiography The usual variety is almost always compound, owing to the firm attachment of the muco-periosteum to the alveolar border Laceration of the gums, the blood-stained saliva soon becoming fœtid, the irregularity in the line of the teeth, some of which have been knocked out or loosened, and the easily elicited crepitus, all constitute a typical picture There is often considerable pain, owing mainly to the tearing of the mucous membrane, but possibly due to implication of the inferior dental nerve The main trunk, however, generally escapes, owing to the position of the fracture in front of the mental foramen, whilst in those behind there is but little displacement Smart hæmorrhage sometimes occurs from laceration of the accompanying artery The posterior fragment is usually raised and displaced inwards, whilst the anterior portion is drawn outwards by the preponderating pull of the internal pterygoid In a bilateral fracture the loose central fragment is displaced downwards

by the causative blow, and held in that position by the muscles, whilst the posterior fragments are drawn upwards and outwards by the temporal and masseter muscles When situated *at the angle* or *in the vertical ramus*, there is such equal muscular support on the two sides that but little displacement results When the fracture passes *through the neck of the condyle*, that process is drawn forwards and inwards by the external pterygoid, whilst the body of the bone is freely movable antero-posteriorly and displaced towards the fractured side When the *coronoid process* is detached, it is dragged upwards by the temporal tendon, but no great displacement can occur, owing to the extensive attachment of the tendinous fibres

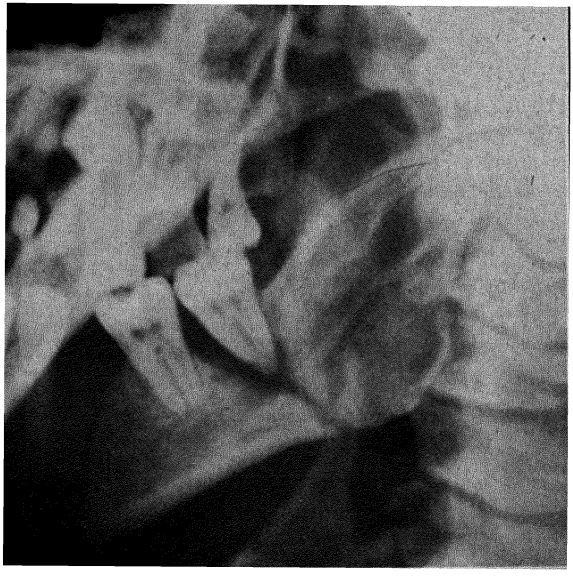


FIG 277.—FRACTURE OF MANDIBLE

Treatment.—Every effort must be made from the first to keep the mouth clean and free from infection by the frequent use of mild antiseptic lotions, especially before and after food The co-operation of a dentist is always essential Teeth that are merely loosened in their sockets may often be left, and will become refixed, but teeth that are quite loose, and all septic roots, should be removed, as also those sound teeth which obviously encroach on the line of fracture The lesion is practically always septic, and the laying open of the deeper parts of the alveolus of any tooth involves it in the septic process, and converts it into a septic foreign body which necessarily must be removed By this practice it is possible that a few teeth which might be saved will be sacrificed, but it is also certain that a great gain in

cleanliness will more than compensate for this by increased rapidity of repair, and decreased likelihood of necrosis and other septic dangers

The occurrence of serious septic osteitis is indicated by increasing pain and discharge, with inflammatory swelling below and outside the jaw, if need be, external incisions must be made to drain abscesses Necrosed fragments of the bone ends are absorbed after a time or are separated as sequestra, and during the interval unremitting care as to cleansing the mouth must be maintained

1 As a temporary measure, and indeed as a permanent appliance in simple cases without displacement of the fragments, a 'barrel bandage should be applied This form of bandage is far superior to the four-tail bandage so often advised in first-aid books About six feet of a two-inch bandage is required The middle of the bandage is



FIG 278 —FIRST KNOT OF BARREL BANDAGE

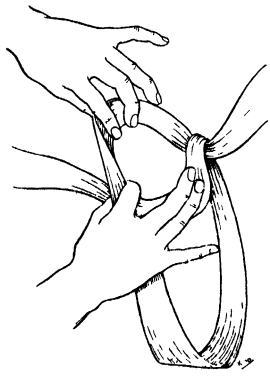


FIG 279 —OPENING OUT THE KNOT



FIG 280 —THE FINISH OF THE BANDAGE

placed under the jaw (Fig 278) and a simple knot is tied over the vertex of the skull The knot is then opened so that the front loop comes in front of the forehead and the back portion under the occiput (Fig 279) The two ends of the bandage are then taken and upward tension is exerted, and by a slight adjustment the two running hitches are made to occupy a position slightly above and in front of the ear (Fig 280) The two ends are then tied in a reef knot on the top of the head This barrel bandage was first described and used by Sir Harold Gillies and Kelsey Fry in the treatment of war fractures of the lower jaw, and it is now universally used

2 In all cases where displacement of fragments is present, treatment must be undertaken in collaboration with a skilled dentist. Several different types of appliance to fix the fragments and steady the jaw are available

The best appliance is *Gunning's interdental splint*, made of non-corrosive metal fitted over the crowns of all the teeth that are left of the lower jaw, only a bar or narrow bridge being present at the site of the fracture, this when fixed in position holds the fragments steadily It is subsequently united to a similar splint fitted to the upper jaw, thereby securing complete rest to the mandible The mouth remains a little open, and a gap between the two splints in the middle line or corresponding to the fracture provides for feeding and irrigation In the absence of sepsis union takes place readily in about five or six weeks

A modification of this plan is available for cases where the jaw is edentulous or has no teeth suitable for fixation purposes A vulcanite splint should then be provided, fitting over both alveolar ridges in the same way as an ordinary plate, and taking support from any teeth in the maxilla that may happen to be present It is held in position

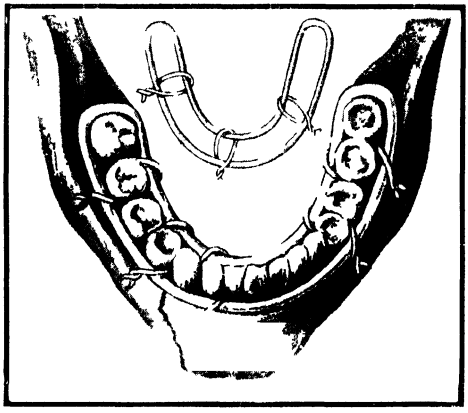


FIG 281 —HAMMOND'S SPLINT FOR FRACTURE OF LOWER JAW

by a four-tailed bandage, and is removable for cleansing purposes Though an ideal result cannot be expected from such treatment, yet it will limit displacement and give comfort Perhaps at a later date, when the parts are clean, it may be possible to fix the fragments by a metal or bone plate applied on the lower border of the bone through an external incision

A less satisfactory method of treatment, but one that will suffice in many of the simpler cases, is the **Hammond wire splint** It consists of a stout wire collar or framework (Fig 281), which encircles the whole series of teeth It is accurately fitted by a dentist, firstly to a plaster cast, subsequently to the jaw itself, and is fixed by passing wires from one half to the other between the teeth

The presence of a second fracture makes fixation much more difficult, but emphasizes the necessity for the assistance of a dentist, who alone can fit the intrabuccal splint necessary in such a case

Slight loss of substance of the maxilla makes no difference in the

principles of treatment Every effort is made to clean the parts, and the fragments are brought into the best apposition possible by the interdental splint, and there allowed to unite, even if one half of the jaw is thereby displaced to one side for a time

Gross loss of substance, such as has frequently occurred after gunshot wounds, can be made good by grafting, and the skill which has restored some of the unfortunate victims of these wounds to something like respectable appearance has been most remarkable and gratifying

Ununited fractures of the mandible are not very uncommon The patient must wait until all sepsis has disappeared and the wound in the mouth is healed, and then external operation holds out a good chance of repair The fracture may be wired, plated, or fixed by a bone graft

Fracture of the Hyoid Bone is uncommon, arising usually from direct violence such as a forcible grasp or the constriction of the neck in hanging Either the body may be broken, or one of the cornua separated The symptoms produced are Pain on attempting to move the tongue, jaw, or neck, a husky voice, and deformity, which can sometimes be detected from without Occasionally the mucous membrane is perforated, and bleeding into the pharynx may occur, whilst œdema of the glottis may supervene The fragments should be approximated as well as possible by manipulation between one finger in the mouth and the hand outside, and the neck then fixed by a porô-plastic collar

Fracture of the Ribs may arise in two distinct ways (1) By *direct violence*, as by blows or stabs, the fragments being driven inwards, and damage to the underlying pleura, lungs, liver, or diaphragm being very likely to occur Compound fractures due to penetrating wounds are not very common apart from military surgery, they are serious accidents as introducing the septic element, and possibly determining pulmonary collapse (2) Much more frequently they are caused by *indirect violence*, as when the chest is compressed between a cart-wheel and the ground, or between a wall and the back of a waggon The ends of the ribs are then approximated beyond the limits of natural elasticity, and they give way at the most convex part, *i e* near the angle The viscera may be contused, but less often than in the former class, although hæmothorax from rupture of the parietal pleura is not uncommon As a rule more than one rib is broken, but the displacement is rarely marked, except in cases due to direct violence, where several ribs have been 'staved in' The fifth to the eighth ribs are those usually injured, being more prominent and fixed at both ends, the first and second ribs are so well protected by the clavicle as to be seldom broken by direct injury, although great violence from above downwards to the outer end of the clavicle may lead to such an accident, the lower ribs often escape on account of their greater mobility Elderly women and persons suffering from various mental diseases, such as general paralysis, are specially prone to this fracture

The **Symptoms** are tolerably obvious, *viz* a sensation of something snapping or giving way, a sharp localized catching pain at the site of

the injury, increased on deep breathing and coughing, and possibly some local extravasation and swelling Pain is elicited by a local examination, and also by conjoined pressure upon the sternum and spinal column, whilst the fracture may be evident on palpation, or crepitus detected when the patient coughs or on auscultation When several ribs are driven in, a marked depression results, but if a single bone is broken in a fat individual, the diagnosis may be extremely obscure The clinical history and treatment of the pulmonary or pleural complications, as also of penetrating wounds, associated with compound fractures, are discussed elsewhere

Treatment —The affected side should be firmly strapped with broad strips of adhesive plaster, so as to limit its movements The strips, 1½ to 2 inches wide, should extend beyond the middle line, both front and back, and are applied from below upwards, whilst the chest is in a state of forcible expiration, each strip overlapping the preceding one and crossing the direction of the ribs (Fig 282) A firm woollen bandage should then be applied over all If the ends of the bone are driven inwards, strapping can rarely be borne, as it tends still further to irritate or compress the lung Under such circumstances all constriction of the chest must be avoided, the patient being confined to bed with a sandbag between the shoulders, and the arm bound to the side When the lower ribs are broken, tight applications are generally contra-indicated, since the diaphragm is likely to be irritated, and troublesome hiccough may result Ribs unite readily, but with a considerable amount of callus, owing to the mobility of the fragments

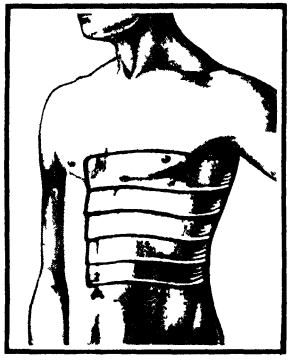


FIG 282 —METHOD OF STRAPPING BROKEN RIBS

Separation of a Costal Cartilage sometimes occurs, giving rise to similar symptoms and requiring the same treatment as a broken rib Occasionally the cartilage itself may be fractured In each case the resulting bond of union is osseous

Fracture of the Sternum is almost always due to direct violence, but is occasionally caused by forcible flexion of the body, and is then generally associated with fracture of the spine The line of fracture is usually transverse, the bone giving way either between the manubrium and gladiolus or a little below this level The fragments may remain *in situ* or the upper portion be displaced backwards, the deformity in such cases being very evident, and great dyspnœa resulting As a late effect, aneurism of the arch of the aorta may occur **Treatment** —The patient should be kept in bed with a pillow between the shoulders, and the chest strapped as for fractured ribs If the patient cannot bear this portion, he should be allowed to sit up with the body leaning forwards Reposition can sometimes be effected by manipulation and extension, but the possible co-existence of a fractured spine must not be overlooked

Fractures of the Upper Extremity.

Fracture of the Clavicle.—No bone in the body, with the exception of the radius, is broken more frequently than the clavicle, this is due to its exposed position and its buttress-like action in keeping out the point of the shoulder, so that every shock to the arm is transmitted through it to the trunk Although sometimes broken by direct violence, fracture is usually due to force directed to the hand or shoulder, and hence is common in falls from horseback, and occurs frequently in jockeys, on the hunting-field, or amongst recruits in mounted corps It is more common in men than in women, and in children is often of a green-stick nature The bone may yield in four different situations, *viz*

1 **At the Sternal End,** an unusual occurrence, due to direct or indirect violence The displacement varies with the line of fracture, if transverse, it is slight, but if oblique—and this is most usual—the outer fragment is drawn downwards and forwards as in the next variety, though to a less degree

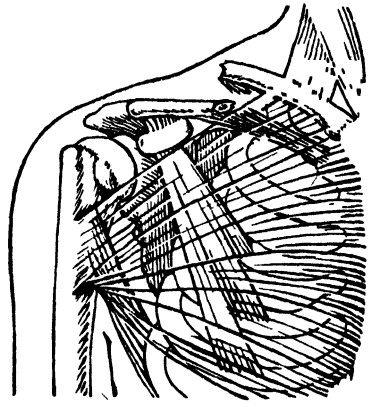


FIG 283.—FRACTURE OF CLAVICLE THROUGH GREATER CONVEXITY

2 **Through the Greater Convexity,** the commonest situation The bone yields about its centre, or a little external to it, and the line of fracture is slightly oblique, running from before backwards, downwards, and inwards The displacement is quite characteristic, and is present in any fracture situated between the rhomboid ligament on the inner side and the coraco-clavicular ligaments on the outer, being less marked, however, when the fracture is nearer the extremities than in the centre of this space The patient gives a history of injury and severe pain, and supports the elbow with the other hand, the head being bent over to the affected side to relax the muscles of the neck, the arm is powerless The point of the shoulder is less prominent than usual, being approximated to the middle line, and on a lower level than the other, whilst at the site of fracture the inner fragment projects This deformity is accounted for by a displacement of the whole outer fragment downwards, forwards, and inwards (Fig 283), the outer end being, however, more displaced than the inner This is mainly due to the weight of the arm acting upon the outer fragment when the buttress-like action of the bone is gone, muscular action has but little effect The position of the inner fragment is probably but little altered, since it is held in place by the rhomboid ligament, the apparent projection of its outer end is mainly due to the depression of the outer fragment

3 **Between the Coraco-clavicular Ligaments,** usually arising from

direct violence, and with but little displacement, owing to the tension of the ligaments and to the fact that the periosteum is not torn across The signs of local trauma and crepitus are, however, present, though not very obvious

4 **At the Acromial End,** external to the trapezoid ligament, and, again, generally produced by direct violence The inner fragment retains its position unaltered, but the outer fragment is dragged down by the weight of the arm, and forwards by the action of the muscles, so that it sometimes lies at right angles to the rest of the bone

Complications arise most frequently in cases produced by direct violence The subclavian vein may be injured, or the brachial plexus, and even the dome of the pleura and the subjacent lung have been wounded Gangrene of the arm has been caused by obstruction to the vessels Great violence has resulted in fracture of the first rib Excess of callus in repair not unfrequently leads to nerve pressure, which for its relief may require operation

Treatment.—Where there is little or no displacement, all that is needed is to immobilize the arm in a sling and to keep the patient quiet In a green-stick fracture, the deformity can be remedied by manipulation, and the arm bandaged to the side

In fractures with displacement the deformity is as a rule easily remedied by drawing the points of the shoulder upwards and backwards, a knee between the scapulæ being used for counter-pressure and steadying of the patient All that is required subsequently is to maintain this position for a time

As an emergency measure the *three-handkerchief plan* can be employed Two large handkerchiefs, folded double and rolled into bands, are placed vertically, one over each shoulder, and under each axilla, each is lightly knotted behind, and the ends firmly tied to the opposite handkerchief across the middle line By this means the point of the shoulder is kept outwards and backwards The third handkerchief is used as a sling, the elbow being kept forwards and the hand placed over the sound clavicle

The simplest method of fixing the fracture in a young patient who is not too fat is by the use of a broad strip of *strapping* over the site of fracture so as to grip both fragments If the right clavicle is broken, one end of the strapping is applied to the left side of the umbilicus and carried up over the chest wall to the clavicle, and thence over the shoulder and down the back to end on the left side of the body below the scapula A folded pad of strapping several layers thick, and with the adhesive side out, may be moulded over the site of the fracture with advantage before the main strip is applied. Fixation thus being effected, the arm is supported in a sling for ten days or so, and then massage and movements of the shoulder are commenced Some slight deformity may occur, but that is not of great importance, granting that the mobility of the arm is early restored At Newmarket, where this plan has been largely used for jockeys, the patients are allowed to ride in about a fortnight

In ladies, where even the slightest deformity is undesirable, it is better to confine them to bed for three weeks, the head is kept low

without a pillow, and a sandbag placed between the scapulæ, the arm being bandaged to the side

In children, one of the best plans of treatment is that suggested by Hey Groves A straight splint is placed horizontally behind the shoulders, and a figure-of-8 bandage round the shoulders and splint, and crossing in front, draws the shoulders back and remedies the displacement This is kept in position for three or four weeks, and necessitates the child lying on its back at night (Fig 284)

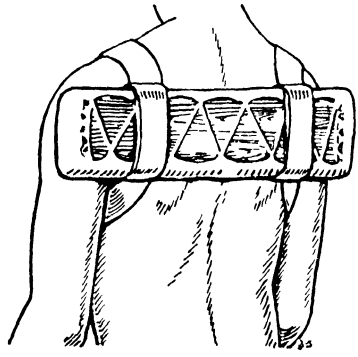
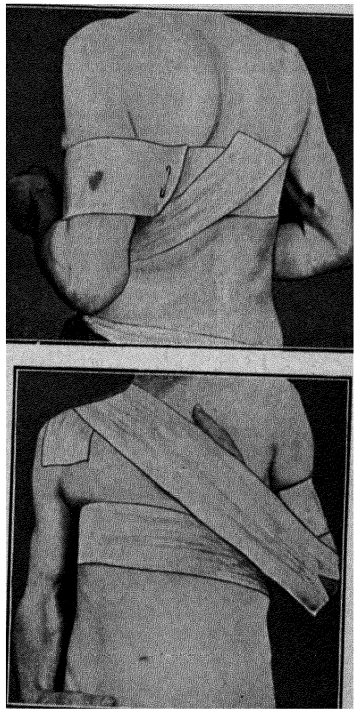


FIG 284.—HEY GROVES METHOD OF TREATING A FRACTURED CLAVICLE

Less satisfactory is the old-fashioned **Sayre's Method** A long strip of adhesive plaster, 3½ inches wide or less, is passed round the arm a little below the axilla as a loop, with the sticky side out, and then around the body with the adhesive side inwards, the arm being drawn well back, and the loop and end secured by stitches (Fig 285) If this has been applied firmly, it may now be used as a fulcrum, so that as the elbow is drawn forwards the point of the shoulder is directed backwards and outwards, and thus the main deformity is overcome Another strip of a similar width is applied over the elbow (a small hole being cut to receive the point of the olecranon), and by this means the elbow is raised and drawn forwards (Fig 286), so that the hand can be placed on the opposite shoulder, and the desired position is thus maintained Probably more than one strip of plaster will be needed in order to secure the arm, whilst an additional bandage is also useful There is no need to maintain this position for more than ten to fourteen days, as massage and movements must then be employed to prevent stiffness, in the intervals of exercises or at night the arm may be bound to the side to avoid accidents, but daily movements must be practised



FIGS 285 AND 286.—SAYRE'S METHOD OF STRAPPING FOR FRACTURED CLAVICLE

Ununited fractures are uncommon, but they occur and may require fixation by operation Vicious union is not rare, but seldom needs treatment

Fractures of the Scapula —1 The **Acromion Process** may be broken by direct violence applied to the point of the shoulder The arm hangs powerless, supported by the other hand, and the shoulder is flattened The irregularity of the bone can be readily detected, and crepitus can be elicited by raising the elbow and rotating the arm Occasionally the tip alone is detached, and then the above signs will not be present **Treatment** consists in raising the elbow, and bandaging the arm to the side

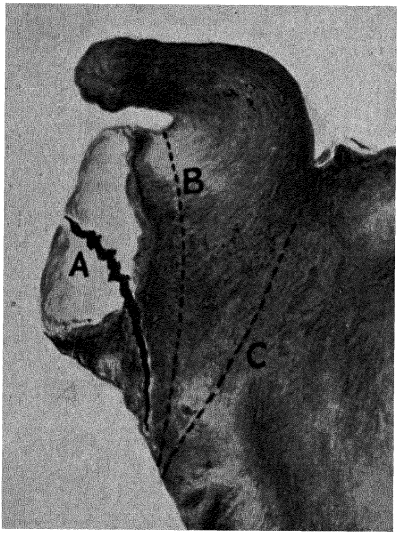


FIG 287 —FRACTURES OF THE NECK OF THE SCAPULA

A Through the glenoid fossa, B, through the anatomical neck, C, through the surgical neck

2 The **Coracoid Process** is rarely fractured, and then only by direct violence There is but little displacement, on account of the powerful ligaments attached to it, and no treatment is needed except to raise the elbow by a sling and keep the arm to the side

3 The **Body** of the scapula is broken as a result of considerable direct violence, which is often primarily received by the spine There is but little displacement when the fracture is comminuted or transverse just below the spine A longitudinal fracture may, however, result in the inner or vertebral fragment being drawn upwards and outwards in front of the axillary portion by the serratus magnus and levator anguli scapulæ The diagnosis is sometimes difficult owing to the presence of a large hæmatoma, but can usually be made by detecting crepitus on grasping the bone firmly, and moving one fragment on the other, or by radiography **Treatment** consists in bandaging the arm to the side, and possibly applying strapping to support the fragments

4 Fracture of the **Neck** is usually due to great violence directed to the shoulder, but is uncommon A portion of the articular surface is broken off and displaced downwards in some few cases of dislocated shoulder (Fig 287, A), or the fracture has been known to run through the anatomical neck (Fig 287, B), either condition causing some flattening of the shoulder, slight lengthening of the arm, and displacement downwards of the head of the humerus, so that the appearance

somewhat resembles that of a dislocation **Treatment.**—The arm must be kept to the side and raised

More commonly, however, the fracture involves the **Surgical Neck** (Fig 287, C), extending from the suprascapular notch above to just below the origin of the triceps muscle, so that the detached fragment includes the coracoid process Flattening of the shoulder results, with prominence of the acromion, lengthening of the arm as measured from the acromion to the external condyle, and crepitus on raising and rotating the limb **Treatment.**—The bone is replaced by pressure in the axilla, if necessary under chloroform, and fixed by an axillary pad or a ∩-shaped leather splint, whilst the arm is kept to the side

Fractures of the Upper End of the Humerus—1 **Of the Anatomical Neck.**—They should be differentiated into those associated with adduction of the lower fragment and those, much less common, accompanied by abduction They are usually due to blows or falls on the shoulder, less commonly to indirect violence, and occur more often in elderly people than in the young The shoulder becomes greatly swollen from effusion of blood, pain on movement is severe, but crepitus may perhaps be felt on rotating the arm, there is usually about half an inch of shortening In most cases the upper fragment is not totally detached, but remains connected with the rest of the bone by a few shreds of capsule, and thus necrosis is prevented, it is sometimes impacted into the lower fragment, and marked deformity of the head of the bone results, which can be detected occasionally by palpation from the axilla If it is completely detached, the small upper fragment is often rotated on its own axis, and even dislocated into the axilla Distinction between these fractures and a dislocation of the shoulder-joint is sometimes difficult, especially where bruising and swelling obscure normal landmarks X-ray will of course confirm the diagnosis one way or the other, and the shortening of the arm when measurement is taken from the acromion process to the olecranon, the presence of the head in the normal position, and the absence of any depression just below the acromion process should serve as diagnostic points

Treatment.—It has been customary in the past to treat these fractures by binding the limb to the chest wall and supporting the arm in a sling Early massage about the fourth or fifth day is commenced and passive movements instituted a few days later Active movements are encouraged from about the tenth day, and union is completed after some six weeks These cases, however, are always accompanied by a certain amount of subsequent arthritis in the joint, and in addition movements are never full, especially as regards abduction The reason for this is obvious in that all essential factors for obtaining a good result in the treatment of a fracture—namely, good reduction of displacement and the maintenance of that reduction—have not been employed The small upper fragment is externally rotated and abducted, and on account of its smallness it cannot be manipulated into alinement with the lower fragment, so that the latter must be brought into apposition with the former If the arm is abducted, rotated externally 90°, and brought forward slightly in front of the frontal

plane, efficient reduction by traction will enable good position to be obtained

Abduction splints are not used as often as they should be, on account of the reported difficulty in maintaining them in position But if they are well padded, and if, after the straps have been tied, some over the opposite shoulder and a second round the chest, fixation is further maintained by turns of plaster-of-Paris bandage, few patients complain of any discomfort and most remark on the complete absence of pain

In the case of adduction fracture, *i e* those in which the lower fragment is adducted towards the chest wall, traction to reduce any overlap displacement is exerted after the arm is abducted, but where abduction exists traction is better applied before the arm is raised In some cases it will be necessary to exert continuous traction, and this may be done by applying zinc oxide strapping to the inner and outer aspects of the arm, fixing the ends of the strapping to a spreader and attaching this to the outer end of the splint by means of a length of cord Movements of the wrist and fingers are instituted from the commencement, and after about four days the elbow-joint is moved daily, the forearm being supported throughout so that no displacement of the fractured surfaces shall occur After about three weeks the traction can be removed and movements of the shoulder commenced gently Not until the patient is able to raise the arm actively to about 140° is the abduction splint removed

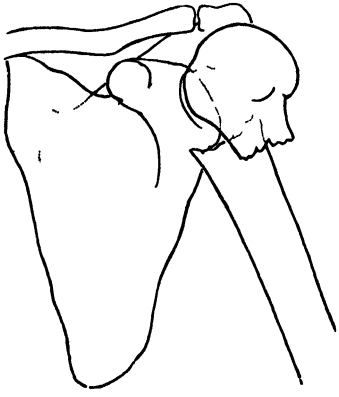


FIG 288 —FRACTURE OF SURGICAL NECK OF HUMERUS, SHOWING THAT THE UPPER FRAGMENT CONTAINS BOTH TUBEROSITIES

A word should be said about anæsthesia in these patients Although in this country local anæsthesia is not popular, it will be found that the application of an abduction splint is rendered far easier with a conscious patient, and in view of this we recommend the employment of local anæsthesia Injection into the site of the fracture of some 20 c.c of 2 per cent novocain gives absolute relief from pain and therefore adequate relaxation

This method of treatment by abduction is unsuitable in very fat patients or in those who are subject to bronchitis or other chest trouble, and in these the older method should be employed

2 **Fractures through the Surgical Neck.**—The bone yields in this case below the muscles attached to the tuberosities, but above or through the insertions into the bicipital groove and its margins of the latissimus dorsi, pectoralis major, and teres major The displacement of the upper fragment varies somewhat, and is often not very great, but in other cases it is abducted considerably The lower fragment is drawn inwards by the muscles attached to the bicipital

groove, and upwards by the deltoid, coraco-brachialis, biceps, and triceps (Fig 288) The appearance of the patient is sufficiently characteristic, the head of the bone is still in the glenoid cavity, so that there is no loss of the fulness of the shoulder (Fig 289), although there is a depression just below unless it is obliterated by the extensive hæmorrhagic effusion

Treatment—These fractures should be treated in an abduction splint (*vide supra*)

Should the fracture be very oblique and the upper end of the lower fragment project much upwards and inwards, reduction may be very difficult and the pressure on nerves and vessels severe In such cases open operation is often desirable An incision is made along the anterior border of the deltoid, which is separated from the great pectoral, and thereby the anterior surface of the bone is exposed.

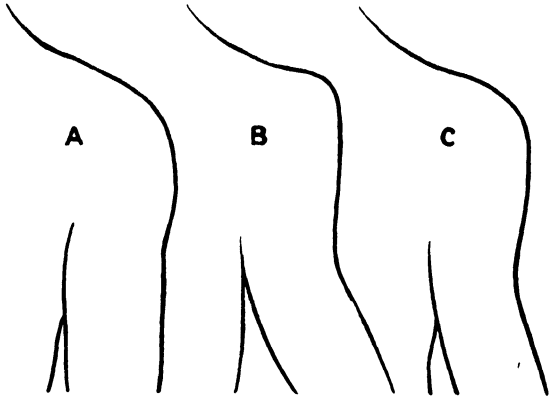


FIG 289—OUTLINES OF SHOULDER

A, Normal shoulder, B, dislocation of the shoulder, C, fracture of surgical neck of humerus

This will often suffice to enable the ends of the fragments to be freed and brought into apposition, fixation being secured by wire, bone-peg, or a suitably curved narrow plate If more exposure is needed, the incision is carried upwards and outwards, so as to enable the anterior portion of the deltoid to be divided about one inch below the acromion process and turned downwards and backwards, thereby bringing into view the outer aspect of the head The muscle is subsequently sutured carefully, and its function is not thereby impaired

3 Where the *Greater Tuberosity* has been torn off either by muscular action, by direct trauma or in association with dislocation of the head of the humerus, or with fracture through its upper part, apposition can be effected non-operatively only by using an abduction splint in the manner indicated above

4 **Separation of the Upper Epiphysis** occurs up to the age of eighteen to twenty years, and involves the head and both the tuberosities (see

Fig 294) The upper end of the shaft is somewhat conical in shape, the apex of the cone fitting into a depression in the middle of the epiphysis (Fig 290) The lesion usually follows the line of the cartilage, but the displacement is often incomplete, partly from the conical projection hitching against the inner edge of the epiphysis (a doubtful occurrence), but mainly from the persistence of a well-marked periosteal sleeve or bridge on the outer and posterior side The shaft usually travels forwards, its upper end projecting so as to be felt or even seen beneath the skin an inch or more below the coracoid process, occasionally a well-marked inward displacement is superadded, so that the condition somewhat resembles a subcoracoid dislocation The presence of the head of the bone in the glenoid cavity should prevent this mistake, whilst the softness of the crepitus distinguishes it from a fracture

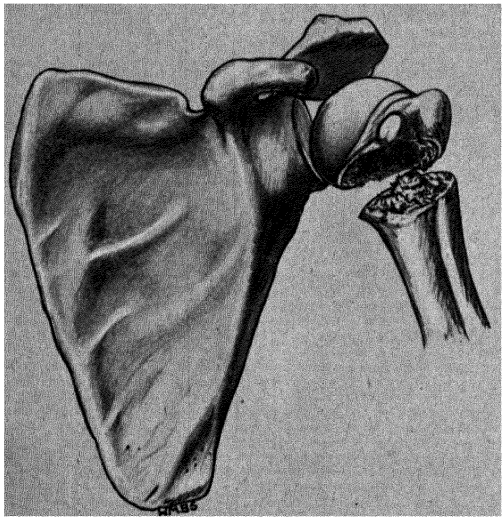


Fig 290 —Separation of the Upper Epiphysis of the Humerus

Treatment — It is most important to reduce this displacement, since otherwise interference with the growth of the limb is almost certain to ensue This may be effected by traction upon the arm under an anæsthetic, assisted perhaps by slight rotary movements or abduction, but should these manœuvres not be successful, operation should be undertaken to restore the parts to their correct position by enlarging the hole in the periosteal sleeve After reduction the limb is treated as for a fracture of the neck Should union occur in the displaced position, considerable limitation of movement results from the projecting edge of the diaphysis, this may be improved by cutting down and chiselling it away

5 **Fracture of the Upper End of the Humerus combined with Dislocation** of the head of the bone is not a very common accident The fracture is generally more or less oblique, and passes through the greater tuberosity or involves the surgical neck

It is produced by severe direct violence, as by a person pitching with great force on the shoulder The head of the bone is first forced into the axilla through a rent in the capsule, the tendons attached to the tuberosities being stretched or torn, and the fracture of the neck

follows Unless seen early, hæmorrhagic effusion makes diagnosis difficult and almost impossible, apart from stereoscopic radiography If unreduced, the displaced head of the bone may remain loose, or union may occur with much deformity, and the production of many adhesions, which may involve the vessels and nerves, and lead to serious after-trouble in the limb

Treatment.—Attempts should be made to reduce the dislocation, steady traction being exerted on the abducted arm by an assistant while pressure is made by the surgeon over the head of the humerus in an endeavour to force it back in position Often, however, the traction will be found insufficient, and in these cases resort to Bohler's traction apparatus will be found very valuable It consists essentially of an abduction splint with a long thumbscrew running through the transverse limb at its outer part This screw is fitted with a hook on that end of it which is within the splint A Steinman's pin or a Kirschner wire is passed through the olecranon process of the ulna, and after a suitable stirrup has been applied this is attached to the hook of the screw by cord As the screw is turned so will traction be exerted on the humerus, usually to such an extent that a sufficient gap between the upper end of the lower fragment and the glenoid fossa is produced to enable easy replacement of the dislocated head The after-treatment will be similar to that previously described Rarely open operation will be required, and the employment of the traction apparatus during reduction is of value

Fractures of the Shaft of the Humerus may arise from any form of violence, whether direct or indirect, and even from muscular violence, as, *e g*, in throwing a cricket-ball The signs of the injury are very obvious and most typical The displacement depends largely on the position of the fracture If it occurs *above* the insertion of the deltoid, but below or through that of the muscles inserted into or around the bicipital groove, the upper fragment is drawn inwards, and the lower upwards and outwards If, however, it is *below* the deltoid, the upper fragment is drawn outwards, and the lower upwards and inwards As the line of fracture approaches the elbow, the displacement tends to become more antero-posterior than lateral, owing to the change in shape of the bone The most common complication is injury to the musculo-spiral nerve which winds round the shaft, and even if unwounded at the time of the accident, it is liable to be involved in the callus

Treatment —Reduction of the deformity is usually effected without much difficulty by traction on the forearm with the elbow bent to a right angle, and manipulation In the simplest cases without displacement the arm is fixed to the chest wall, the most perfect means of immobilizing the limb In all cases the forearm should be kept in full supination and directed a little forwards at an angle of about 25 degrees to the plane of the anterior chest wall, thereby avoiding internal rotation of the lower fragment

In cases where the displacement is easily corrected and there is no great tendency to recurrence, the simplest method of fixation is by means of a plaster-of-Paris splint This is best applied in the form of

a plaster slab which extends from the acromion process, down the outer side of the arm, round the elbow, and up the inner side into the axilla It is held in place by a few turns of plaster bandage

Fixation must be maintained for four weeks or more, but from early days full movements of the wrist and fingers are allowed, and also of the radio-ulnar joints

When the fracture is oblique or comminuted, prolonged extension is often necessary in order to maintain the fragments in good position, and the patient must be put to bed if abduction is also required Weight extension over a pulley may be utilized, the fixative adhesive plaster taking its pull from the elbow to the fold of the axilla, short splints are applied to support the limb Perhaps more satisfactory

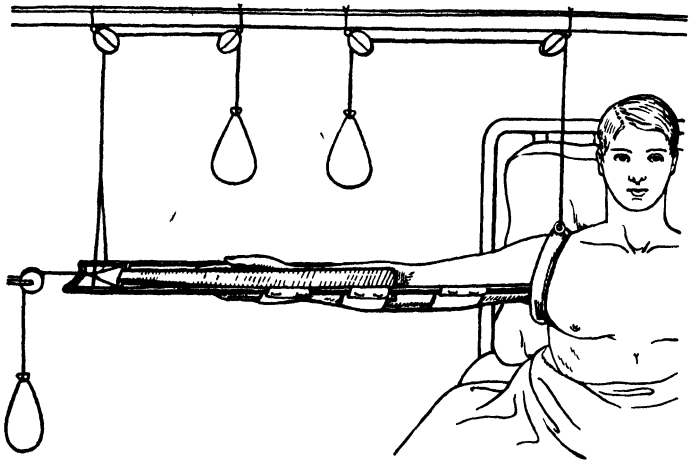


FIG 291 —THOMAS'S SPLINT APPLIED FOR FRACTURE OF HUMERUS REQUIRING EXTENSION, ABDUCTION, AND SUSPENSION

The hand is in full supination, and the ring of the splint kept in position by a counterpoising weight Extension is effected by a weight, the end of which is attached to the extension strapping or glued-on bandage, which reaches to the elbow Of course a complete trough is required, only three flannel bands are depicted here, and short splints and bandages are omitted

for this purpose is the short Thomas's splint, the well-padded ring of which takes its purchase from the axilla and chest wall (Fig 291) Extension is effected by fixation to the splint, or by traction with a weight, the forearm is placed in full supination The limb, of course, lies in a flannel trough, and if need be short arm splints are added to assist in correcting deformity The splint with the arm is slung from a suitable overhead support, or otherwise kept from contact with the bed Consolidation of the fracture, if closed, may be expected in three to five weeks One objection to the Thomas splint for fractures of the arm is that the elbow is liable to become stiff This can be prevented if at the end of seven to ten days passive movement of the elbow (including pronation and supination) is undertaken once a day,

the arm being, of course, firmly supported Another difficulty lies in the restoration of the carrying angle, which is liable to be lost unless the lower end of the humerus is drawn inwards slightly towards the inner bar of the splint

In cases where prolonged extension is necessary, but abduction is not required, one of the many flexed-arm splints now available should be employed Of these, Robert Jones's modification of Thomas's splint (Fig 292) is perhaps the best, the ends of the plaster extension straps are tied to the cross-pieces that project below the elbow, or may be connected with a spring or elastic tractor, and short lateral splints may be added The rules as to the position and movements of the forearm indicated above must also be followed

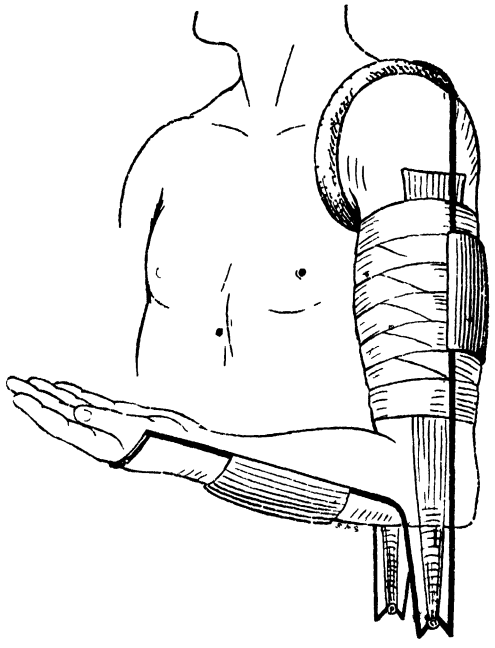


FIG 292 —FLEXED-ARM SPLINT (ROBERT JONES) APPLIED FOR FRACTURED HUMERUS REQUIRING EXTENSION WITH THE ELBOW FLEXED

Open fractures are treated on one of these two latter splints, perhaps for choice the Thomas, inasmuch as thereby easier approach can be secured to the wounds Where extensive sepsis is present, and the treatment may have to be prolonged, stiffness of the elbow is very apt to follow unless early mobilization is undertaken When the wounds are so placed as to hinder the application of strips of plaster, extension should be exerted through a pin or wire passed through the olecranon process of the ulna

Operation for the fixation of a fracture of the shaft of the humerus should not often be needed, and, of course, is undertaken only for closed fractures or for open ones where asepsis of the wound is assured The bone is best approached from the outer side of the biceps, between it and the deltoid, or triceps, the position of the musculo-spiral nerve must always be kept in mind Wiring is usually difficult, and plating is the best means to adopt

Ununited Fracture occurs not unfrequently in the humerus, and is probably due to the fact that the necessity for fixing and supporting the elbow-joint has not been appreciated, the forearm being allowed to hang loose on the false plea of tending to diminish the shortening

It also follows compound fractures where much bone has been removed or destroyed More perfect fixation and improvement of the general health may cure it, otherwise operative treatment may have to be undertaken

Fractures of the Lower End of the Humerus —1 **Transverse Supracondyloid Fracture,** involving the shaft about 1 or 2 inches above the joint, is due either to a fall on the hand with the arm bent, when the lower fragment is usually displaced backwards, or much less commonly to a fall on or violence directed to the point of the elbow, when the displacement is either forwards or backwards When the lower fragment is displaced backwards, it is also drawn up by the action of the triceps upon the olecranon, a certain amount of angular as well as vertical deformity being thus produced, when displaced forwards, apparent lengthening of the forearm results, with a loss of prominence

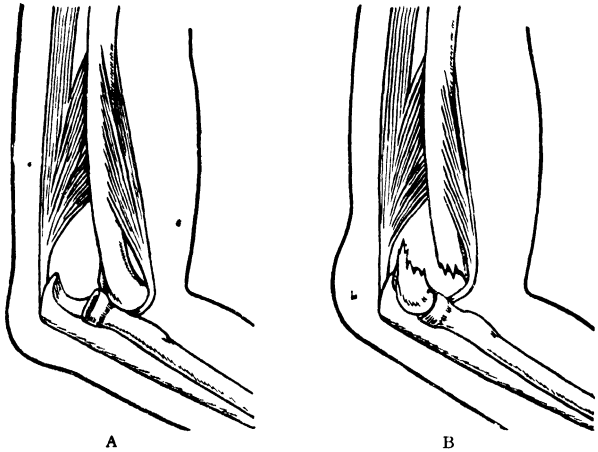


FIG 293 —FRACTURE OF LOWER END OF HUMERUS (B) COMPARED WITH DISLOCATION OF RADIUS AND ULNA BACKWARDS AT ELBOW (A)

of the olecranon The former of these conditions is likely to be mistaken for a dislocation of both bones backwards at the elbow (*cf* Fig 293, A and B), but may be recognized by the following facts (*a*) The relative position of the bony points at the elbow is unimpaired, in a dislocation they are necessarily disturbed (*b*) The length of the arm measured from the deltoid tubercle, which can be easily felt at the back of the acromion, to the outer condyle is diminished in a fracture, but remains unaltered in a dislocation. On the other hand, the length of the forearm, as measured from the external condyle to the styloid process of the radius, is shortened in a dislocation, but remains unaltered in a fracture (*c*) The forward projection of the lower end of the upper fragment is felt above the crease of the joint, whilst in a dislocation it corresponds with it (*d*) The deformity is easily reduced with crepitus, but readily reappears, in a dislocation the bones are replaced with difficulty, but after replacement they

usually remain in position Lateral deviation sometimes occurs, and the restoration of the normal 'carrying angle' must always be aimed at It may be difficult and at times almost impossible to recognize this condition at once, owing to the amount of swelling and ecchymosis present, and therefore a radiographic examination of all serious elbow injuries is essential Delay in order to permit of the reduction of the swelling is liable to be followed by serious consequences

Treatment.—Reduction is produced by flexing the forearm in the position of mid-pronation to a right angle and exerting traction on this while the displaced fracture is moulded into position. One of two methods is then advised for maintaining the reduction A plaster slab round the elbow and extending from the olecranon process to the axilla is applied as in fractures of the shaft of the humerus, and is maintained in position by a few turns of bandage A further slab, while extension is still being maintained by an assistant, is applied, extending on the outer side of the arm and forearm from the knuckles to the shoulder, it also being fixed by a few turns of bandage When the plaster has set, the arm is preferably supported in an abduction splint, but can be supported in a sling If there is any tendency for the deformity to recur, traction can be exerted by strapping applied to the plaster cast The plaster is kept on for some four to six weeks Although in this method there is immobilization of the elbow-joint for some considerable time, this is desirable, as if early movement is instituted ossification in the brachialis anticus muscle is very liable to occur

Alternatively the arm may be fixed by a figure-of-eight bandage extending between the arm and forearm in a sling in a position of flexion for a similar period of time. At the end of about four weeks the flexion is gradually reduced, and by six weeks the patient is allowed to discard the sling altogether The somewhat stiff elbow is gradually mobilized by physical treatment, and in addition the effect of gravity is to encourage complete extension

If in either of these methods there is more than a minimum of swelling in the fingers or wrist, *the plaster or bandage should at once be removed* in order to relieve any pressure caused by reactionary bleeding and œdema around the site of the fracture, and until this subsides reduction of the fracture cannot be repeated

In rare cases where reduction of the fracture is exceedingly difficult this may be effected by traction exerted through a wire or pin placed through the olecranon process the stirrup of which has been connected to Bohler's screw traction apparatus

2 **T- or Y-shaped Fractures** usually occur as a result of direct injury In a T-shaped fracture a longitudinal fissure extends into the joint through the centre of the lower fragment of a supracondyloid fracture, in a Y-shaped fracture the fissure starts at the articular line and bifurcates above so as to detach both condyles Sometimes the fragments are not completely detached, and then, although there is much bruising and pain, crepitus is not obtainable, at other times the condyles are separated completely and will move on each other with crepitus, the elbow being increased in breadth Displacement of the

forearm laterally (usually outwards) often accompanies this lesion Great swelling and ecchymosis are rapidly developed, and diagnosis apart from radiography is often difficult If there is no separation of the fragments, **treatment** as for the transverse supracondyloid fracture suffices, but when they are completely detached, attempts to replace the fragments are usually unsuccessful, and it may be wise to operate in order to remove the blood and enable the fragments to be manipulated into position and fixed there by screws, wires, plates, or bolts, but not unless complete asepsis is assured

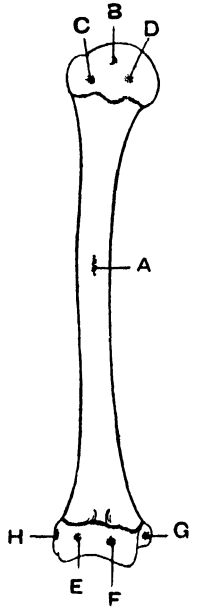


FIG 294 —CENTRES OF OSSIFICATION OF THE HUMERUS

A, Shaft appears at eighth week of intra-uterine life, B, centre for head in first year, C, centre for great tuberosity in third year, D, centre for lesser tuberosity in fifth year B, C, and D fuse in sixth year to form one epiphysis, which joins the shaft at twentieth year

E, Centre for capitellum in third year, F, centre for trochlear surface in eleventh year, G, centre for internal condyle in fifth year, H, centre for external condyle in twelfth year E, F, and H coalesce about the fourteenth year and join the shaft at the seventeenth year, G remains separate until the nineteenth year

3 Fracture of the **Condyles** (Fig 295) usually results from direct injury, though the outer is sometimes broken by indirect violence, such as a fall on the hand, since the laxity of the elbow-joint on this side allows considerable mobility between the radial head and the capitellum of the humerus Fracture of the **external condyle** (Fig 295, A) always involves the elbow-joint, and is more common than that

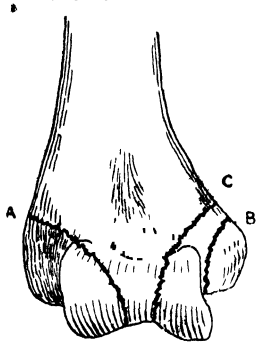


FIG 295 —FRACTURES OF CONDYLES OF HUMERUS

A, of external condyle
B, of internal epicondyle
C, of internal condyle

of the inner The line of fracture runs from the condyloid ridge downwards and inwards so as to separate the capitellum, or even to encroach upon the trochlear surface The fragment is rotated forwards, and can be felt to move independently with crepitus, which may also be produced by rotation of the hand and radius The acci-

dent is associated with much pain and ecchymosis Fracture of the **internal condyle** may be intra- or extra-capsular The *extra-articular* variety (Fig 295, B) consists of a mere displacement of the tip of the condyle (or epicondyle), and in young people is probably a separation of the epiphysis, which remains distinct from the shaft till the age of eighteen or nineteen years (Fig 294, G) The small fragment is drawn a little downwards by the muscles attached to it, and may be associated with injury of the ulnar nerve The *intra-articular* form (Fig 295, C) is the more common, and extends from the condyloid ridge to the trochlear surface, implicating the coronoid and olecranon fossæ The fragment is displaced a little upwards and backwards, the ulna usually accompanying it, so that on extending the elbow the olecranon appears unduly prominent, the lower end of the humerus projects anteriorly, and the forearm is slightly adducted (cubitus varus) The ulnar nerve may also be injured in this case

Treatment —Complete flexion of the elbow with traction downwards of the forearm in the direction of the axis of the limb will often enable the surgeon to manipulate the fragment into position If the arm is then fixed in front of the chest with the elbow fully flexed, and the hand pronated and resting under the chin, repair in good position may be obtained Movements follow along the lines indicated on p 585, too vigorous massage and passive movements are harmful rather than beneficial

A failure to secure complete reposition of the fragment will necessitate open operation, and its fixation by wire, bone-peg, or screw, but as already noted, this is undesirable in children

4 **Fractures in the Neighbourhood of the Lower Epiphysis of the Humerus** and involving its complete or partial separation are very common accidents in children At birth and for some years afterwards the epiphysis consists of a single mass of cartilage (Fig 294), including the two condyles as well as the articular surface, and these are all involved in any separation, together possibly with a fragment of the diaphysis

As, however, growth and ossification proceed, the shaft encroaches rapidly upon the inner portion of the epiphysis, so that the epiphyseal line becomes almost rectangular, the internal condyle being isolated from the rest of the epiphysis As a result, this type of injury after the age of six or seven is placed at a somewhat higher level, and scarcely ever encroaches on the epiphyseal line. It is usually transverse and runs through the olecranon fossa The displacement is generally backwards, often with some amount of lateral displacement or deviation **Treatment.**—Reduction can usually be accomplished by flexion with some amount of traction In young children, as in adults, it is best to avoid splints, and trust merely to keeping the limb in a state of full flexion, the hand being in pronation Where there is much swelling from hæmorrhage, it may not be possible to gain complete flexion at once, but as the swelling subsides it can be gradually increased In a few cases it may be desirable to make an incision through the periosteum on one or both sides of the bone, so as to allow the blood to escape and enable the lower fragment to be

manipulated into position, but no attempt should be made to fix it by nails, screws, or wire Flexion is maintained with the hand just below the chin for two or three weeks, or until all local tenderness has disappeared, and then the sling is relaxed so as to allow the hand to drop 3 inches, and the after-course is as for the transverse supracondyloid fractures Parents must, however, always be warned from the first that a perfect restoration of function cannot be guaranteed, as the fossæ at the lower end of the humerus are encroached on and are liable to be filled up with bone, and hence complete flexion or extension may be hindered Some amount of deformity also may persist, and growth subsequently may be defective or irregular, giving rise to cubitus varus or valgus

Fractures of the Ulna.—1 The **Olecranon** is frequently broken by direct violence, the patient falling on the bent elbow, but occasionally by muscular action The line of fracture usually runs through the base of the process at its attachment to the shaft, and is for the most part transverse Should the tendinous and periosteal coverings of the bone remain intact, there is but little separation, but if the fracture is complete, the detached fragment is drawn up by the triceps and tilted backwards, whilst the bones of the forearm are subluxated forwards. Great swelling in and around the joint comes on early, on examination, the detached fragment can be readily distinguished, and between it and the shaft a sulcus, which increases on flexing and diminishes on extending the forearm If the fragments are not brought accurately into apposition, fibrous union occurs, and although the new cicatricial tissue may stretch considerably, a useful elbow sometimes results, in some cases the fragment is drawn up and fixed to the humerus, and a false joint is developed below it If, however, the fragments are brought in contact, bony union follows, though even then some impairment of function may result from the formation of adhesions In all cases the ulnar nerve is exposed to injury, though it is rarely affected

Treatment.—An endeavour may be made to approximate the fragments manually and to maintain this reduction by a well-moulded slab secured with some turns of plaster bandage with the arm set at a right angle

If this fails or if the bony fragments are obviously too far separated, it is better to cut down on the affected region, and, after cleaning out blood-clot and shreds of tendon, the fractured surfaces are brought together with lion forceps They are maintained in position by suture of the aponeurosis over the olecranon, or preferably by drilling two transverse holes, one through each portion of the bone, threading a piece of silver wire, kangaroo tendon, or even ordinary catgut through these holes and tying, thus approximating the broken surfaces

The limb is then put up in plaster in a position of mid-pronation with the elbow bent to a right angle for three weeks

2 The **Coronoid Process** is so deeply placed and so well protected that fractures must necessarily be very uncommon, except as an accompaniment of dislocation of the ulna backwards The signs relied on in making a diagnosis are that reduction of the dislocation is easier

than usual and associated with crepitus, and that the deformity is likely to recur The **Treatment** consists in apposing the bony surfaces, if possible, by complete flexion of the forearm

3 The **Shaft of the Ulna** is often fractured by itself as a result of direct violence, to which its exposed position renders it peculiarly liable Fracture also occurs as a complication of several of the forms of dislocation of the radius alone The superficial position of the posterior border renders examination of the bone easy, if displacement or a breach of substance occurs, it is readily detected, but when merely a fissure exists, it is not so easy to make out The constant pain referred to one spot, the slight mobility, and possibly crepitus, indicate the character of the lesion No longitudinal displacement can occur if the radius remains intact, and under such circumstances the only deformity consists in a slight drawing forwards of the upper fragment by the brachialis anticus, whilst the lower fragment is approximated to the radius by the pronator quadratus **Treatment.**—The arm is placed midway between pronation and supination, the deformity corrected, and the limb kept at rest between anterior and posterior splints, or in plaster of Paris

4 The **Styloid Process** may be detached by direct violence, or as a complication of fracture of the lower end of the radius The displacement may be considerable and very evident, being governed by the direction of the violence **Treatment** consists in replacing the fragment by manipulation, and applying a plaster cast extending from the knuckles to the elbow for three weeks

Fractures of the Radius.—1 The **Head of the Radius** may be broken alone, but this accident is often associated with other injuries to the elbow, as, for instance, fracture of the outer condyle or some form of dislocation The line of fracture may be transverse or vertical, or comminution may occur, the displacement is slight if the orbicular ligament remains intact In complete separation the head is immovable, and crepitus is produced when the arm is rotated, bony union usually follows, with more or less impairment of function, but sometimes the head, or a portion of it, remains detached as a loose body, in the latter case the small fragment may get between the articular ends from time to time and lock the joint **Treatment.**—If there is little displacement, or if manipulation results in a good reposition of the fragments, the arm is placed in a plaster cast extending from the knuckles to half-way up the humerus with the forearm in a position of supination for four weeks

2 The **Neck,** *i e* the portion between the orbicular ligament and the biceps tuberosity, is occasionally broken The lower fragment is drawn upwards and forwards by the biceps, causing a bony projection on the front of the elbow, especially evident on attempting to flex the joint, whilst the forearm is pronated with loss of the power of rotation, and the head of the bone does not accompany the shaft on rotating it passively **Treatment.**—This is similar to the treatment outlined for fractures of the head

3 The **Shaft** of the radius is not unfrequently broken by direct violence or more rarely by falls on the palm, the latter accident,

however, rarely causes fracture except at the lower end Many types of *chauffeur's fracture* of this bone have been described, but most often it involves the lower end of the radius, about 2 to 3 inches above the wrist, and results from a jerk backwards of the starting handle of the car due to premature ignition Well-marked anterior displacement is usually present

There is usually little difficulty in diagnosing a fractured radius, the chief signs are localized pain and loss of power of active rotation, whilst passive rotary movements are accompanied by crepitus, the head of the bone and upper fragment remaining immobile below the outer condyle, unless impaction is present The *displacement* is somewhat characteristic If the fracture is situated *above the insertion of the pronator teres*, the upper fragment is flexed and fully supinated by the action of the biceps and supinator brevis, whilst the lower fragment is drawn towards the ulna and fully pronated by the unopposed action of the two pronator muscles

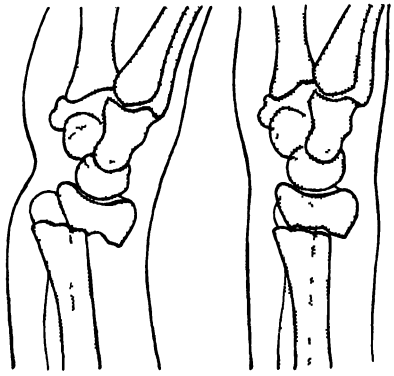
When the fracture is placed *below the insertion of the pronator teres*, the upper fragment is drawn forwards by the action of the biceps, and inwards by the pronator, assuming a position midway between pronation and supination, the lower fragment may be slightly approximated to the ulna by the direct action of the pronator quadratus, the hand is fully pronated looking downwards Union to the ulna by callus thrown across the interosseous space has been known to occur

Treatment.—In those fractures situated above the insertion of the pronator radii teres muscle, the limb must be reduced and set up after reduction in a position of full supination If this is not carried out, perfect apposition of the bony ends cannot be obtained If the arm is pronated, the pronators of the lower fragment relative to that of the upper is much greater, the tendons of abductor pollicis longus and the extensor pollicis brevis are drawn taut and tend to squeeze the lower fragment towards the mid-line

In fractures situated below the insertion of this muscle, however, the limb should be put up in a mid-position Reduction can usually be effected by traction exerted on the forearm by an assistant pulling on the fingers and the thumb, while counter-traction is maintained either by a second assistant grasping the upper arm or by passing it through a fixed webbed band, the surgeon manipulating the bony ends into position A plaster slab is then applied to the extensor surface of the limb extending from the knuckles to half-way up the arm, this is maintained in position by several turns of plaster bandage The plaster is kept on for a period of five to six weeks Occasionally, in spite of easy reduction, owing to the tearing of the ligaments of the inferior radio-ulnar joint, as soon as the traction has been removed the displacement recurs In these cases one of two procedures may be employed An open operation may be advised with fixation of the fragments by a bone peg or a Lane's plate, or Bohler's method may be employed This consists in passing a wire or pin, one through the olecranon process and another through the lower end of the radius and ulna. The fracture is then reduced in the usual way and the

plaster applied to incorporate the projections of the wires When the plaster has set and the traction is released the fragments cannot slip, as they are maintained in position by the wires, the ends of which are embedded in the plaster

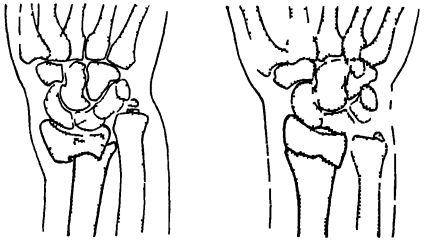
4 The **Lower End of the Radius** is broken with extreme frequency, constituting what is known as **Colles's Fracture.** This injury occurs most commonly in women of advanced years, although it may happen at any age or to either sex It is almost invariably due to falls upon the outstretched palm, when the hand is completely pronated and extended The line of fracture is placed about 1 inch from the wrist, though rather under than over this It is usually transverse from side to side, but is oblique in an antero-posterior direction, sloping from above downwards and forwards, so that the fracture is nearer the wrist-joint in front than it is behind (Figs 296 and 297)



(*a*) (*b*)

FIG 296 —TRACINGS FROM X-RAYS OF A COLLES'S FRACTURE

(*a*) Backward tilt of lower fragment, (*b*) tilt corrected, but slight backward displacement still remains a result compatible with reasonable function



(*a*) (*b*)

FIG 297 —COLLES'S FRACTURE, SHOWING (*a*) RADIAL DEVIATION AND IMPACTION, (*b*) AFTER REDUCTION

The *displacement* is somewhat complicated (*a*) The lower fragment is carried backwards and a little upwards, owing to the direction of the violence, *viz* a fall on the outstretched hand, the radius being compressed between the ground and the weight of the body, and yielding at what is evidently a weak spot, this deformity is maintained by the radial extensor muscles of the wrist, and often by impaction of the fragments (*b*) From the fact that the main violence is received on the thenar eminence, the outer side of the lower fragment is displaced more than the inner, which remains fixed to the ulna by the strong inferior radio-ulnar ligaments This position is in part kept up by the extensor of the thumb and the supinator longus, but mainly by impaction of the fragments (Figs 298 and 299) The hand and carpus always follow the lower fragments, and hence, the former is abducted, causing the styloid process of the ulna to become unduly

prominent, and lower than that of the radius, whereas it is normally placed on a slightly higher level In bad cases the styloid process of the ulna is actually torn off, or the internal lateral ligament ruptured, allowing displacement outwards of the whole hand (*c*) The



FIG 298 —COLLES'S FRACTURE LATERAL VIEW

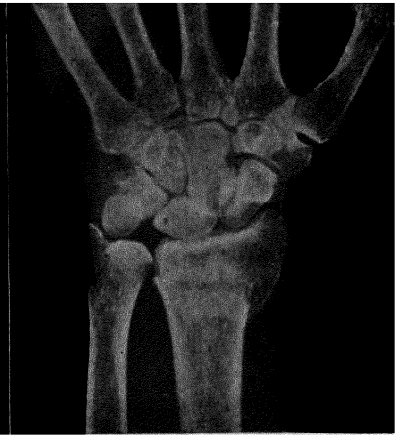


FIG 299 —COLLES'S FRACTURE POSTERO-ANTERIOR VIEW

The lower radial fragment is impacted and displaced outwards and backwards

lower fragment is also rotated around a transverse axis, so that the lower articular surface looks backwards as well as downwards, a displacement due to the fact that in falling the force is directed, through the carpus, more to the posterior than to the anterior aspect of the bone (*d*) The upper fragment is pronated and approximated to the ulna by the pronator quadratus muscle The *deformity* produced by the fracture is therefore very characteristic The hand is in a position of radial abduction, and usually pronated, with the fingers somewhat flexed (dinner-fork deformity) Three abnormal osseous projections are present (i) The styloid process or head of the ulna is very marked, owing to the radial abduction of the hand (Fig 301), (ii) on the back of the wrist is a prominence which terminates abruptly above, caused by the projection of the lower fragment (Fig 300), and (iii) corresponding to this dorsal projection there is a well-marked depression on the palmar surface, and above it a less sharply defined swelling, which gradually shelves into the forearm, due to the upper fragment Pronation and supination are lost, and, as a rule, there is neither



FIG 300 —COLLES'S FRACTURE LATERAL VIEW

crepitus nor preternatural mobility, owing to impaction of the fragments An important diagnostic point is the relative position of the two styloid processes, normally, that of the radius is below that of the ulna, but in cases of fracture it is on a level with or above it

The fracture is commonly impacted, the upper fragment being firmly driven into the cancellous tissue of the lower end, excess of violence may, however, disimpact, but often at the expense of comminution of the lower fragment Union is effected without difficulty, but the patient should always be warned at an early date that some deformity may persist about the wrist, as well as some impairment in the subsequent mobility of the fingers and hand, owing to adhesions in the joint or tendon sheaths

Treatment.—Early correction of the deformity is essential in every case Even in elderly subjects, correction should be undertaken Anæsthesia by nitrous oxide is usually sufficient, but should the general condition of the patient make the use of inhalation anæsthesia indvisable, local anæsthesia gives excellent results, and is preferred by many operators

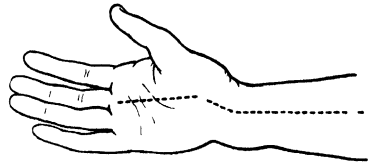


FIG 301 —COLLES'S FRACTURE PALMAR VIEW

The skin is cleansed and painted with iodine A fine needle is inserted at the level of the fracture one and from the outer side The piston is withdrawn and blood should flow into the syringe from the hæmatoma surrounding the fracture, 5 to 10 c c of 2 per cent novocaine solution are then injected slowly In the event of failure to withdraw blood, two or three separate injections must be made at different sites After ten minutes, complete anæsthesia and muscular relaxation should be obtained

Reduction is best effected by grasping the injured wrist between the two hands One thenar eminence rests against the palmar aspect of the lower fragment, the other against the dorsal aspect of the radial shaft, just above the fracture By firm pressure the deformity is increased by forcing the lower fragment backwards, thus disimpacting the fracture A slight 'wriggle' will aid the manœuvre

The position of the thenar eminence of the operator is now changed, that on the dorsal aspect making contact with the lower fragment, while that on the palmar side makes contact with the shaft Firm pressure now causes reduction of the deformity, and at the same time the patient's hand is carried into *adduction*

The manipulation may be summed up thus increase deformity to disimpact, reduce, ulna deviate 'A firm grip with slight traction and twist of the wrist completely reduces the deformity It requires knack rather than strength' (R Jones)

The completion of the reduction is recognized by the restoration of the normal concavity on the anterior surface of the lower end of the radius and by the relative positions of the two styloid processes The position of the fragments should always be checked by X-ray photographs taken in two planes after the splint has been applied

Splintage —A splint should always be applied, even where the initial fracture has been merely a ' crack ' with no deformity

Care should be taken in applying the splint that the deformity does

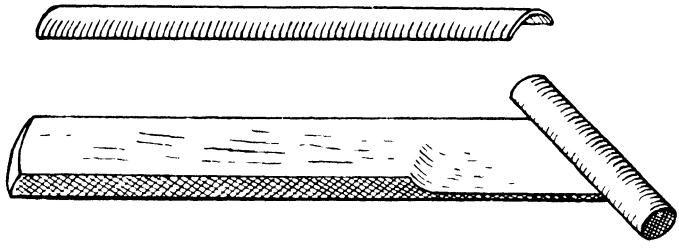


FIG 302 —CARR'S SPLINT FOR COLLES'S FRACTURE OF LEFT HAND

not recur, although in the majority of cases this will not happen with gentle handling

(1) *Carr's Splint* (Fig 302) may be used

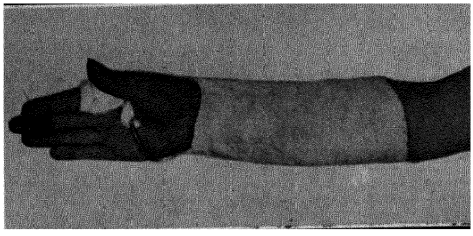


FIG 303 —PLASTER APPLIED TO COLLES S FRACTURE

Although supplied in two portions, it is only necessary to use the palmar half To this is attached an oblique rod, which may be grasped by the fingers, so maintaining the hand in a position of ulnar deviation The splint should be padded with thick felt and an extra pad placed at the wrist, so that this joint is maintained in slight palmar flexion The splint is fixed in position by two bands of adhesive strapping, one situated in the upper part of the forearm, the other crossing the dorsal aspect of the hand

(2) By far the most effective method of fixation is plaster of Paris A ' slab ' is made from eight layers of bandage and of a length to extend from below the elbow to the knuckles It is applied to the dorsal aspect of the forearm and hand, either direct to the skin or over a single layer of flannel, and bandaged into position with flannel bandage It must *not* be wide enough to encircle the limb completely A thin ' twist ' of plaster or a piece of stout wire is carried, between

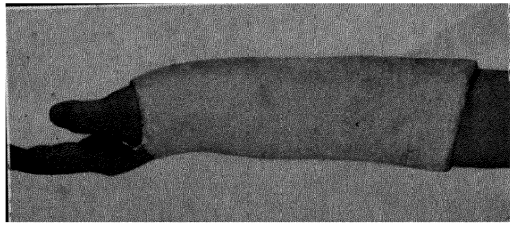


FIG 304 —PLASTER FOR COLLES S FRACTURE

the thumb and first finger, across the palm The hand is held in *slight* palmar flexion and ulnar deviation until the plaster has 'set' (Figs 303 and 304)

After-Treatment.—Active movements of the fingers, thumb, elbow and shoulder must be encouraged from the outset Union is seldom firm under *three weeks*, and should tenderness persist the splint should be retained for four or five weeks The use of a sling should be discouraged In younger people, no massage is necessary until the splint is removed, but in older patients it may be advisable to start gentle massage at the end of four or five days, in which case a Carr's splint, rather than plaster, should be employed

A fracture of the lower end of the radius, known as *Smith's fracture*, is occasionally met with, in which the displacement of the fragment is exactly the reverse to that seen in Colles's fracture, *viz* the lower end of the radial shaft projects posteriorly, whilst the lower fragment is displaced anteriorly **Treatment** is conducted as for a Colles's fracture

5 **Separation of the Lower Epiphysis** of the radius occurs in young people under twenty, and when it is displaced backwards simulates somewhat closely a Colles's fracture (see Fig 267) The lower end of the diaphysis projects anteriorly to a much greater extent, and, indeed, may protrude through the skin of the wrist, and then grave septic complications may supervene, leading to more or less extensive necrosis, indeed, the author has removed the whole shaft of the radius as a sequestrum due to acute osteomyelitis caused in this way The lower end of the ulna may be involved in the accident, either the epiphysis being separated or the shaft broken a little above This condition may be mistaken for a backward dislocation of the wrist, but a diagnosis can be readily made by observing the relative position of the styloid processes to the carpal bones Lateral displacement occurs in some cases **Treatment** is practically the same as for Colles's fracture

Should arrest of growth result, the hand retains its connection with the stunted radius, but the ulna continues to grow downwards, and its lower end projects on the inner and posterior aspect of the carpus, which is pushed *en bloc* towards the radial side, but without any marked abduction (Madelung's deformity)

Fracture of both Bones of the Forearm may result from direct violence or falls on the palm Any part of the bones may yield, but the middle and lower thirds are most frequently affected When due to direct violence, both bones may be broken at the same level, but if due to a fall on the palm, the ulna usually gives way at a higher level than the radius The line of fracture may be transverse or oblique, and the displacement varies both with this and with the force employed The upper fragments are usually drawn together and pronated, whilst the lower end of the radius is drawn up by the supinator longus In young people a not uncommon result of falls in the football field or at the skating-rink is a complete fracture of the lower third of the radius, and a green-stick fracture of the ulna (Fig. 266). The upper fragment of the radius is displaced forwards in front of

the pronator quadratus, which prevents its replacement even by traction under an anæsthetic The diagnosis is usually simple, since there is, as a rule, obvious deformity

Treatment—It is most important in this fracture to restore the bones completely to their correct alinement, since failure to do so almost always involves serious impairment of function, both as regards rotation and the movements of the fingers In a few cases cross-union follows, but this is not common when reasonable precautions have been taken Under general or local anæsthesia traction is exerted in the manner described above, the forearm being either supinated or pronated according to the position of the radius in relation to the pronated radii teres The surgeon manipulates the fractured ends into alinement and then applies a plaster slab extending from the knuckles to well up the arm proximal to the elbow, this is then covered by a plaster bandage, the whole being carefully moulded to support the bones at the site of the fractures The plaster should remain on for at least six weeks If on relaxing extension there is a recurrence of the displacement, one of two procedures may be adopted Bohler's manœuvre, in which a wire is passed through the lower ends of the radius and ulna and another through the olecranon, and after reduction in the way previously described the ends of the wires are incorporated in a plaster case and so preventing any alteration in the position of the bones, is most valuable Alternatively open operation and fixation of the fragments may be advised



FIG 305 —FRACTURE OF THE SCAPHOID SOME SIX WEEKS AFTER A SPRAIN OF THE WRIST

The fracture was not diagnosed until after an X-ray had been taken

The ulna is easily exposed by an incision along its posterior border, but it is less easy to reach the radius without damaging the muscles The incision should pass behind the supinator longus, between it and the radial extensor tendons, the origin of the extensor muscles of the thumb may have to be disturbed, but with care no permanent damage follows, in the upper part the position of the posterior interosseous nerve must be remembered The ends of the bones are freed and brought into position, and fixed by suitable means, a plate to the radius is sometimes needed, but the ulna may usually do without it

Fractures of the Carpus—These may result from direct violence in the nature of a severe crush, and then several of the bones may be involved, and the lesion may be compound The ordinary treatment of such a condition must be followed, and the part kept at rest on a palmar splint

Any injury to the wrist of more than minimal severity should be X-rayed to exclude the possibility of injury to the scaphoid bone In the past many injuries have been treated as sprains which in point of fact were undoubtedly fractures of the scaphoid, and inefficient treatment spells a lifetime of pain and limitation of the use of the wrist The blood-supply of the scaphoid bone is by means of two vessels, one entering the tuberosity and the other the middle of the bone If a fracture occurs through the proximal part or through the centre in such a way as to damage the artery in that position this will result, with inefficient immobilization, in the death of that portion as a consequence of its insufficient blood-supply This is associated with pain on dorsiflexing the wrist, subsequent arthritis

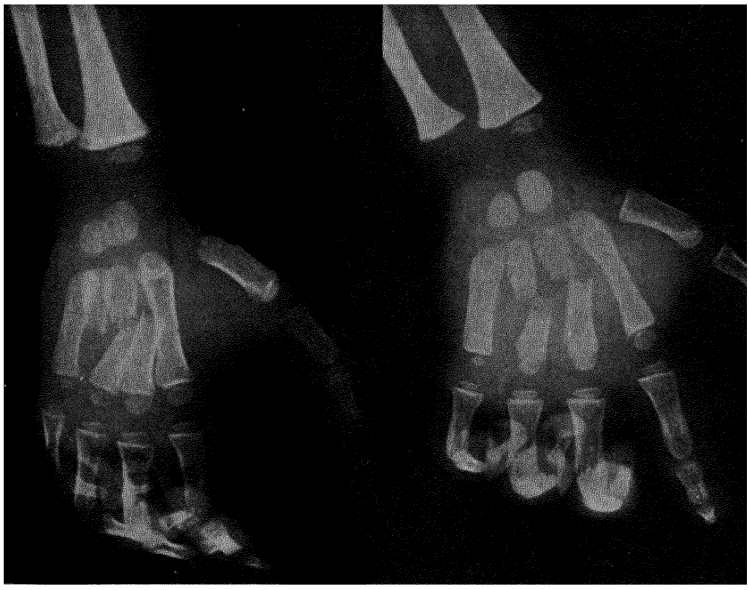


FIG 306 - FRACTURED METACARPAL BONES

and general rarefaction of the carpal bones The patient complains of pain in the region of the anatomical snuff-box associated with some swelling and pain on dorsiflexion X-ray may reveal a crack in the scaphoid at first only recognizable with a lens, but if the joint is not immobilized this crack will become very obvious in the course of a few weeks (Fig 305) **Treatment** for this condition consists in complete immobilization of the wrist by a plaster extending from the knuckles to high up in the forearm, immobilization being maintained until union of the fragments is completed, a process which will take some twelve weeks or more

Fractures of the Metacarpal Bones and Phalanges (Figs 306 and 307) are not uncommon, particularly in the third and fourth fingers, being

due to direct violence, and hence often transverse There is generally but little displacement, though occasionally the fragments may overlap, whilst a certain amount of localized swelling and tenderness is always noted

Treatment of a fractured metacarpal with little or no displacement is merely immobilization of the hand of a cock-up splint for two weeks or so, but if the fragments overlap and shortening of the finger is threatened, prolonged extension is required This is easily effected where one metacarpal alone is involved by applying a metal palmar plate, to which is fixed a solid bar reaching below and beyond the finger Adhesive plaster is fixed to the finger front and back by encircling strips, or the finger of a glove is glued on, and tape carried through the tip These bands tied firmly to the rounded termination of the projecting bar provide the needful extending force If several metacarpals are broken, it is better to apply a light plaster case to the forearm, in which is incorporated a piece of heavy-gauge wire, bent as in the illustration (Fig 308) The extension tapes



FIG 307 —FRACTURE OF FIFTH METACARPAL BONE AT ITS NECK

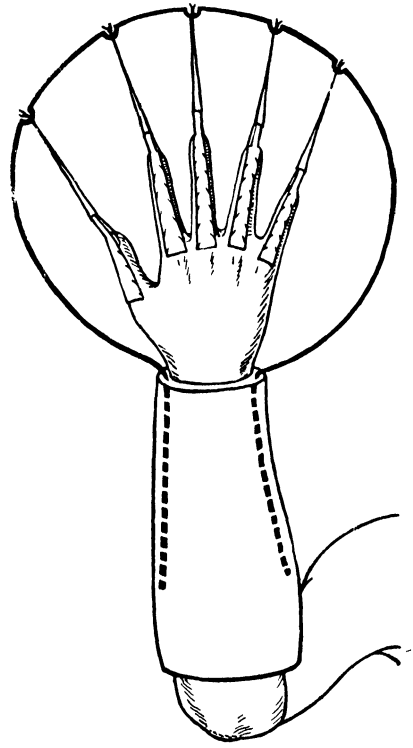


FIG 308 —TREATMENT OF FRACTURED FOREARM OR METACARPALS BY EXTENSION

This appliance could also be utilized for some less serious cases of fracture of the forearm needing extension where the patient cannot remain in bed The lateral bars must then be carried up either side of the arm and join together behind the elbow which is fixed to them so as to give support for counter-extension

from the fingers are tied to the wire loop in the manner shown Operation for these conditions is undesirable, as it almost certainly interferes with the tendons, and their subsequent mobility is jeopardized

Bennett, of Dublin, has described an interesting fracture of the first metacarpal (*stave of the thumb*), which is due to indirect violence, and not very rare The line of fracture is oblique (Fig 309), separating the anterior portion of the base, which remains *in situ*, from the rest of the shaft, which is drawn upwards and backwards by the long extensor tendons, so as to lie behind the trapezium Should the displacement be overlooked, the bone unites in this position, and the deformity, which persists, determines weakness and disability of the thumb

Treatment —Reduction is usually effected with ease by traction, and prolonged extension as described above is necessary



FIG 309 —BENNETT'S FRACTURE

Fractures of the Pelvis

Fractures of the pelvic bones are almost always the result of direct injury, such as falls, blows, gunshot wounds, or crushes in railway, carriage, or motor accidents For convenience they may be described under the following headings

1 **Fractures of the False Pelvis** — A portion of the crista ilii may be broken off, or the anterior superior spine separated, or merely a fissure in the bone produced The displacement is rarely great, although a portion of the crest may be drawn down by the glutei muscles, or the anterior superior spine displaced by the sartorius Considerable pain is always present, especially on any vigorous respiratory movements, but crepitus is rarely to be detected Union occurs readily if the patient is kept quiet in bed with the shoulders raised, and the legs supported to relax the muscles A flannel bandage round the pelvis gives comfort and support

Septic penetrating wounds, such as follow gunshot injuries, are liable to result in a subacute spreading osteomyelitis which is most troublesome Not unfrequently an abscess forms on the inner aspect of the bone, communicating with the exterior by the narrow passage in the bone made by the penetrating body Pus may track up and down the iliacus muscle, and the cavity fills and empties itself through the wound from time to time The only treatment that is effective consists in opening up the external wound and enlarging the aperture in the bone so as to secure effective drainage, or it may be necessary to open up the iliac fossa from the front, burrowing through and under the iliacus muscle

2 **Fracture of the True Pelvis** is a much more serious accident

The line of fracture in front usually runs into the obturator foramen, and involves both the horizontal and descending rami of the pubes or the ascending ramus of the ischium (Fig 310) This is frequently conjoined behind with a fracture in the neighbourhood of the sacro-iliac synchondrosis either on the same or opposite side, but more frequently the latter The **Symptoms** are those of severe shock and pain in and around the pelvis, especially on movements of the legs or on coughing There may be local ecchymosis and tenderness over the pubic ramus, as also deeply in the iliac fossa, and the patient either cannot stand, or feels as if he were falling to pieces on attempting to do so Usually there is but little deformity, although occasionally displacement backwards of the innominate bone is visible, and depression of the pubic symphysis or of the ischial or pubic rami may be palpable Crepitus may be elicited on grasping the iliac bones, and moving them one on the other, but such a method of investigation must be indulged in very sparingly

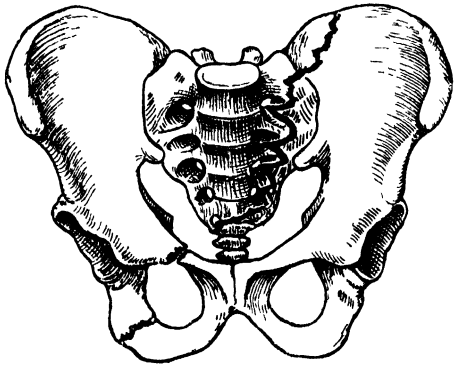


FIG 310 —FRACTURE OF THE PELVIS

The fracture runs through the sacrum on the left side, and through the horizontal and descending rami of the pubes of the opposite side

The chief dangers from a fractured pelvis arise from the presence of co-existent *visceral lesions*, especially to the urethra, bladder, or rectum The membranous portion of the urethra is torn by the displacement of the pubic symphysis, and this is indicated by escape of blood from the meatus Every effort must be made to prevent extravasation of urine, and *the patient warned against passing water, however urgent the desire* Rupture of the bladder results in pelvic or intraperitoneal extravasation, according to the site of the lesion The rectum may be punctured by the displaced pubic rami, and on examination the ends of the bones may be felt in the rectum The vagina and the pelvic vessels and nerves are less frequently injured

Treatment.—The patient should be moved with the greatest care, both on account of the shock and also for fear of producing or increasing visceral complications As a first-aid measure a binder may be fixed round the pelvis He is put to bed on a divided mattress (Fig 327) with fracture-boards beneath it, and kept quiet until the shock has in measure passed off The treatment of the actual fracture will depend on whether a single or a double break in the continuity of the pelvic ring exists If there is a break through one or both of the pubic rami, through the body of the ilium, or if there is a break in the symphysis pubis, it is quite obvious that no deformity can occur, and treatment of these cases by rest in bed for three weeks is all that is required

Where a double break is present there is likely to be some displacement, usually more marked towards the front of the pelvis than at the back, as in these fractures the pelvis tends to open like a book, the binding being placed posteriorly In some cases the displaced fragment is also pulled upwards If the patient is compressed while standing sideways, the anterior segment will break through both pubic rami or through the pubic ramus of one side and the symphysis pubis There is some upward displacement of the separated part, the replacement of which can sometimes be effected by manipulation Some displacement, however, is of little moment, and these patients treated by rest in bed in a supine position for from four to six weeks do very well

Where there is a fracture through the symphysis or pubic bones associated with one through the sacro-iliac joint or the body of the ilium, that half of the pelvis will be displaced upwards Reduction can be effected by supporting the patient on a plaster table on the sound side and exerting traction on the leg of the fractured side A double plaster spica is then applied This remains on for a period of three months, during which time the patient is encouraged to lie on the sound side

A very careful examination is made to exclude visceral injuries

1 *Ruptured Urethra*—Bleeding from the meatus and bruising and swelling often of a butterfly shape in the perineum suggest this lesion Under full aseptic technique an endeavour is made to pass a catheter If failure results the urethra is probably completely torn, whereas if the catheter is passed successfully a partial tear is likely to be present In the latter case it is probably best to leave a catheter in for some fourteen days, and from then on to subject the patient to periodic bougie treatment to avoid the formation of a stricture If suppuration occurs in the perineum this must be incised and the bladder drained suprapubicly Some surgeons advise incising over the perineum and passing a catheter from the incision into the bladder, the wounded urethra being repaired subsequently when all the œdema and bruising has subsided Where there is a complete rupture of the urethra a suprapubic cystostomy should be performed at once, the repair of the urethra being effected at a later stage

In those injuries in which the membranous urethra is torn great difficulty is experienced in approximating the ruptured ends, as the prostate and bladder tend to fall upwards and backwards and at the same time there is little tissue in or around the distal ruptured end through which a suture may be introduced There is in these cases complete inability to pass a catheter, and on suprapubic cystostomy the location of the rupture will be evident The following procedure is then adopted A retrograde catheter fitted with a flange at the end opposite to the eye is passed through the prostatic urethra and its end drawn up into the suprapubic wound A second catheter is then passed down the penis and as it emerges through the ruptured membranous urethra is also drawn up into the suprapubic wound The ends of the two catheters are united with a thread, and the retro-

grade one is guided through the membranous and penile urethra by traction on the second catheter It is then drawn tight, and the flange will press on the prostate in the bladder, pulling it and the bladder downwards to approximate the ruptured urethral ends The catheter is fixed in this position of tension either by a small weight or by strapping it to the thigh A suprapubic drain is then introduced and a thread attached to the flange of the suprapubic catheter drawn through this in order that the latter may be removed in some fourteen days' time The cave of Retzius is also drained

All these cases of ruptured urethra will probably require instrumentation subsequently to avoid or treat a resulting traumatic stricture

2 *Extraperitoneal Rupture of the Bladder* is recognized by the inability to withdraw urine on passing a catheter or the withdrawal of only a little blood-stained fluid, and the extravasation of fluid into the tissues above the pubis Treatment consists in exploration and repair of the rent with perhaps suprapubic drainage If the fluid in the tissues has been present for some time and infection has occurred, this will require wide incisions for drainage

3 *Intraperitoneal Rupture of the Bladder* gives rise to similar findings, but shock is much more marked and there may be signs of fluid in the abdomen or even of general peritonitis Exploration is required, the rent in the bladder being repaired and the peritoneum closed, an extraperitoneal suprapubic cystostomy then being instituted

4 *Damage to the Rectum* if severe demands a temporary colostomy, but otherwise the case should be treated expectantly If the pararectal tissues become infected, wide incisions will be necessary

3 **Fracture of the Acetabulum** is of two types (1) The posterior lip is broken off by the head of the femur, which is dislocated backwards by the same accident Reduction is effected easily and with crepitus, but the displacement usually recurs, and to prevent it prolonged and effective extension is required with the leg abducted (2) A heavy fall on the trochanter may cause (*a*) a simple fissure extending into or across the cavity, or (*b*) a starred fracture, possibly resolving the cavity into its three constituent elements, or (*c*) it may even drive the head of the bone into the pelvis (*central dislocation of the femur*) A mere fissure of the acetabulum produces but few symptoms beyond a little pain and impairment of movement, but if the head of the bone is driven into the pelvic cavity, the symptoms are much more serious, on account of the associated injuries to the viscera and the greater amount of violence employed The case will resemble one of fracture of the neck of the femur, but there is usually only very slight mobility, and the head may be felt within the pelvis on rectal examination An attempt should be made to free it by horizontal traction outwards and manipulation through the rectum, extension is then maintained, and passive movement commenced early

4 **Fracture of the Tuber Ischii** has been known to occur from falls in the sitting position. The diagnosis is often obscure, as the displacement is slight

5 **Fracture of the Sacrum** is always due to direct violence of considerable severity, such as kicks, blows, or gunshot wounds It is not unfrequently comminuted, and may be accompanied by injury to the bladder or rectum, damage to the lower sacral nerves may result in loss of power of these viscera In a transverse fracture, the lower fragment is usually displaced forwards, and may cause pressure upon the rectum, irregularity in the shape of the bone may be detected by rectal examination or from without **Treatment**—The lower fragment should be replaced if possible, but considerable difficulty may be experienced in keeping it in position A well-fitting pelvic band, with rest in bed, is probably all that is necessary Injury to the rectum with fæcal contamination of the wound may require colostomy

6 **Fracture of the Coccyx** occurs during parturition or results from falls or blows, although its mobility often protects it from injury Great pain is felt on walking, or on any movement which increases the intra-abdominal pressure, such as straining, coughing, defæcation, etc , since the coccygeus muscle forms part of the pelvic diaphragm A rectal examination reveals preternatural mobility of the lower fragment, angular deformity, and perhaps crepitus The **Treatment** consists in keeping the patient at rest until union has occurred, it is impossible to apply any apparatus, and hence the bone may unite at an angle, causing pain, discomfort, and difficulty in parturition *Excision of the bone* is then required The patient lies semi-prone with the legs slightly flexed, or in the lithotomy position, and a longitudinal incision is made in the middle line The apex and lateral margins of the bone are cleared, and the ligamentous tissues uniting it to the sacrum divided by the knife, the bone is now laid hold of by sequestrum forceps, and its remaining attachments severed, due precautions being taken not to encroach on the rectum Two or three stitches are inserted, and also a drainage-tube for a few hours, the dressing is secured in position by a T-bandage The bowels should be confined for some days after the operation

Falls upon the coccyx, unaccompanied by fracture, sometimes give rise to a most severe and intractable type of neuralgia, known as **coccydynia,** which may quite prevent the patient from following his avocation It is probably due to adhesions forming between the posterior sacral nerves and the bruised periosteum If sedatives fail in giving relief, the bone must be excised

Fractures of the Femur.

In treating fractures of this bone it is of paramount importance, if full functional activity is to be obtained, to aim at perfect anatomical reconstitution If this is neglected union may occur, but even so the abnormal stresses to which the weight-bearing joints will be subjected will give rise to osteo-arthritis and limitation of the activity of the patient In considering these fractures it is convenient to divide them into those affecting the upper end, those affecting the shaft, and those of the lower end

Fractures of the Upper End of the Femur

1 **Transcervical or so-called Intracapsular Fracture** (Fig 311) — This is most frequently met with in persons of advanced age, and especially in females This is explained by the atrophic changes which take place in the cervix femoris of elderly people The spaces between the bony cancelli are enlarged and loaded with soft fat, whilst the ensheathing compact tissue is thinned and the 'calcar femorale' of Merkel, *i e* the process of thick cortical substance running from the lesser trochanter to the under part of the head, is atrophied It often requires but little violence to produce this fracture, the causative accident being merely some slight stumble or fall, such as slipping off the kerb or tripping upstairs, the bone yields, and the patient falls to the ground The line of fracture varies, being either transverse or oblique, and is mainly intracapsular Some of the fibres reflected from the under surface of the capsule to the neck of the bone may remain untorn at first, but later on they may give way from reactionary softening, injudicious manipulation, or attempts to use the limb Two types of this fracture must be differentiated from the point of view of diagnosis, prognosis, and treatment the abduction fractures, which are rare, and the adduction fractures, which are common (80 per cent)

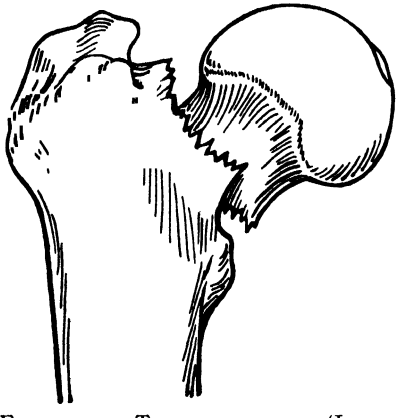


FIG 311 —TRANSCERVICAL (INTRACAPSULAR) FRACTURE OF THE CERVIX FEMORIS

The history given in both cases of some trivial injury is similar, and there may be a certain amount of shock associated with the pain of the fracture On examination, in the majority of cases, the limb is rolled out in a position of eversion, this being largely due to the action of gravity Some adduction is also present Shortening of the leg by half an inch or so can be demonstrated by a measurement taken from the anterior superior iliac spine to the internal malleolus, and in addition the great trochanter will be found to be raised This is best demonstrated by the following tests

Nélaton's Line (Fig 312) is one drawn from the anterior superior spine to the most prominent point of the tuber ischii (AB) The centre of this (D) corresponds to the top of the great trochanter, if the limb is placed in the axis of the body, but if either abduction or adduction is present the top is situated slightly above or below the line Definite elevation of the bone above the line indicates shortening of the limb due to dislocation backwards, fracture of the neck, or absorption of the head and neck from disease

Bryant's Test Line (Fig 312) In this the patient lies flat on a horizontal couch, and a vertical line (AC) is drawn from the anterior

uperior spine, a thin wooden rod held against the side answers this urpose admirably The perpendicular distance of the top of the reat trochanter from the line (CD) is compared with a similar ieasurement of the opposite side, definite shortening may thus be iscovered In the normal adult this measurement is usually about ½ inches

In the abduction fracture there is no external rotation, and some legree of internal displacement may be present It will be found hat as opposed to a degree of coxa vara present in the adduction ype, there is in this fracture some coxa valga, with lowering of the reat trochanter as determined by the tests described above X-ray xamination will often show impaction of the fracture with the fragnents rotated in such a way that an angle opening forwards and utwards, as opposed to the disimpaction and the angle opening backwards and inwards in the dduction variety

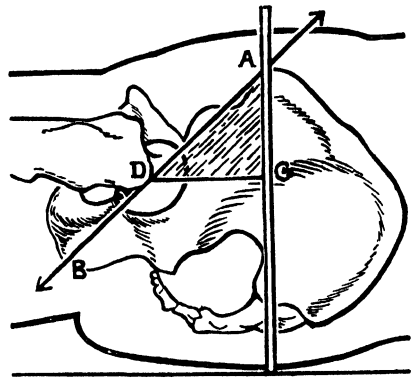


FIG 312 — NELATON'S LINE AND BRYANT'S MEASUREMENT FOR ASCERTAINING POSITION OF GREAT TROCHANTER

Treatment —That of the abduction type of fracture is simple, s union readily occurs All that s necessary is to place the affected high in a plaster spica extending lown to the knee on the injured ide This is kept on for some hree months, weight - bearing being allowed from the commencement

With the adduction fractures reatment is difficult and less atisfactory Some years ago t was the custom to regard hese fractures as ununitable, nd the unfortunate patient was reated by rest in bed with alf-hearted attempts at immobilization of the hip-joint with sandbags At the end of two or three months the patient was allowed p, with probably at the most fibrous union or a pseudo-arthrosis, often with a backward displacement of the femoral neck Such treatnent is occasionally practised to-day, but cannot be condemned too trongly except in exceptional cases, because they are deprived of the hance of obtaining bony union and full function Two methods of reatment may be used, but in either a preliminary period of extension by means of skeletal or skin traction with the leg on a Braun's or Thomas's splint should be employed, as pain and shock are relieved hereby and the displacement is partially reduced

(1) By means of a *Whitman's Plaster* This is suitable for patients without chest complications such as bronchitis, and for those who apart rom the fracture are comparatively fit After spinal anæsthesia has been administered the patient is put on an orthopædic table and he sound leg fixed in abduction Traction is then exerted on the njured limb by an assistant in an abducted position, and the knee

is then flexed so as to use the lower leg as a lever to obtain full internal rotation The knee is straightened and pressure on the foot is exerted gently to impact the fragments After padding all bony prominces with felt a well-moulded plaster is applied from under each axilla and including the whole of the affected limb After about a week a walking iron projecting vertically down from the inner aspect of the affected leg is applied and the patient is encouraged to get about The plaster is kept on for some six months, when bony union should have occurred In some cases periodical X-ray examination will show that the head of the femur has become dense and necrotic, indicating that viability cannot be hoped for, and then the plaster must be removed

(2) By means of a *Smith-Petersen Pin* This is a triflanged stainless steel pin which, following the reduction of the fracture in the manner indicated above, is introduced into the neck of the femur through the great trochanter and thence on into the head (Figs 313 to 315) Head and neck of the femur are then held immovably together, the three flanges on the pin preventing any rotation

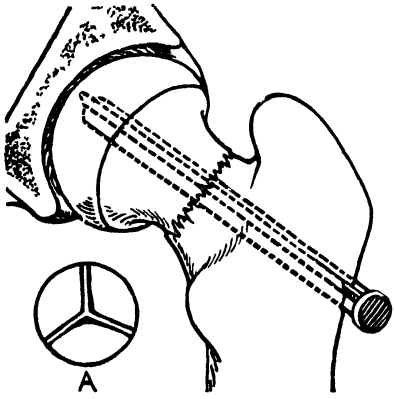


FIG 313 —METHOD OF INSERTING SMITH - PETERSEN'S PIN FOR FRACTURF OF NECK OF FEMUR

A, Cross-section of pin

The pin is difficult to introduce, and one of two ways may be attempted, the open or the closed In the former the hip-joint is exposed by an incision passing down from the anterior superior iliac spine on the outer aspect of the thigh The rectus femoris muscle is retracted from the tensor fascia femoris and the upper part of the femoral shaft, the capsule, neck, and great trochanter are exposed The capsule is incised and the fracture reduced A pin, the length of which has been previously estimated, is then driven through the great trochanter Rotation of the leg outwards will determine whether it is appearing at the mid-point of the fractured neck If so, internal rotation of the leg is repeated and the pin driven home If not, the pin must be extracted and the process repeated A firm dressing is applied, and at the end of about a month the patient is allowed up, with a short spica plaster bandage which is retained for six months

In the closed method two or three Michel's clips are applied to the skin in what is thought to be the projected line of the neck of the femur An X-ray is then taken and all except the clips approximating to the mid-cervical line are removed After exposure of the great trochanter two or three Steinmann's pins are driven in in the direction approximating to the line previously determined Another X-ray is taken

and a Smith-Petersen pin driven along the best-placed Steinmann pin, and for this purpose the former is provided with a central longitudinally running channel The guiding pin is removed and the wound closed Subsequent treatment is similar to that previously described

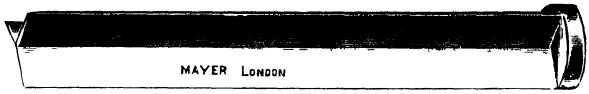


FIG 314 —SMITH-PETERSEN'S PIN

Non-union In otherwise fit cases it is often worth while attempting some operative procedure to minimize the deformity If the head is still viable, fixation with a Smith-Petersen pin is worth a trial, in other cases a subtrochanteric osteotomy in which the upper fragment is strongly adducted by a pin driven into it so that when union occurs some of the weight will be taken by the lesser trochanter Whitman's operation, in which after removal of the head of the femur an attempt is made to fashion a new one from the neck of the femur, is worth a trial, the great trochanter being transplanted lower down the femoral shaft to permit of sufficient leverage for the glutei muscles



FIG 315 —SKIAGRAM SHOWING SMITH-PETERSEN S PIN IN POSITION IN A CASE OF FRACTURE OF THE NECK OF THE FEMUR

(3) Certain cases, unsuitable for treatment by the above methods, should be treated in bed, weight extension being applied by means of a Thomas's splint After six to eight weeks walking is started with the aid of a caliper

Massage and gentle movements can be initiated after three weeks, and particular attention should be paid to the knee-joint

(4) Finally, in those patients too infirm for serious treatment to be attempted, hope of bony union must be abandoned and a caliper fitted at once It should be stated, however, that good results following the use of the Smith-Petersen nail have been reported in patients over eighty years of age

2 **Intertrochanteric Fracture of the Femur** (the so-called *extra-capsular fracture* of the neck), always involves the hip-joint, since the capsule extends to the shaft of the bone along the anterior inter-trochanteric line, and leaves no portion of the neck uncovered in this situation The line of fracture is therefore only extra-capsular behind (Figs 316 and 317)

Mechanism—It is usually the result of violence acting transversely upon the trochanter major, as from a heavy fall upon the hip The posterior part of the neck, being weaker than the anterior, first gives way, the whole neck then yields, and the severed head and neck are impacted into the junction of the trochanter and shaft The majority of these cases are thus primarily impacted, continuation of the violence producing disimpaction, coupled either with detachment of one or

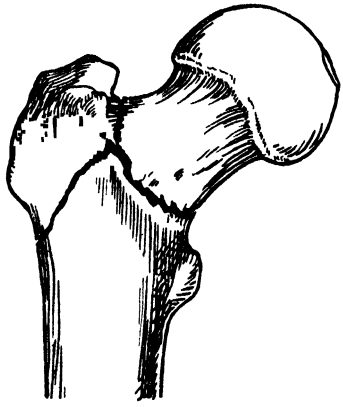


FIG 316 — INTERTROCHANTERIC FRACTURE OF CERVIX FEMORIS (SEMI-DIAGRAMMATIC, FROM THE FRONT)

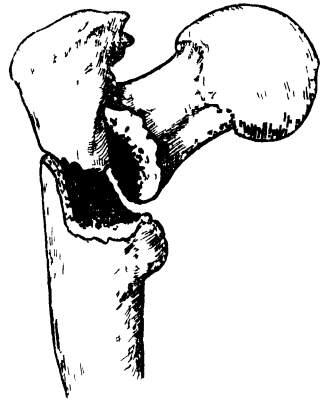


FIG 317 — INTERTROCHANTERIC FRACTURE OF NECK OF FEMUR, SEEN FROM BEHIND (COLLEGE OF SURGEONS MUSEUM)

The head and neck are depressed, and the trochanter major drawn slightly upwards.

both trochanters, or with comminution of the great trochanter, at least three, and perhaps four, fragments are thus produced (Fig 317) Disimpaction may also follow at a later date from the rarefaction associated with the early stages of repair or from injudicious manipulation; and thus the shortening, which may at first be slight, often increases at the end of a few days The upper fragment remains in the acetabulum, whilst the lower end is drawn up and everted

Union of the fragments is much more certain in this variety than in the transcervical, and it is often accompanied by a considerable development of callus, which may subsequently impair the movements of the limb, whilst secondary bending and late increase of the shortening may occur if the patient walks too soon

The **Signs and Symptoms** of the transcervical and intertrochanteric fractures may be contrasted.

(*a*) The signs of *local trauma, viz* pain, bruising, and swelling, may be present in both, but whilst slight in the transcervical variety, they are often very marked in the intertrochanteric

(*b*) *Crepitus* is evident in the unimpacted forms of each, but it is unnecessary and, indeed, extremely unwise to elicit it by forcible manipulation, especially in the transcervical variety

(*c*) *Loss of power* is perhaps more marked in the intertrochanteric form than in the transcervical Cases of the latter in which the patient has been able to walk into hospital some days after the accident are not unknown, and are probably due to impaction

(*d*) *Eversion* is a most characteristic feature in both varieties, the limb lying absolutely helpless on its outer side, except in the adduction variety of transcervical fracture This displacement is accredited to the natural weight of the limb, to the greater fragility of the back of the cervix, causing it to be more comminuted than the anterior surface, and, lastly, to the greater power of the external rotator muscles

(*e*) *Shortening* is slight in the early stage of transcervical fractures, and much greater in the intertrochanteric, even reaching to 2½ or 3 inches It is indicated by displacement of the trochanter upwards, due allowance being made for the position of the limb as regards abduction or adduction

(*f*) The *position of the great trochanter* is of the greatest importance It is raised above its ordinary level, and displaced backwards owing to eversion of the limb, and it is approximated to the middle line of the body

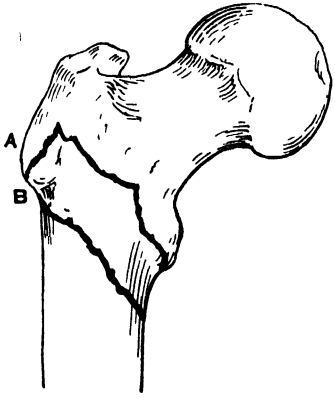


FIG 318.—A, PERTROCHANTERIC FRACTURE OF FEMUR, B, SUB TROCHANTERIC FRACTURE

Diagnosis.—A *severe contusion* of the hip, which may be associated with marked eversion, is known from a fracture by the absence of shortening and crepitus, there is no displacement of the trochanter, which rotates in a normal manner The shortening which sometimes follows, owing to subsequent atrophy of the neck, may, however, complicate matters In a *dislocation* the head of the bone can be felt in an abnormal position, and hence no difficulty should be experienced in its recognition In *chronic osteo-arthritis* of the hip a patient may fall and present for examination a limb with definite shortening and marked bony crepitus It will be found, however, that there is no acute eversion, pain, or loss of power, whilst the existence of similar disease in other joints may assist the surgeon Moreover, osteo-arthritis of the hip usually results in prominence of the trochanter, and not in flattening, as occurs after fracture, the fascia, too, above the trochanter is never relaxed in osteo-arthritis, always in fractures

3 **Fracture through the Great Trochanter** (the *pertrochanteric* frac-

ture of Kocher) closely resembles the intertrochanteric fracture, the lesion running from the inner and under part of the neck obliquely upwards and forwards through the base of the trochanter (Figs 318, A, and 319) The lower fragment is displaced upwards and everted, and its upper edge can often be felt distinct from the top of the great trochanter, which does not move on rotation of the limb, there is also much thickening about the trochanter, and pain on pressure over it This injury needs to be carefully distinguished from—

4 The *subtrochanteric* fracture, which encroaches on the upper end of the shaft In this both trochanters are included in the upper fragment (Fig 318, B), which is flexed by the ilio-psoas and abducted,



FIG 319 —FRACTURED NECK OF FEMUR WITH SEPARATION OF LESSER TROCHANTER

whilst the lower fragment is drawn up on its outer aspect and behind it, with considerable shortening and complete eversion

Treatment —In those fractures of this group in which the element of coxa vara is not great, and in which the fracture tends to be transverse, immobilization after reduction in a Whitman's plaster may be sufficient, but in most cases continuous traction after reduction has been effected under anæsthesia is probably the ideal Traction may be exerted through strapping applied to the skin, but better still is a Steinmann's pin driven through the lower part of the femur just above the condyles The limb is set up in a Thomas's splint and traction, which may require to be considerable as a start (some twenty pounds), instituted

This should be maintained for about three months, at the end of which time a walking caliper splint is used for a further similar period

5 **Fracture of the Great Trochanter** is rare, and always due to direct violence, in the young it occurs as an epiphyseal lesion (Fig 320) The trochanter, or a portion of it, is separated from the rest of the bone without any loss of the continuity of the shaft Independent movement of the fragment with crepitus is usually obtainable, and if the displacement is at all marked, an operation to fix it should be undertaken

6 **Fracture of the Lesser Trochanter** results from muscular violence and is associated with pain over the inner and upper part of the thigh and inability to flex the thigh when sitting down Treatment consists in immobilizing the thigh in flexion almost to a right angle and in internal rotation for a month

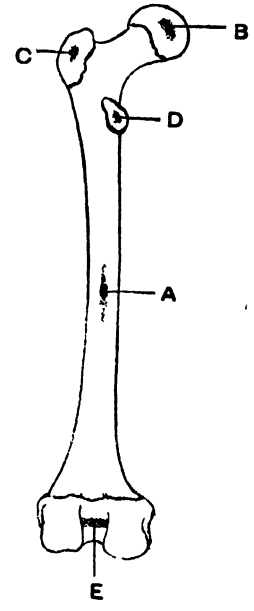


FIG 320.—CENTRES OF OSSIFICATION OF FEMUR

A, For shaft, eighth week of intrauterine life B, for head, first year, fusing with shaft at eighteenth year, C, for great trochanter, third year, fusing with shaft at eighteenth year, D, for lesser trochanter, twelfth year, fusing with shaft at eighteenth year, E, for lower epiphysis, at birth, fusing with shaft at twentieth year

Fractures of the Shaft of the Femur are extremely common in spite of the apparent strength of the bone Any part may be involved, particularly the centre, whilst they occur at the lower end more frequently than at the upper In the latter situation they are usually due to indirect violence, whilst at the lower end they generally result from direct injury, either form of violence may lead to a fracture about the middle of the bone, and radiography has shown that spiral fractures are by no means uncommon Exact diagnosis is sometimes difficult, owing to the amount of swelling from hæmorrhage, and to the muscularity of the part

In almost every case *displacement* occurs, the direction and amount of which depend not only on the line of fracture, but also on the situation In the *upper third* (Fig 321), the small upper fragment is usually tilted forwards by the ilio-psoas, and abducted and everted by the gluteus minimus and external rotators, whilst the lower fragment is drawn upwards and to the inner side of the upper by the hamstring and adductor muscles, marked eversion also resulting, partly from the weight of the limb, and partly from the action of the adductors, but such a complicated displacement is not always present

In the *middle third*, if due to indirect violence, the line of fracture usually slants from above downwards and backwards, causing a simple

overriding of the fragments or an angular deformity The lower fragment is drawn upwards and inwards, either in front of or behind the upper fragment, and is usually everted The upper fragment is sometimes tilted forwards If due to direct violence, the fracture is more or less transverse, often comminuted, and any form of displacement may then occur In either case there is extensive laceration of the quadriceps extensor muscle, and the sharp end of either fragment may be caught in its fibres, and reduction of the deformity thereby hindered Considerable hæmorrhage follows, and a large collection of fluid blood around the ends of the bone sometimes impedes reduction and repair

In the *lower third* the fractures which arise from direct force are transverse, the lower fragment may then be tilted backwards by the gastrocnemii muscles (Fig 322),

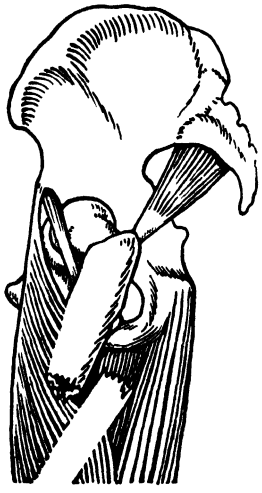


FIG 321 —FRACTURE OF UPPER THIRD OF FEMUR, SHOWING DISPLACEMENT OF BONE

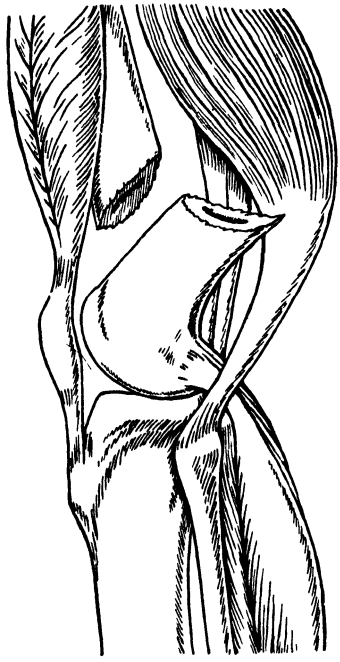


FIG 322 — FRACTURE OF LOWER THIRD OF FEMUR, SHOWING DISPLACEMENT OF LOWER FRAGMENT BACKWARDS

and compress or rupture the popliteal vessels, perhaps causing gangrene Oblique or spiral fractures from indirect violence, sloping from above downwards and forwards, are also met with, the upper fragment is driven into the substance of the quadriceps muscle, and may become fixed in it, projecting immediately beneath the skin close to the upper border of the patella, whilst the lower fragment is drawn up behind If such a case is left unreduced, non-union is likely to ensue, the knee-joint is generally penetrated by the lower end of the upper fragment

Open (Compound) Fractures of the femur have been only too common during the past few years as the result of military activity, and may result from any form of gunshot wound A rifle bullet travelling cleanly inflicts little damage on the soft tissues, and may traverse the cancellous structure of the femur near the neck or close to the knee without causing any solution of continuity, if, however, it hits the compact shaft, a complete fracture results, often with great comminution

In civilian practice open fractures of the femur are generally the result of direct violence, such as street, railway, or machinery accidents, they are associated with much laceration and often with severe infection of the overlying soft tissues, and hence the patients, when first seen, are often in a condition of grave shock

The history of these cases is very similar to that of all open fractures (p 556), the peculiarities depend on the central position of the bone in the limb, rendering drainage and accurate fixation of the fragments more difficult Consequently, infective troubles in the wound and of the bone are frequently observed Necrosis is not uncommon, and, owing to the density of the compact bone, the sequestrum is long in separating, even when union occurs it may be associated with much shortening and deformity, and the knee may be stiff Sinuses may persist for long, and the convalescence is often very slow

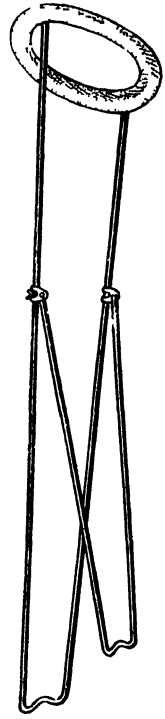


FIG 323 —THOMAS'S SPLINT WITH MOVABLE LEG-PIECE TO PERMIT MOVEMENT OF KNEE-JOINT

The Treatment of Fractures of the Shaft of the Femur —I **Prolonged Extension** is necessary in some fractures of the upper end, and in almost all fractures of the shaft, if the fragments are to be satisfactorily replaced and shortening prevented Powerful muscles are attached to the fragments, and to counter their activities effective extension is needed

In the past Thomas's splint (Fig 323) has held pride of place in the treatment of these fractures, but from all points of view Braun's is the more valuable It consists essentially of an angled frame, the part designed to support the thigh being set at about 30 to 40 degrees, so that the femur is always flexed to that extent (Fig 340) Traction can be readily exerted in the line of femur in the manner shown in figure without any obstruction from the lower leg The limb is supported by flannelette bandages running between the limbs of the splint Counter-extension is provided by using the body weight, the lower end of the bed being raised on blocks But in order to prevent the frame from sliding down it should be fixed to the foot of the bed Over the head of the bed and attached firmly to it should hang a

support, so that the patient may raise himself up with his arms Traction may be exerted by one of three methods, old means such as Sinclair's foot-piece being really only of historical interest

(*a*) *By Adhesive Plaster* In this method wide strips of adhesive plaster are fixed, one on the inner side of the thigh and one on the outer In order more easily to mould the strapping to the limb it is beneficial to make a number of oblique cuts along the whole length (Fig 324) The ends of the strapping are carried beyond the knee and attached to a spreader, which consists essentially of a square of

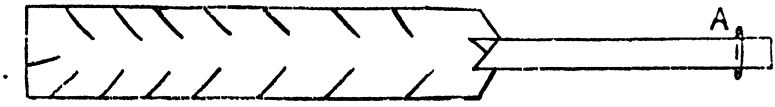


FIG 324 —METHOD OF CUTTING AND FOLDING THE STRAPPING IN APPLYING EXTENSION

wood with a hole drilled through the centre (Fig 325) Through this a length of cord is threaded, and this is carried over the pulley at the end of the splint and a weight attached to its end To prevent the strapping slipping it is further maintained in position by spirally arranged strips of strapping placed over it, which, however, never surround the limb, so that there shall be no obstruction to the circulation Similar strapping extension is applied to the lower leg

(*b*) *By Unna's Paste* In this method the principle is exactly similar, but the extension is exerted through calico strips fixed to the thigh by Unna's paste

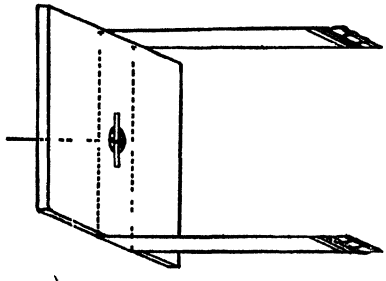


FIG 325 —METHOD OF ARRANGING STRAPPING ON 'SPREADER'

(*c*) *By Skeletal Traction* Here traction is exerted directly through the bone by a Steinmann's pin or Kirschner's wire passed either through the lower end of the femur in fractures of the shaft or upper end, or through the tibial spine when the lower end is involved (Fig 326) The ends of the pin or wire are connected to a stirrup, and through this extension is exerted Of all forms of extension this is by far the most admirable and satisfactory A more powerful pull can be exerted, there is no strapping to be pulled gradually down the leg, and in cases of compound fracture there is no strapping to interfere with the dressing of a wound

In fractures of the femur an initial extending force of some fifteen to twenty pounds is required, but when reduction has been effected for a week or so this may be reduced Where the upper end of the femur is fractured the limb must be put up in a position of full abduction, and in order to prevent rotation of the pelvis it is advisable to fix the sound leg in a similar position Where the fracture is in the upper

part of the shaft less abduction is necessary, and in the lower end the limb should be fixed in a straight position Any tendency for external rotation to occur can be prevented by a loop of bandage attached to the outer part of the pin and fixed by a piece of cord over a pulley attached to a Balkan beam, which consists of a wooden overhead bar attached by vertical posts at either end of the bed resting on solid floor supports Foot drop is prevented by attaching some strapping to the sole and fixing to its upper end a cord passing over a pulley-system attached to the Balkan beam If there is any loss of the normal anterior curvature of the femur, a small pad placed behind the site of fracture will remedy this, and similarly in fractures of the lower end of the femur any valgus deformity is counteracted by a rubber pad placed between the frame of the Braun's splint and the inner aspect of the thigh

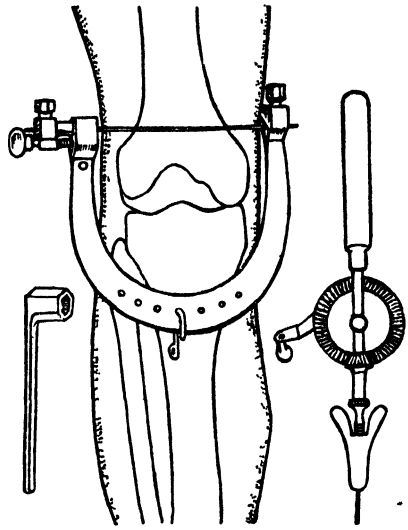


FIG 326 —DIAGRAM OF KIRSCHNER'S WIRE INSERTED INTO THE LOWER END OF FEMUR

The heavy stirrup is necessary in order that the wire may be held under tension after it has been inserted A drill for inserting the wire is also shown

The mattress on which the patient lies may advisably be of the divided type (Fig 327), so that removal of the central portion permits of access to the back and buttocks, which can thereby be better protected from bedsores, and bedpans, etc , can be more easily employed From the start the patient is encouraged to move the hip-joint by hoisting himself with his arms into a position in which the hip is flexed, by means of the support above the bed

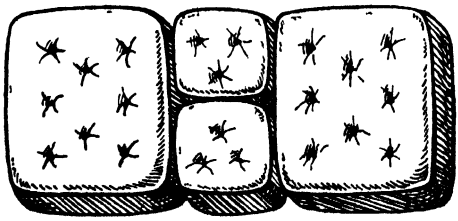


FIG 327 —DIVIDED MATTRESS FOR TREATMENT OF FRACTURES OF THE PELVIS, FEMUR, ETC

Passive movements of the knee-joint are carried through daily and active ankle movements are encouraged - None of these movements will in any way alter the position of the fragments, which are well held by adequate extension and support, and, in addition, the joints do not become stiff or the muscles wasted, rendering subsequent recovery of function far quicker If the fracture is set up in such a way as to allow no joint movements, in all except young persons the joints will rapidly become stiffened, and many weeks of subsequent

physical treatment will be required to restore anything like normal mobility

Traction in these cases needs to be continued for from two to three months, and it is better in the later weeks to remove the pin and replace the extension by strapping to avoid any possibility of infection occurring After some weeks the pin will have become loosened by bony absorption round it, and the slight movement present is liable to encourage bacteria to pass into the substance of the bone

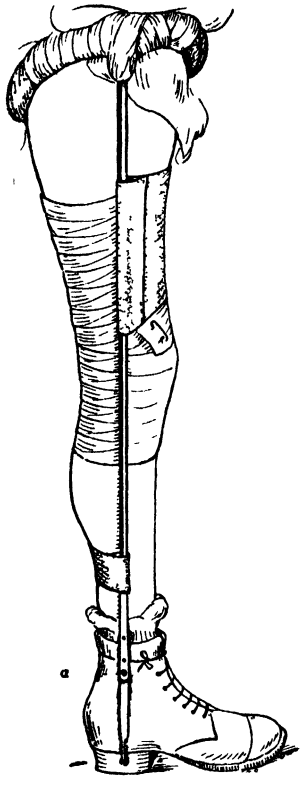


FIG 328 — WALKING CALIPER FOR USE AFTER FRACTURES OF THE LOWER EXTREMITY

a indicates the position of a screw which fixes the overlapping ends of the two segments of which the appliance consists, thereby modifying the length for varying patients

Following this a further three months is required in a walking caliper before weight-bearing is allowed, but in all cases the procedure must be controlled by X-ray examination

When the fracture has united it is undesirable to put a Whitman's plaster on and allow the patient to get about, because all the good that has been done in keeping the joints mobilized will be undone

In fractures through the lower end of the femur the lower fragment will, if the line of fracture is above the points of origin of the gastrocnemii, be rotated backwards The case should be treated similarly on a Braun's splint, but skeletal traction should be exerted not through the lower end of the femur, as on account of the position of the fracture there is the danger of drawing a pin placed below it through the knee-joint, but through the tibial spine Movement of the hip can be commenced at once, but those of the knee must not be attempted for some two or three weeks Traction is maintained for about five or six weeks, but the pin should be removed after three weeks, as if traction is exerted on it for longer there is the danger of producing an unstable knee-joint as the weight acts indirectly through the lateral ligaments At the end of this time a weight-bearing caliper should be used for a further similar period (Fig 328) Occasionally in oblique fractures in this region reduction is difficult, and open operation may be required

In children up to ten or twelve years of age, Bryant's plan of treatment (Fig. 329) is excellent It consists in slinging up the limb at right angles to the body from an overhead beam, utilizing the child's

weight as the extending force Adhesive plaster extension is applied to both limbs, the sound leg is tied up out of the way, the injured limb may be tied to the beam, or a weight passing over a pulley may be utilized In any case the child's pelvis should just be lifted from the mattress so that the body weight really acts, the insertion of an unnecessary pillow negatives the object desired If abduction is also needed, the overhead beam should be set across the bed, and fixation effected as suggested above This position is maintained for four or five weeks, and then the limb is loosened and massage and movements permitted, but the patient is not allowed to walk until a calliper has been fitted

An alternative method consists in making use of strapping traction,

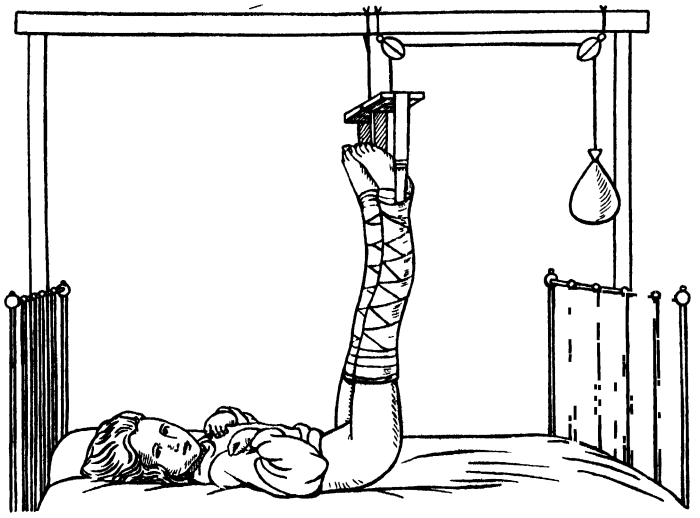


FIG 329 —BRYANT'S METHOD OF EXTENSION FOR TREATMENT OF FRACTURE OF THE FEMUR IN SMALL CHILDREN

The right leg is fractured, and has the weight attached to it, the left leg is merely tied up to keep it vertical and out of the way

but instead of using a Thomas's or other splint the limb is enveloped in a plaster cast, which can easily be suspended from a Balkan beam by means of several plaster loops included in it The extension is maintained by passing the cord over a pulley at the bottom of the bed and attaching a suitable weight

For the obstetric fracture which occurs in babies the best treatment is to apply a small padded splint on the outer side of the thigh The thigh should be kept abducted

II **Operative Treatment** for fractures of the shaft of the femur is occasionally necessary Surrounded as it is by a muscular bed, sometimes of great thickness and strength, it is almost impossible to influence the alinement of the fragments into which the femur is broken if extension fails in this object Short splints and pads are

of little use when opposed to powerful and healthy muscles, and hence, in spite of all a surgeon's skill and effort, operation is sometimes required One must, however, repeat the warning that it is a serious procedure, and must not be resorted to without due consideration or by those who are not expert in bone surgery

In the **upper third** exposure of the fracture is made through an incision along the posterior aspect of the great trochanter downwards for a sufficient distance to enable the quadriceps to be turned forwards and the biceps backwards, the lower fibres of the gluteus maximus may need to be divided Fixation is best secured by a plate with six or eight screws, it may be possible to reach the anterior as well as the posterior surface, and to this a second plate may be secured

In the **middle third** the incision should be made to the outer aspect of the rectus femoris muscle, cutting through the substance of the vastus externus Plates or wire are best adapted to secure alinement, with a very oblique fracture a couple of silver wire mattress sutures is perhaps the best means of fixation

In the **lower third** operation is best undertaken through an incision on the outer side in front of the ilio-tibial band, but not unfrequently it is desirable also to have an incision on the inner side extending up from the internal condyle Plates can then be fixed on both sides of the bone after reduction of the deformity

Fractures of the lower end of the femur are of several different types

1 **T- or Y-shaped Fracture of the Condyles.**—In this a transverse fracture close to the knee is complicated by a fissure which runs into the joint, separating the two condyles, or more frequently a Y-shaped fissure may start from the intercondyloid notch The condition is very painful, the joint is distended with blood, the bone may feel broader than usual, and crepitus may be detected on grasping the knee Comminution is not uncommon **Treatment**—Reduction is best effected by exerting traction through a Steinmann's pin traversing the tibial spine, the limbs being set up on a Braun's splint Careful moulding of the fractured condyles will often yield a good result, but if this fails operation to fix the fragments by screws, nails, plates, or bone pegs will be necessary

Traction should be maintained a month to six weeks, and a plaster cast to the [illegible] of the limb then applied with the knee in extension This is kept on for another month

2 **Separation of either Condyle** usually results from direct violence, but occasionally has followed such an indirect injury as catching the toe against the kerbstone There is no shortening, but the leg may be deflected towards the side injured, and the knee-joint be full of blood The fragment which is tilted backwards by the gastrocnemius may move separately from the shaft, and give rise to crepitus **Treatment.**—Reposition is sometimes effected by flexion of the limb and manipulation, but in healthy adults treatment by operation is often desirable, the fragment being fixed by screws, bone-pegs, or plates

3. **Separation of the Lower Epiphysis of the Femur** (Fig 320, E) is not a rare accident, and is frequently due to a child sitting behind a

cab and getting a leg entangled between the spokes of the revolving wheel The limb is thus forcibly hyper-extended at the knee, and the epiphysis becomes detached and is carried forwards The lower end of the diaphysis projects behind, and may compress the popliteal vessels, gangrene has been known to result As in the humerus, the line of separation does not always correspond to the epiphyseal line, but sometimes encroaches on the shaft Suppuration occurs in a fair proportion of the cases **Treatment.**—Reduction is effected by an assistant making traction on the tibia in the line of the limb so as to stretch the quadriceps, then the thigh is gradually flexed by the surgeon, standing above and with both hands clasped beneath it The epiphysis is by this means restored to its normal position, and the limb may then be splinted, *e g* plaster, with the knee flexed to about 60 degrees Walking should not be permitted for at least six weeks

Fractures of the Patella.

The patella is broken either by muscular force or by direct violence, and the conditions produced are so different that a separate description is necessary

1 **Fractures by direct violence** may traverse the bone in any direction, but are most often vertical or star-shaped, and frequently comminuted They are usually mere fissures without displacement, owing to the aponeurosis or capsule of the bone remaining intact There is a good deal of subcutaneous bruising, and perhaps some effusion into the joint, whilst on careful palpation the fissure may be felt, and crepitus occasionally detected **Treatment** consists in keeping the limb at rest on a back-splint, and perhaps applying evaporating lotions Massage and passive movements are commenced early where there has been much hæmorrhage into the joint, and the use of a walking caliper permits the patient to get about at an early date Operative measures are rarely required



FIG 330.—FRACTURE OF PATELLA, WITH SEPARATION OF FRAGMENTS

2 **Fractures due to muscular force** are always transverse, usually complete, and, when they involve the fibrous aponeurosis, associated with considerable displacement

Mechanism.—When the knee is semi-flexed, the patella is poised upon the front of the condyles of the femur, resting upon the middle of its articular surface, in this position any sudden and violent contraction of the quadriceps, as in attempting to recover one's equilibrium after having slipped, takes the bone at a disadvantage, and may succeed in snapping it (Fig 330) Possibly in some people there is a predisposing weakness, as cases are not rare in which the other patella is broken at a later date The fragments may be almost equal

in size, but the lower is often the smaller, either of them may be again divided vertically, or comminuted (Fig 331)

The **Signs** of this fracture consist of loss of power in the limb, pain, distension of the joint with blood, and separation of the fragments, which can be readily felt and sometimes seen This displacement is due to unopposed muscular action, and is not excessive unless associated with rupture of the lateral expansions of the vasti muscles Union by bone is rarely obtained apart from operation, owing to the separation of the fragments, and the carrying in of loose tags of the fibrous aponeurosis or capsule, which yields at a different level to the bone Fibrous union is the usual result, and when this is short and strong it is quite satisfactory, but more commonly the bond of union slowly yields when the limb is used, so that the two fragments are once again separated, merely a bridge of fibrous tissue intervening, the joint being left in a weak state, and the power of active extension of the leg much impaired or lost (Fig 332)



FIG 331.—FRACTURED PATELLA

The **Treatment** of these fractures may be grouped under two headings, *viz* either by the use of simple retentive apparatus, or by open operation

1 *Simple retentive apparatus* may be employed in cases where the fragments are not widely separated, and can be readily brought into contact, or where the patient is not a good subject for operation

A posterior splint extending from the gluteal fold to the foot may be used The displaced fragments may be approximated by means of suitable pads At the end of three weeks a ham-splint is substituted and the patient allowed to get about on crutches with his knee in a rigid splint, which can be easily removed for daily massage and passive movements At the end of five or six weeks



FIG 332.—FIBROUS UNION OF FRAGMENTS OF PATELLA (KING'S COLLEGE HOSPITAL MUSEUM)

active movements are permitted It is probable that only fibrous union is obtained by this method of treatment, but this is satisfactory and strong enough if the patient can give the time (six to twelve months) to ensure its solidification The strength of this fibrous union is best illustrated by the fact that if the bone gives way a second time, the lesion takes place through the bony, and not through the fibrous tissue When, however, the patient has to work for his living, it is essential that repair should be established at as early a date as possible, and this can only be secured by operative treatment

2 The *open plan of treatment*, originally advocated and perfected by Lord Lister, is undoubtedly the best, in that it permits of the removal of the tags of fascia and aponeurosis, which always intervene It

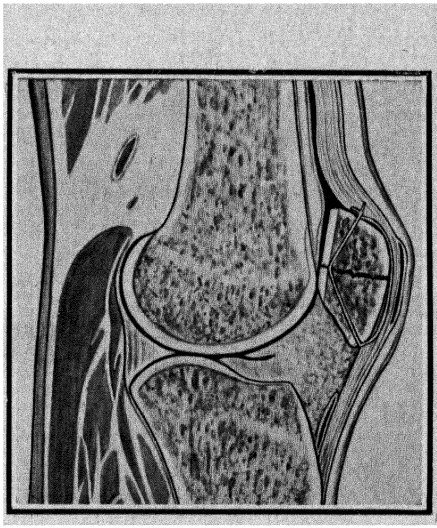


FIG 333 —LISTER'S PLAN OF SUTURING PATELLA BY OPEN OPERATION

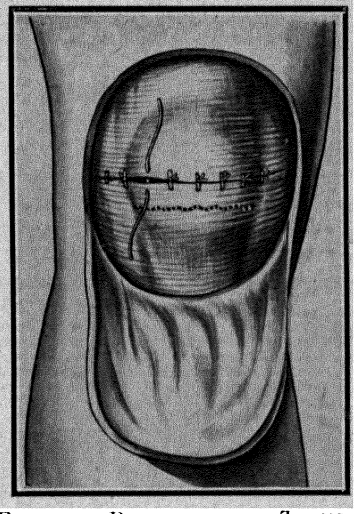


FIG 334 — RESTORATION OF TRANSVERSE FRACTURE OF PATELLA BY CATGUT SUTURES APPROXIMATING THE FIBRO-PERIOSTEUM

may be wise to delay operation for a few days in order that the joint may recover from the immediate effects of the injury

A horseshoe-shaped flap is turned down, exposing the fractured ends of the bone, which are cleared of all clot and fibrous shreds Tracks for the wire sutures are now made by a drill, extending from the upper and lower ends through the centre of the bone, so as to emerge on the fractured surface just in front of the articular cartilage (Fig 333), should the drill emerge at different levels on the faces of the fragments, cartilage or bone must be chipped away to make a channel in which the wire may lie, so that the two fragments are exactly level, with no inequality of the articular cartilage A stout sterilized silver wire is then passed, the bones are brought into apposition, and the wire twisted into a knot or loop, which is hammered or pressed down into

the tendinous or periosteal tissue over the upper fragment, so as to keep it from projecting under the skin and causing irritation A second wire is sometimes needed in order to prevent rotation of the fragments The wound is closed, and the limb kept on a ham splint (Fig 335) In healthy adults passive movement may commence in

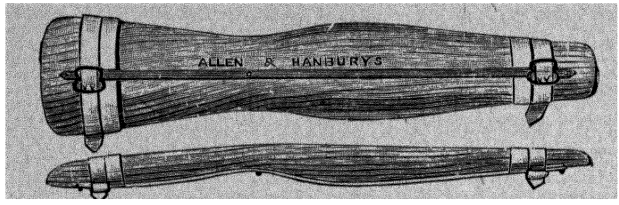
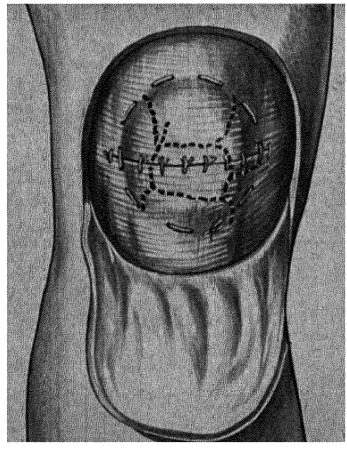


FIG 335 — HAM SPLINT, WHICH IS USED AFTER OPERATION FOR FRACTURED PATELLA

ten days, and by the end of a fortnight the patient is allowed to walk in the simpler cases, but in complicated fractures and in elderly people it is better to keep the limb immobilized for a little longer period

Of recent years there has been a considerable reaction against the method of burying silver wire in the tissues, especially when passing through a bone exposed to tension or movement The wire may become disintegrated and break, or rarefactive osteitis may be caused thereby Surgeons at the present time are rather favouring methods which depend on absorbable ligatures in the form of unchromicized catgut The joint is opened and cleansed of blood-clot, and loose fibrous tags are removed Antero-



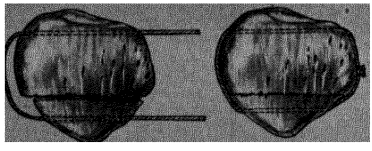


FIG 336 — DIAGRAM SHOWING HOW A FRACTURED PATELLA MAY BE WIRED IN A HORIZONTAL MANNER

FIG 337 — COMMINUTED FRACTURE OF PATELLA TREATED BY INTERRUPTED SUTURES

posterior *cerclage* of the bone with two or three strands of stout catgut is undertaken, and after bringing the fragments into apposition by manipulation these are firmly tied (Fig 337) The rent in the fibro-periosteum and lateral tendinous expansions is also closed by sutures In cases where there is but little displacement, the cerclage sutures

may be omitted, in others, especially when the bone is in more than two fragments, a circumferential cerclage may be desirable as an added precaution After-treatment is much as indicated above, but active movements are perhaps commenced a little later, in that catgut is being relied on, and not silver wire, to maintain the co-apposition of the fragments until the time when osseous union is fully established

In cases which have not been operated upon, and where fibrous union and an unstable joint have resulted, it may be impossible to get the fragments together by open operation Much, however, can be achieved by taking a strip of fascia lata and passing it through the lower part of the quadriceps tendon, and then through the ligamentum patellæ, as practised by Hey Groves (Fig 338) This operative procedure has a definite stabilizing effect on the joint, and patients can often resume their occupations

If the fragments cannot be brought absolutely together, the same treatment may be adopted, and the patient allowed to get about with a loop of silver wire between the fragments, the quadriceps is stretched by this means, and a subsequent operation may prove successful in gaining bony union



FIG 338.—METHOD OF STABILIZING THE PATELLA IN AN OLD-STANDING CASE WITH FIBROUS UNION

A strip of fascia lata is turned down and made to encircle the patella passing the quadriceps extensor tendon above and through the ligamentum patellæ below

Fractures of the Leg

Fractures of the Tibia Alone —Several varieties are described

(*a*) **Fracture of the Spine** on the articular surface is accompanied by much bleeding into the joint If the displaced fragment is not replaced, permanent disability will result Usually this can be effected following aspiration of the joint under full aseptic conditions by extending it to the full and maintaining the extension for two months Until the swelling has subsided it is desirable to apply a pressure bandage and a back splint, this subsequently being replaced by a plaster cast with a walking-iron Occasionally open operation is required, when the fragment will be either seated firmly down into its bed or removed

(*b*) **Fractures of the Condyles** —Either one or both condyles may be fractured If the lateral one is fractured, there will be a certain amount of abduction deformity, and if the medial one adduction is present Reduction is effected by strong traction in a longitudinal

axis with an element of abduction or adduction opposite to that of the deformity, the limb being put up in plaster in extension for two months Where both condyles are affected strong traction exerted through a pin passed through the os calcis is required This is maintained for six weeks or so, the limb then being put up in a spica with a walking-iron for a further two months Occasionally open operation and fixation of the fragments with a peg or nail are required

(*c*) **Fractures of the Shaft of the Tibia** are usually caused by direct violence They are transverse in the upper part of the bone and oblique

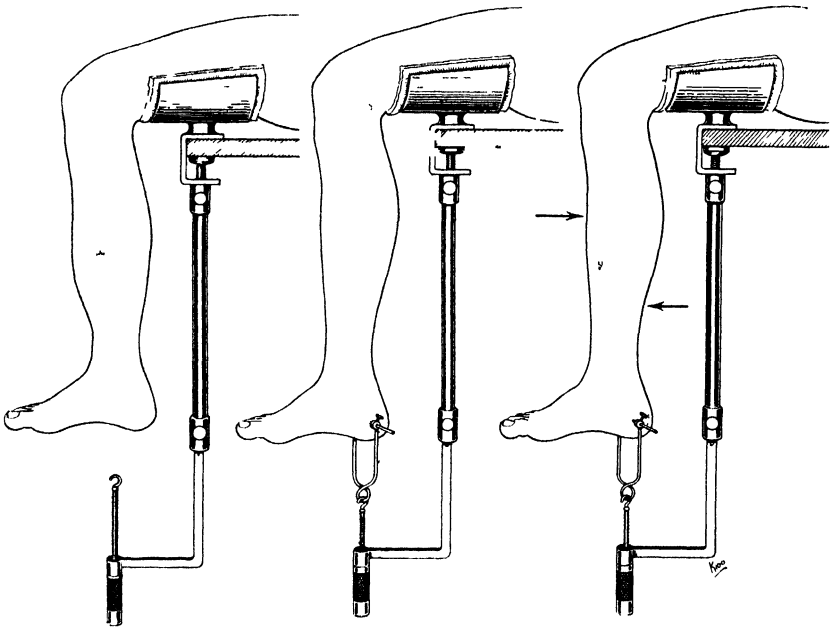


FIG 339.—REDUCTION OF A FRACTURE OF THE SHAFT OF THE TIBIA BY TRACTION WITH A PIN THROUGH THE OS CALCIS (WATSON-JONES)

below The fracture is diagnosed by feeling an inequality on running the fingers along the shin, together with pain at this spot on firmly grasping the bones above and below There is often but little displacement, since the fibula acts as a splint, but the lower end of the upper fragment, which is usually pointed, is tilted forwards by the action of the quadriceps, and may pierce the skin Reduction is usually easy to effect by traction and manipulation, although occasionally in a transverse fracture it is necessary to pass a Steinmann's pin and exert strong traction through this before the slight overlap which is present can be reduced and the ends disimpacted (Fig 339) A plaster cast extending to the knee is then applied, and if there is much

bruising it is best to bivalve this until it has subsided If the cast is then loose, a new one is applied fitted with a walking-iron and left on for two months or more

(*d*) The **internal malleolus** is occasionally separated as the result of direct injury, apart from any other osseous lesions, constituting what is known as *Wagstaff's fracture* There is comparatively little displacement, but the malleolus is loose, and crepitus can usually be obtained on moving it backwards and forwards Union by fibrous or osseous tissue ensues, but often in a more or less abnormal position, in consequence of which the integrity of the ankle-joint is disturbed, and weakness or lameness may follow **Treatment** consists in bringing the fragment into position by inversion of the foot and manipulation, and maintaining this by strapping or plaster of Paris for some weeks, massage and gentle movements are, of course, allowed after a week or ten days, but only if the movements are painless Failure in reposition of the fragment necessitates its fixation by operation, a bone-peg is the best to use

Fractures of the Fibula alone are by no means uncommon In those of the shaft there is usually a minimum of deformity and little pain They are due to direct violence It suffices to apply a plaster cast to the lower leg, allowing this to remain on with a walking-iron for six weeks When direct violence is applied to the inner aspect of the knee-joint the head of the fibula may be fractured with considerable displacement, and perhaps injury to the external popliteal nerve Only open operation can effect efficient reduction, and the fragments are maintained in position by wiring A plaster cast extending to the tuber ischii is applied for six weeks If efficient reduction of the fracture is not performed, weakness of the knee-joint and often involvement of the nerve will result

Fracture of both Tibia and Fibula is a very common accident, due to both direct and indirect violence, if to direct violence, any part may be injured, both bones yielding at the same level, but if in consequence of an indirect injury, the tibia usually gives way at its weakest part, *viz* at the junction of its middle and lower thirds, and the fibula at a higher level The fractures are often oblique, running in any direction, although the obliquity is most frequently directed downwards, forwards, and inwards The lower fragment is generally drawn upwards on account of the contraction of the powerful calf muscles, and often rotated outwards from the weight of the foot, hence there is well-marked shortening The ordinary characteristics of a fracture are very evident, and but little difficulty can ever be experienced in making a diagnosis The fracture is likely to become compound when due to indirect violence, owing to the sharp end of the upper fragment of the tibia piercing the skin

The fracture of the tibia has been proved by radiography to be frequently of a spiral character, and is then probably always due as much to forcible torsion of the limb as to vertical strain The rotation is an important element, and the shortening is sometimes less marked than in simple oblique fractures, there is frequently some difficulty in getting satisfactory approximation of the fragments, even on opera-

tion, owing to the broken ends becoming engaged in the fibro-muscular tissues around

Treatment.—In those fractures in which the displacement is minimal or where simple traction is sufficient to produce reduction in a good position—and this especially applies to transverse fractures—it is sufficient to apply a plaster slab extending from the toes to the knee joint and fix this by turns of plaster bandage Sometimes where the fracture is higher up it is advisable to include the thigh in the plaster in addition to the lower leg The foot should be placed as near the right-angle position as is possible, but if dorsiflexion to that extent produces displacement of the fracture it should not be insisted

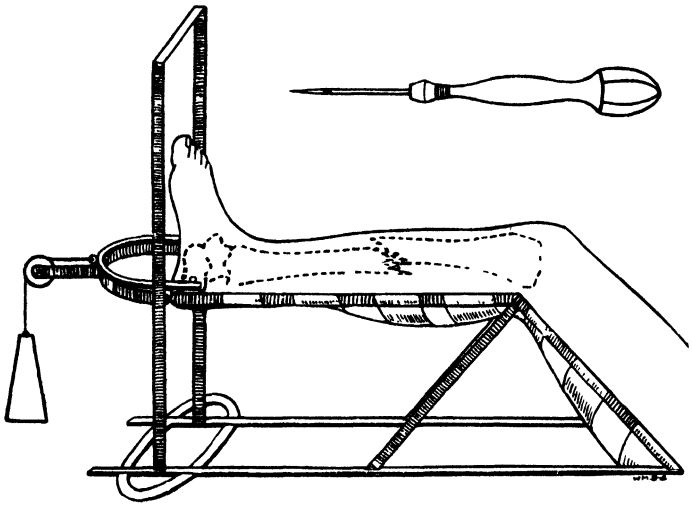


FIG 340—BRAUN'S SPLINT

The leg is supported on flannel slings Traction is made from a pin passed through the os calcis by the weight which hangs over the end of the bed Counter-extension is obtained by tilting up the lower end of the bed on blocks The shape of the splint ensures that the knee is kept flexed but allows the patient to be propped up in bed with pillows The pin and its introducer are seen above

on It is absolutely essential to keep an eye on the limb for the onset of any swelling subsequent to the application of the plaster, and if more than a minimal amount appears around the toes the plaster must at once be bivalved or even removed to avoid the possibility of gangrene occurring When the patient is going to be away from observation, it is necessary to bivalve the plaster at the time of its application The following day the patient is fitted with a walking iron and is allowed to get about The plaster should be retained until union has occurred, a process taking three months or more Often following the removal of the plaster there is some reactionary œdema of the leg, but this can be prevented by applying either Unna's paste or elastoplast before the patient starts weight-bearing When

following reduction the displacement recurs, some alternative treatment is required One of two methods may be adopted The traction may be maintained by means of Steinmann's pin passed through the os calcis, the limb being set up in a Braun's splint (Fig 340) and supported in its reduced position by a plaster cast applied to the calf and foot When sufficient callus has formed effectively to prevent any further displacement, usually in some six weeks' time, a walking-iron is applied for a further similar period (Fig 328) This method should be used for the treatment of compound fractures in these bones, because besides maintaining a reduced position it enables any dressings that may be required to be effectively carried out However, this method has all the disadvantages of keeping the patient in bed for some time To avoid this Bohler has devised a very effective form of ambulatory treatment A pin is passed through the lower end of the tibia and fibula and another through the spine of the tibia The fracture is reduced by traction exerted through the lower pin, and the limb is then encased in plaster while extension is maintained When the plaster has set around the projecting ends of the pins, these are held immobilized and thus effectively prevent any recurrence of the displacement A walking-iron is fitted and the patient enabled to get about Some surgeons in severe fractures advocate open operation with maintenance of position by some mechanical device, but the cases in which this is required are few

Fractures in the neighbourhood of the Ankle-joint are usually produced by indirect violence, such as wrenches, twists, slips, or falls on the feet Lateral displacement of the abduction or adduction type was formerly considered to be the chief cause, but radiography has demonstrated that forced movements of version are even more important and frequently accompany the former—eversion with abduction, and inversion with adduction—and the resulting fractures are correspondingly modified In addition, when once the tibio-fibular mortice has been impaired, the weight of the body aggravates the mischief, whilst the back-push of the foot may damage the posterior margin of the tibia, causing the so-called marginal fracture which complicates many of the more serious lesions These accidents should therefore be termed *fracture dislocations of the ankle*

1 Fractures due to **Displacement of the Foot outwards** constitute by far the largest and most important group They result from the patient slipping on the inner side of the foot, as from off a kerbstone The two elements of eversion and abduction enter into and colour the picture, and may be combined in many ways to produce various types of injury

(*a*) In the *simpler* forms, one or both bones may be broken, but there is no lateral displacement of the foot and astragalus if the inferior tibio-fibular ligament remains intact When the foot is forcibly displaced outwards, the strain mainly falls upon the internal lateral ligament, and this gives way or the internal malleolus is torn off if the stress is too severe The astragalus is thereupon driven outwards against the external malleolus, and excess of violence leads to fracture

When *eversion* is the chief cause of the lesion, the fracture is generally

oblique from above downwards and forwards, it may pass through the malleolus or be situated above it, but, of course, in the latter case there is more deformity

In the *abduction* type the fibular fracture is more or less transverse, the upper end of the lower fragment being displaced inwards It is possible for both malleoli to be broken off at their bases and displaced inwards or outwards, but this *bi-malleolar fracture* is very uncommon and of a different character entirely In the abduction group the fibula is usually broken just above the malleolus, but often somewhat higher It was to a fracture of this type placed about 3 inches above the tip of the malleolus and associated with injury to the internal malleolus or internal lateral ligament with marked abduction of the foot that the term *Pott's fracture* (Figs 341 and 342) was originally applied

When forcible eversion and abduction are combined in producing the fracture, a more complicated type of injury may result, and not unfrequently some degree of comminution may co-exist

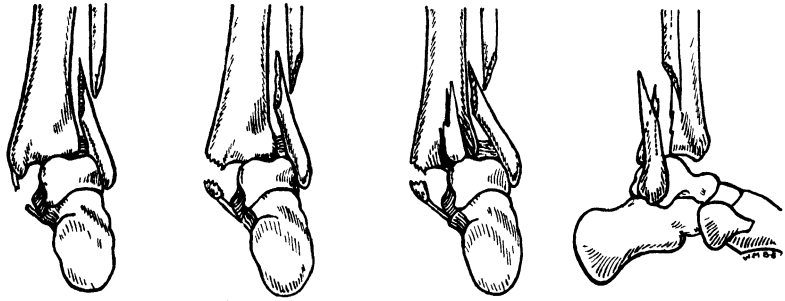


FIG 341 FIG 342 FIG 343 FIG 344

FIGS 341-344 —DIAGRAMS OF POTT'S AND DUPUYTREN'S FRACTURES SEEN FROM BEHIND AND LATERALLY TO SHOW DEFORMITY AND LESIONS IN THE BONES

(*b*) A much more serious injury is that to which the term *Dupuytren's fracture* (Figs 343 and 344) has been applied In this the interosseous tibio-fibular ligament yields more or less completely, or the flake of the tibia to which it is attached is torn off, the foot, carrying with it the lower portion of the fibula and the superficial flake of the tibia, which has been detached, is displaced firstly outwards, and so long as the upper surface of the astragalus does not clear the lower articular surface of the tibia, there is merely lateral displacement with marked abduction of the foot and increased breadth of the ankle Should the force continue to act, the astragalus may be carried sufficiently outwards to clear the lower end of the tibia, and then an upward and to a less degree a backward displacement is added, causing great eversion of the foot and deformity of the ankle On the inner side either the ligament or the malleolus may yield It is often associated with a marginal fracture of the posterior lip of the tibia

(*c*) In another variety the injury consists in the usual type of fracture of the fibula, associated with an almost transverse fracture of

the tibia, just above the base of the inner malleolus In this form the lower end of the shaft of the tibia projects beneath the skin, and is likely to be mistaken for the tip of the malleolus, if this error is committed, and the fracture allowed to unite without proper rectification, considerable deformity results (Fig 345)

(*d*) A similar injury in children and young people may produce a separation of the lower epiphysis of the tibia, whilst the fibula yields at a higher level The line of separation in the tibia is more or less transverse, but may extend into the diaphysis on the outer side

(*e*) Finally, in not a few cases wedge-shaped *marginal* chips may be broken off the anterior or posterior edges of the articular surface of the tibia, according to the direction of the violence

In almost all of these varieties the ankle-joint itself is involved, and this, combined with the amount of bleeding that occurs into tendon sheaths and muscles around, and the difficulties sometimes experienced in complete reduction, explains why the results are frequently so unsatisfactory Sometimes after union has occurred pain and deformity become increased owing to the patient being allowed to walk too early, the result being that the callus yields to the weight of the body Should union occur with the foot in a false, *i e* everted, position, a large mass of callus develops between the shaft of the tibia and the malleolar fragment (Fig 345)

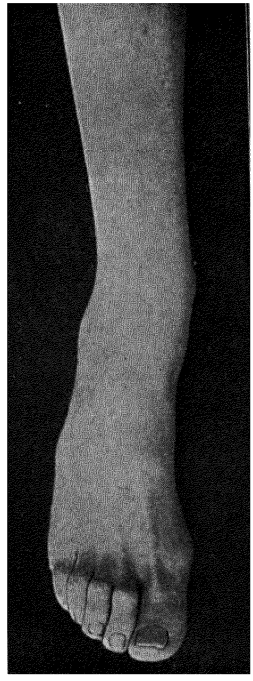


FIG 345.—MALUNITED SUPRA MALLEOLAR FRACTURE, SHOWING CHARACTERISTIC ABDUCTION AND EVERSION

2 **Displacement of the Foot inwards** — When the patient slips on the outer aspect of the foot, the astragalus is forcibly driven against the inner malleolus, which may be broken off or impacted into it The outer malleolus is dragged inwards with the foot, and owing to the integrity of the inferior tibio-fibular ligament, which acts as a fulcrum, the fibula yields at the same spot as in Pott's fracture The foot is displaced inwards, and perhaps slightly backwards

3 **Displacement of the Foot backwards,** by catching the heel and tripping forwards, is usually associated with fractures of the tibia and fibula through or just above the malleoli, but eversion of the foot is absent

It is essential in all injuries of the ankle to have a thorough radiographic examination, which should be both antero-posterior and lateral The importance of this is evident from the fact that many an oblique

fracture of the internal malleolus is scarcely visible in an antero-posterior radiograph, although very evident displacement is really present It is also most desirable that the limb should be again radiographed after reduction and fixation, as it is extremely easy for some recurrence of the displacement to take place during the application of the retentive dressing

Treatment.—The surgeon cannot exercise too much care in the reduction of the deformity caused by these fractures The following points must be carefully noted (*a*) The foot must be at right angles to the leg, and with this object in view treatment must be conducted, at any rate for a time, with the knee bent so as to relax the tendo Achillis (*b*) The heel must not project unduly backwards, thereby indicating that reduction has not been perfectly accomplished The articular surface of the astragalus should be within the grasp of the tibio-fibular mortice, and there must be neither anterior nor posterior projection if movements are to be subsequently free (*c*) Lateral displacement and torsion must also be corrected, and apart from radiography this is secured when the inner surface of the great toe, the internal malleolus, and the inner edge of the patella are in the same plane It is well, however, to compare the foot with its fellow, and in every case to have the limb radiographed after reduction

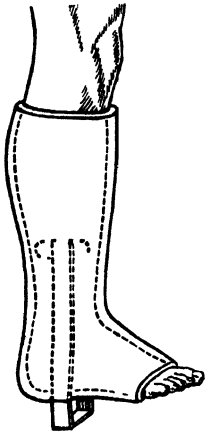


FIG 346.—PLASTER AND METAL STIRRUP AMBULATORY SPLINT

In reducing these fractures, therefore, the knee must be flexed and counter-extension made therefrom, traction is then exercised upon the foot to overcome both the antero-posterior, the lateral, and the rotary displacements Manipulation will determine that a broken internal malleolus is in apposition with the shaft, and that the anterior edge of the tibia does not project unduly over the articular surface of the astragalus

Reduction having been obtained, fixation is best secured by means of a plaster-cast extending from the tip of the toes to a point just below the knee-joint The foot should be at right angles to the tibia, and the os calcis slightly inverted, the fore-part of the foot 'square' with the ground, as in walking (Fig 346)

Massage and movements are usually unnecessary until after the fracture has united, if ambulatory treatment be adopted A walking iron should be fitted and the patient told to walk, without crutches, after two or three days The period required for union is about ten weeks When the cast is removed it is wise to substitute a firm bandage of crêpe or elastoplast to limit œdema

In cases where the displacement cannot be maintained by the plaster, continuous traction should be exerted for several weeks with the limb supported on a Braun's splint with a posterior supporting plaster cast, and by means of a Steinmann's pin passed through the os calcis

Operative treatment is quite justified in cases where it is impossible to reduce the fragments by manipulation under a general anæsthetic The replacement of the astragalus in a complete tibio-fibular mortice is so important that surgeons should not hesitate, when asepsis can be assured and the necessary manipulative skill is available, to cut down on and fix by plates or screws the separated fragments A short plate on the fibula reaching above and below the line of fracture has a wonderful steadying effect upon the parts, especially if one of the screws be of sufficient length to traverse the fibula completely and penetrate the tibia, it can be easily removed under a local anæsthetic at a later date when it has done its work

In cases of vicious union after Pott's fracture, it is usually necessary to redivide the fibula, and to excise a V-shaped portion of the tibia, perhaps extending into the ankle-joint, so as to enable the malleolus to be brought into contact with the shaft The lower fragment must be fixed to the upper by a plate, screw, or peg

Attention has already been drawn (p 627) to a serious sequela of the fractures induced by abduction and eversion (and these probably constitute 90 per cent of the whole), *viz* the development of flat-foot Naturally it results from an unremedied displacement, but even when reduction has been effectively secured and the bones have healed in good position, it may occur if walking is permitted too early, or especially if the arch of the foot is not sufficiently supported, and the weight deflected to the outer side by increasing the thickness of the sole of the boot on the inner, whilst the use of a walking-caliper is another necessary precaution

Fracture of the Os Calcis is a common complication of falls on the feet from any but a very small height The bone consists of a shell of compact bone which splits longitudinally when subjected to excessive strain, the lateral portion and the sustentaculum tali together with the medial portion of the posterior articular surface being separated from the central portion Occasionally the anterior part of the bone is crushed, and on other occasions the lower and posterior part of the bone may be fissured Associated with muscular action the so-called 'beak' fracture or separation of the posterior part of the tuberosity just above the insertion of the tendo Achillis results The fracture is recognized by the pain over the bone, the bruising on the plantar surface, and the broadening in this region X-rays will reveal the extensive fissuring and comminution that is present (Fig 347), and it seems small wonder that the ultimate result of treatment of these fractures is often eminently unsatisfactory and accompanied by some such subsequent pain that subastragaloid arthrodesis is sometimes required

Treatment.—Where there is little displacement or simple fissuring of the bone all that is required is to put the limb up in plaster, which may be fitted with a walking-iron, and maintaining this for some eight weeks or so In treating the 'beak' fracture the displaced fragment can easily be replaced if the foot is held in a position of partial plantar flexion, which position is maintained during the period of immobilization In all other cases an attempt must be made to restore the bone

to its normal shape This is effected by exerting traction through a pin passed through the os calcis of some fifteen pounds' strength, and while this is maintained squeezing the lateral walls of the os calcis together either manually or with a clamp This traction, exerted whilst the leg is placed on a Bohler's traction apparatus, reduces the vertical squashing of the bone and restores the angle which the anterior part of the superior surface makes with the posterior to approximately normal Any antero-posterior shortening of the bone is corrected by traction exerted, not in the long axis, but at an angle of 45 degrees to this posteriorly One of two procedures may then be adopted Either the limb may be set up in a Braun's splint with continuous traction for some three months, or else while traction is maintained



FIG 347 —FRACTURED OS CALCIS

a pin is passed through the lower end of the tibia, and this and that through the os calcis are incorporated in the plaster, thus preventing a recurrence of the displacement when the traction is withdrawn A walking-iron may then be fitted and the patient allowed to get about in this It should be maintained for some three months

Fractures of the Astragalus may result from direct injury or from falls on the feet, and may affect the body or neck of the bone If there is much comminution and collapse of the body, traction by a pin through the os calcis should be exerted for some six weeks, a walking-plaster then be substituted for a further similar period Often, however, a fixed ankle will result In fractures through the neck, the fractured surface of the proximal portion is rotated downwards, and

so strong traction with the foot in plantar flexion is necessary to impact the fractured ends, the limb then being put up in plaster in slight plantar flexion

Fractures of the Metatarsals usually result from direct injury, but occasionally may occur as a result of prolonged marching over uneven roads (march fracture) Where no displacement exists, the leg and foot should be put up in a walking-plaster for some five or six weeks In cases of displacement a wire frame with traction similar to that used for fractured fingers should be employed

CHAPTER XXI

DISEASES OF BONE.

General Considerations.—Bones are divided into the long, the short, and the flat, each of these consisting of compact and cancellous tissue In the short bones there is but a thin layer of compact tissue surrounding a cancellous central mass, the meshes of which are filled with medullary fat and connective tissue In the flat bones the compact tissue forms two limiting plates, separated by a layer of cancellous tissue (known in the skull as the diploe) In long bones the shaft consists of a tube of compact structure, surrounding a space which is normally filled with medulla, and known as the medullary canal, at each end it gradually merges into a larger mass of loose cancellous tissue, the interstices of which are similarly packed with vascular fatty medulla, which apparently performs the function not only of maintaining the nutrition of the bone, but also of elaborating the blood Prolongations from the medulla extend into the Haversian canals, and are thence continuous with the periosteum, so that the mineral skeleton has incorporated within it a vascular fibro-cellular mass which permeates the whole structure

The *vascular supply* of a bone is derived (*a*) from the nutrient artery which passes into the medullary space, and there breaks up into branches which ramify through the whole of the medullary tissue, and thence extend into the Haversian canals, and (*b*) from the periosteum, an exceedingly vascular ensheathing membrane, from which small vessels pass perpendicularly into the Haversian canals, and establish a communication between the two systems These latter vessels are especially numerous and large close to the epiphyses Large veins occur in the medullary and cancellous interior, and are frequently thrombosed in inflammatory mischief, if the thrombus becomes infected, and so disintegrated, pyæmia is very likely to ensue

The *growth* of bone manifests itself in three different directions (i) It increases in length from the shaft side of the epiphyseal cartilage (or metaphysis), the epiphysis itself growing but little In the upper limb the chief increase in length occurs at the shoulder and wrist, whilst in the leg it is mainly evident on either side of the knee-joint, and this in spite of the fact that the so-called nutrient arteries are directed away from these points (ii) Increase in breadth is produced by new formation under the periosteum (iii) A bone increases in density by a new deposit of osseous tissue around the Haversian canals and cancellous spaces

Finally, it must be pointed out that the development and growth of the skeleton are largely dependent on the healthy activity of the

ductless glands, the pituitary and thyroid bodies certainly have considerable influence, and it is possible that the suprarenal, pineal, and thymus bodies are also not without effect Enlargement of the parathyroid glands due to over-activity results in generalized osteitis fibrosa, a disease which may be arrested by the removal of the enlarged parathyroid Moreover, efficiency of the food-supply and the presence of sunlight or its equivalent, together with the provision of certain mineral salts, are necessary if healthy bone is to be laid down or maintained

Inflammation of Bone.

Much needless confusion has arisen in connection with this subject owing to the undoubted difficulty of understanding the pathological phenomena, but also largely due to careless and contradictory nomenclature The following considerations may assist in making the subject more clear

1 All inflammatory affections of bony tissue might rightly be termed **osteitis,** but when the medullary cavity of a long bone is particularly affected the term **osteomyelitis** is substituted, as also sometimes when masses of cancellous tissue, as in the os calcis, or sheets of it, as in the diploe, become the seat of acute inflammation The term **periostitis** applies to the ensheathing membrane, the vascular connection between it and the underlying bone explains why inflammation of this structure is always associated with a superficial or deep osteitis, and why in an acute infective inflammation of the medulla of a long bone the periosteum is also liable to be affected

Epiphysitis is the term applied to inflammatory affections of an epiphysis, which it must always be remembered has a vascular supply distinct from that of the diaphysis As will be explained later, acute pyococcal affections do not often commence in the epiphysis, although it may be involved secondarily in an inflammation commencing in the neighbouring shaft, chronic diseases, *e g* tubercle and syphilis, do, however, involve epiphyses more frequently, though they are not limited to them

2 In all inflammatory affections of bone the vascular structures are primarily involved, *i e* the medulla and its prolongations, the mineral element is only affected secondarily The resulting phenomena, *viz* hyperæmia, exudation, and tissue change, differ in no wise from those seen elsewhere, save that the effects are modified by the limited space in which the vessels lie, and the resisting character of the surrounding bony tissue Hence any *acute* inflammation involving compact bone, associated with vascular engorgement and rapid exudation, leads to *necrosis* from thrombosis, due to increased pressure within the unyielding bony canals If, however, the bone involved is cancellous, or the process *subacute,* so that the tissue-liquefying properties of the exudation and the tissue-absorbing activity of the leucocytes can come into play, then *osteoporosis* or *rarefaction* of the bone follows, a condition sometimes termed *caries* Not unfrequently, however, some of the more resistant fragments of the bony cancelli escape absorption and die *en bloc,* constituting a condition of *caries-necrosis* On the

other hand, if the inflammation is *chronic*, and due to causes other than tubercle or the pressure of tumours, then new formation occurs, and *osteosclerosis*, or condensation, is most likely to result Tubercle in bones, as elsewhere, causes primary rarefaction of the tissue attacked, though sclerosis may be associated with or follow it

3 It must always be remembered that necrosis, caries, and sclerosis of bone are **results** of inflammation, and not pathological processes or distinct disease Each of them may arise from many distinct causes Thus **Necrosis** results from the following conditions (*a*) From acute localized suppurative periostitis, the sequestrum or dead mass being then simply a superficial plate or flake of the compact exterior (Fig 348), the process by which it is cast off being described as 'exfoliation', (*b*) from acute infective osteomyelitis, the sequestrum often involving the whole thickness of the bone, and invading more or less of the length of the diaphysis, if the condition is not early and efficiently treated (Figs 352 and 355), (*c*) from acute or subacute infective osteitis of cancellous bone, the sequestra being small spiculated fragments of the bony cancelli which have escaped absorption, (*d*) from tuberculous disease of cancellous tissue, the sequestrum being light and porous, often infiltrated with curdy material, and rarely separated completely from surrounding parts (Fig 364), (*e*) from syphilitic disease of cancellous or compact tissue, usually resulting from excessive sclerosis, or gummatous disease of the periosteum which has become septic (Fig 366), (*f*) from the action of local irritants, *e g* mercury or phosphorus fumes gaining access to the interior of the teeth, (*g*) occasionally as a simple senile loss of nutrition, as in senile gangrene, and (*h*) a variety described by Sir James Paget under the name of 'quiet necrosis,' occurs as a result of direct injury, the sequestrum separating without suppuration, it is one of the causes of loose bodies in joints, and especially the knee, following a blow on one of the condyles

The presence of dead bone in a limb may be suspected when one or more sinuses are present, discharging pus or serum according to circumstances, with puffy granulations, pouting round the opening, and the underlying bone thick and enlarged A probe passed down the sinus can usually be made to strike against the sequestrum, perhaps after passing through a casing of new bone, and its fixity or freedom may be demonstrated in this manner

Caries, or, as it is sometimes called, *osteoporosis* or *rarefaction of bone,* is characterized by a soft and spongy state of the bone, which, if it can be reached, readily breaks down on pressure with a probe It may result from the following conditions (*a*) from acute or subacute infective inflammation of cancellous tissue, (*b*) from tuberculous affections of the cancellous tissue or periosteum, (*c*) from syphilitic disease of the medulla or of the under surface of the periosteum The spongy vascular condition of the bone ends during the early stages of repair of a fracture is practically identical with this condition

Pathologically, it is characterized by the replacement of the medulla by granulation tissue, which usually contains some large multinucleated cells, or *osteoclasts*, and these seem to be closely connected with the removal of the bone The cancellous tissue becomes hollowed

out to accommodate these granulations, and the osteoclasts are usually found occupying shallow depressions known as 'Howship's lacunæ' In tuberculous and syphilitic lesions the bone corpuscles often undergo fatty degeneration

Caries may occur with or without suppuration (*C sicca* or *suppurativa*), sometimes the development of granulation tissue is excessive, as when it fungates into a joint (*C fungosa*) Not unfrequently it is associated with necrosis, constituting a condition of *caries-necrosis* (or *C necrotica*), as in infective inflammation of cancellous bone, minute spiculated sequestra being found in the discharge, whilst in tuberculous osteitis sequestra of larger size often occur In fact, caries and necrosis bear much the same relation to one another as ulceration and gangrene of the soft tissues

If caries is recovered from, a condition of sclerosis usually follows, sometimes with loss of substance and deformity

Sclerosis of bone (osteosclerosis) is invariably the result of some chronic inflammatory affection, *e g* (*a*) chronic periostitis, whether simple or syphilitic, (*b*) chronic osteomyelitis, simple, tuberculous, or syphilitic, or (*c*) chronic osteitis of the compact bone, which is always secondary to one of the former In all cases the condition is due to a slow formation of new bone within the Haversian canals or cancellous spaces, thus diminishing their lumen, in syphilis this may progress to such an extent as to lead to their total occlusion, and even to localized necrosis from lack of blood-supply, especially when sepsis gas occurred In tuberculous bones the sclerosed tissue is always at some distance from the focus of mischief, and may be looked on as Nature's attempt to limit the spread of the disease, it forms also the final tissue or bone-scar in the process of repair when a cure has been obtained by natural or surgical means

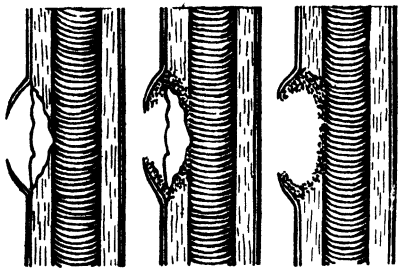
Acute Inflammation of Bone.

1 **Acute Localized Periostitis** usually arises as a result of traumatism applied directly to the bone, with or without an open wound, it may also be determined by an extension of inflammatory mischief, as in an alveolar abcesss

Pathologically, the process consists of hyperæmia and of exudation into the periosteum, which becomes swollen, turgid, and thickened This may be followed in due course by resolution, or may leave the bone thickened and in a condition of chronic inflammation, or suppuration may ensue, and with it usually a limited superficial necrosis In the last event pyogenic organisms of no great virulence find an entrance to the area of mischief, and probably in cases due to trauma through the abraded or injured skin, in other instances they may come from neighbouring foci of inflammation, or from the blood The inflammatory process extends to the small vessels entering the bone from the under surface of the periosteum, these become dilated, thrombosed and strangled by the pressure of the exudation around them, and finally pulled out from the osseous canals by the tension of the subperiosteal effusion Consequently, the vitality of the superficial layer of bone is impaired, if not destroyed, for an area corre-

sponding almost exactly to that from which the periosteum has been stripped (Fig 348, A)

As soon as tension has been relieved by the escape of the pus, repair commences Where the mischief is slight and superficial, the involved bone may entirely recover, necrotic portions being absorbed, if the surrounding parts are sufficiently vascular If the dead portion of bone is compact and more extensive, it will be separated from the subjacent living tissues by one of the processes already described, whilst on the under surface of the stripped-up periosteum a casing of new bone develops, constituting an *involucrum* or sheath, at first spongy and cancellous in texture, but finally hard and sclerosed In the centre of this new formation are found one or more openings or *cloacæ* through which the discharge escapes, and corresponding in position to the apertures in the periosteum and skin made for the exit of the pus (Fig 348, B)



A B C

FIG 348—SUPERFICIAL NECROSIS RESULTING FROM A LOCALIZED PERIOSTITIS (DIAGRAMMATIC)

A represents the necrosed tissue lying in continuity with the surrounding living bone, the periosteum is stripped up from it, and has an opening through which the pus has been discharged B shows a later stage in which the sequestrum is being separated by a process of rarefying osteitis in the immediately contiguous living bone, whilst an involucrum, or sheath of new bone, is formed from the under surface of the periosteum, a cloacal aperture remains in the involucrum for the escape of discharges C shows the condition of affairs after the sequestrum has been removed

Clinically, the symptoms of acute localized periostitis consist in the ordinary phenomena of acute inflammation, the pain being of an intense aching character, worse at night, and increased by lowering the limb or by any kind of pressure If a subcutaneous portion of bone is involved, a painful swelling develops, at first brawny in character, but when suppuration has occurred the centre softens, whilst the skin over it becomes red and œdematous When an abscess has burst or been opened, bare bone is felt beneath the periosteum, and the greater part of this denuded structure usually dies, and must then be either absorbed or separated, in either case a sinus remains for a time, leading down through a cloaca in the involucrum to the sequestral cavity From this either pus or serum will be discharged, according to whether a mixed infection of the wound has occurred or not The time required for the separation of a portion of dead bone varies with its size and density, and with the vascularity of the surrounding parts, thus it may take over three months for a sequestrum to be set free from the shaft of the femur, whereas a period of five or six weeks will suffice if the ulna or radius is involved. That the sequestrum is free may be ascertained by

moving it with a probe within the osseous cavity, or perhaps more safely by radiography

Treatment.—Rest, elevation of the limb, and fomentations are usually relied on locally in the early stages, and favourable reports have been given as to the value of Bier's induced hyperæmia If, however, the affection is not readily checked, and suppuration threatens or develops, a free aseptic incision down to the bone is the best means of preventing or limiting necrosis When necrosis has occurred, the parts must be carefully dressed and kept aseptic until the sequestrum is absorbed or set loose In the latter case an incision is made over the involucrum, the periosteum stripped from it, one of the cloacæ enlarged, and the dead bone removed The cavity will then rapidly fill up and heal by granulation

2 **Acute Infective Osteomyelitis** (*syn* **Acute Necrosis, Acute Diffuse or Infective Periostitis, Acute Diaphysitis, Acute Panostitis**).—This disease usually occurs in children, and in boys more often than in girls (6 1), and not unfrequently follows one of the exanthemata, *e g* measles or scarlet fever It generally commences before the age of puberty, and is an affection of the gravest import, the multiplicity of names attached to it suggests quite accurately that its manifestations may be very diverse in character

Pathology.—The patients are always in an unhealthy condition, with low germicidal powers, and may present one or many foci of local suppuration, *e g* diseased teeth, or ulcerated gums or throats, impetigo, otitis media, or the evidence of lesions in the gastric or intestinal mucous membranes An infected condition of the blood is almost always present before the attack The causative organisms are usually *staphylococci* (78 per cent), but *pneumococci* were found in 14 per cent , and *streptococci* in 6 per cent , these figures refer to 400 consecutive cases

A slight injury in the shape of a strain or a wrench, which is often entirely overlooked, may suffice to determine a small hæmatoma which provides a suitable nidus for any organisms circulating in the blood-stream Moreover, the fact that the vessels on the metaphyseal side of the epiphysis are end-arteries is a further determining factor in the hold-up of any circulating emboli The majority of the ligaments and not a few tendons are inserted into the epiphysis, and hence articular strain must be mainly felt in the juxta-epiphyseal region, *e g* immediately beyond these insertions It has been already mentioned that the traumatic separation of epiphyses is liable to be followed by suppuration, even in healthy children, and it is easy to understand that in an unhealthy child a very slight injury in the epiphyseal region may determine a similar process

The disease almost always starts in the soft vascular tissue of the metaphysis (p 640), but in a few instances (mainly amongst young adults) it may be preceded by a patch of localized periostitis, suggesting that an acute infection has supervened upon a subacute periosteal focus The nature and extent of the inflammatory phenomena depend largely ont he exact situation of the infective focus, the amount of resistance offered by surrounding tissues, and the virulence of the

organisms As in any other part of the body, the trouble is most likely to travel along the line of least resistance

(1) If the process commences in the periphery of the juxtá-epiphyseal region close to the periosteum, the line of least resistance will be towards that structure, and hence a *subperiosteal abscess* may form, whilst the central portions of the bone may escape almost entirely (Fig 349) The size of this abscess varies, but considerable portions of the diaphysis may be denuded, resulting in extensive necrosis It rarely spreads to the neighbouring joint, owing to the close bond of union which exists between the diaphyseal periosteum and the epiphyseal cartilage In this form an early incision to let out the pus may suffice to prevent necrosis, or, at any rate, to limit it The constitutional symptoms will be less severe than in other varieties, there is less likelihood of the development of pyæmia, and the toxic fever soon disappears after the removal of the pus Subsequently the same course of events occurs as in the localized variety of acute periostitis, *viz* an involucrum forms, perforated by one or more cloacæ, and the sequestrum in time separates

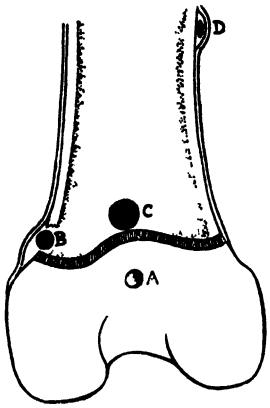


FIG 349—ORIGINAL FOCI OF OSTEOMYELITIS

A, In epiphysis, B, under periosteum at end of diaphysis, C, in metaphysis the usual site, D, under periosteum along shaft

A good illustration of this type is to be found in the acute periostitis which affects the *lower end of the femur* It almost always starts posteriorly, stripping the thin periosteum off the back of the bone as far as the bifurcation of the linea aspera Its preference for this situation is due to the fact that strains upon the knee-joint are mainly felt when the limb is hyper-extended, and that such strain is directed to the posterior ligaments, and hence the posterior portion of the epiphyseal line is likely to suffer Suppuration follows, and if not recognized and treated early, may burst through the thin periosteum and be widely diffused under the quadriceps The involucrum in this affection is often defective behind

(2) Should the process start in the centre of the metaphysis, it may spread in several directions, and the results vary considerably

(*a*) The process may reach the periosteum first, and then the phenomena of a diffuse subperiosteal abscess, as indicated above, with the addition of the symptoms due to its deeper origin, will manifest themselves This is, perhaps, the most usual course for the disease to take

(*b*) If the infection extends along the medullary cavity, the most typical form of osteomyelitis ensues (Fig 350) The medulla becomes intensely hyperæmic, the veins are thrombosed, localized foci of suppuration and gangrene appear, and in consequence of the increased pressure infective emboli are likely to be detached and pyæmia

to follow Even if the latter does not supervene, the general condition is profoundly affected by the absorption of toxins Suppuration also occurs beneath the periosteum, although the amount of pus may not be great at first, but the membrane is stripped up from the diaphysis, perhaps to such an extent as to involve the whole length and circumference of the shaft Unless prompt measures are taken to limit the progress of the disease, necrosis is certain to follow, usually implicating the whole thickness of the diaphysis, and sometimes its whole length, in fact, the diaphysis is occasionally found lying loose in an abscess cavity, the two epiphyses having been detached A similar result is sometimes due to the trouble starting at each end of the

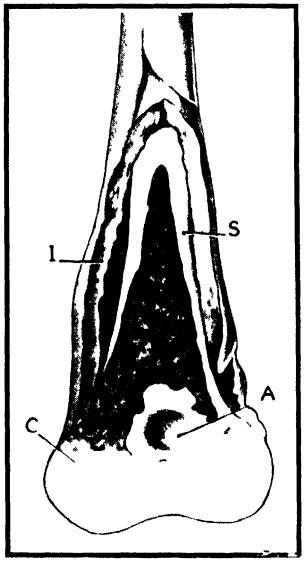


FIG 350 — ACUTE OSTEOMYELITIS OF THE LOWER END OF THE FEMUR IN A CHILD OF NINE WEEKS

A, Abscess cavity in lower end of diaphysis, S sequestrum I, involucrum C, epiphysis

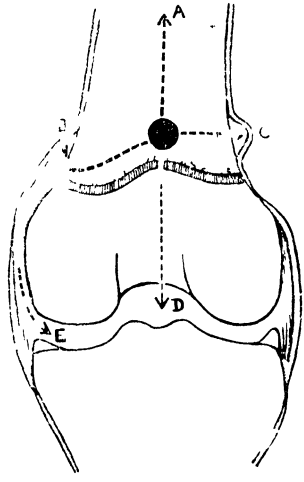


FIG 351 —SPREAD OF OSTEOMYELITIS

If the primary focus is in the metaphysis spread may occur down the medulla (A), through the compact tissue near the diaphyseal cartilage under the periosteum (B), or into the joint (L), through the compact tissue of the diaphysis to form a subperiosteal abscess (C), or directly through the epiphysis into the joint (D)

diaphysis As a rule the epiphysis, even though detached, retains its normal position, but sometimes it becomes displaced, and then deformity results

(*c*) Owing to the intimate connection between the periosteum of the diaphysis and the epiphyseal cartilage, the [illegible] joint usually escapes infection, although it is often the site of a sterile synovial effusion Should, however, the epiphyseal line be within the joint, as in the hip, it must perforce become the seat of an acute infective arthritis as soon as the bacteria reach its periphery The elbow-joint is similarly liable to suffer when bacteria attack the

upper end of the ulna, since the epiphysis is a mere flake of bone, and the greater part of the olecranon is derived from the shaft. Sometimes the junction cartilage is softened and destroyed by the organisms, so that the inflammation spreads through the epiphysis to the articular cartilage, which is eroded, and the joint opened. Occasionally the pus burrows along the soft tissues outside the bone, as along the biceps groove into the shoulder-joint.

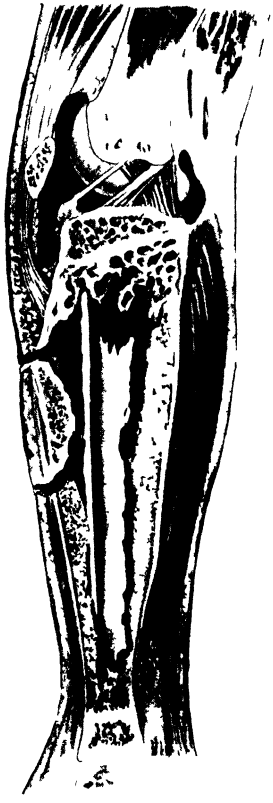


FIG. 352.—OSTEOMYELITIS OF THE TIBIA (KING'S COLLEGE HOSPITAL MUSEUM).

The sequestrum composed of the eroded diaphysis, lies in a cavity surrounded by new bone from which discharging sinuses open on to the skin. The knee-joint is distended with fluid.

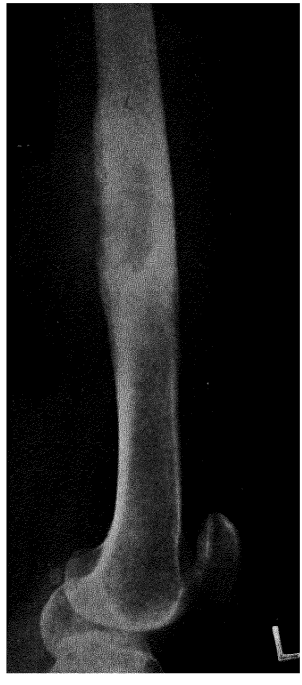


FIG. 353.—CHRONIC ABSCESS IN THE MIDDLE OF THE SHAFT OF THE FEMUR (BRODIE'S ABSCESS).

(*d*) When the organisms are of a less virulent type, the process may be much more localized and subacute in nature, resulting in a limited central necrosis, or in a chronic abscess inside the bone (*Brodie's abscess*) if the part involved consists of a mass of cancellous tissue, as in the head of the tibia. A similar condition may affect certain epiphyses which occur away from joints, and some chronic abscesses in such situations as the great

trochanter may be explained on these grounds A chronic abscess of this nature may exist for many years, and cause much thickening of the surrounding bone from sclerosis (Figs 353 and 354)

Another mild type is that known as **Albuminous or Serous Osteomyelitis** It is usually seen in young children, and in not a few cases is due to the pneumococcus, but in others is caused by a staphylococcus of low virulence, *e g* the *St pyogenes albus* The local and general phenomena are both less severe in character, and often clear up without the onset of necrosis The swelling is brawny and œdematous, and even if pus forms it is delayed and not accompanied by acute pain, neighbouring joints are likely to be distended with a serous exudation The temperature does not run high, and there is but slight leucocytosis Early operation does harm in these cases, which should be treated by rest and hot applications If an abscess forms, it is opened and drained, and if necrosis occur no attempt must be made to remove the sequestrum until it has separated

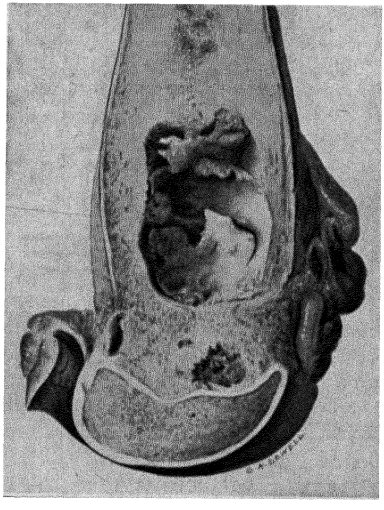


FIG 354 —LOCALIZED ABSCESS IN THE LOWER END OF THE FEMUR EXTENDING FROM THE EPIPHYSEAL LINE UPWARDS INTO THE MEDULLA (FROM SPECIMEN IN THE COLLEGE OF SURGEONS MUSEUM)

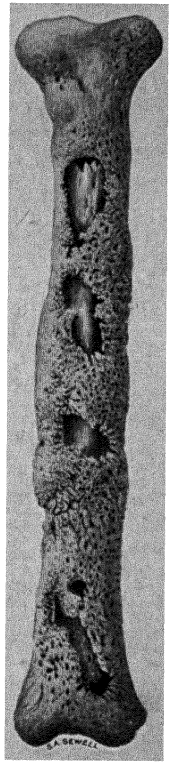


FIG 355 —NECROSIS FOLLOWING ACUTE OSTEOMYELITIS (FROM SPECIMEN IN COLLEGE OF SURGEONS MUSEUM)

The irregular new bone of the involucrum is well seen, and within it portions of the sequestrum

An occasional result of a subacute non-suppurative osteomyelitis

is bending of the affected bone, especially if the patient is unable to put any pressure or weight on it

(3) In the flat bones, such as the innominate, scapula, and those of the cranium, the cancellous tissue becomes filled with pus, and owing to the abundant supply of veins pyæmia is very likely to develop Abscesses may form on both sides of the bone, and a large extent of necrosis may result In the skull a subcranial abscess may develop, and possibly a true abscess in the brain

Clinical History.—The disease usually commences abruptly with a rigor, followed by high fever and severe pain in the limb, which soon becomes swollen, brawny, and congested It may be mistaken for an acute attack of rheumatism, although the fact that the interarticular portion is affected, and not the joint, should prevent this error The pain is of an extremely severe nature, so that the child screams whenever the limb or even the bed is touched

Should the trouble be mainly limited to the periosteum, evidences of its being stripped off the bone and of the accumulation of pus beneath it soon show themselves An abscess forms which may quickly transgress its periosteal boundary and burrow under fascial or muscular planes, its limitation to the diaphysis has been already explained, but, although the neighbouring joints may escape infection, they are very likely to suffer from a serous exudation, and subsequently some restriction of movement may be observed Sooner or later the abscess bursts or is opened, giving exit to a larger or smaller quantity of pus, and the subjacent bone is found bare and apparently dead Possibly the relief of tension may suffice in some cases to limit the mischief, the periosteum again becoming adherent to the bone, and a cure being established without extensive necrosis More frequently a considerable portion of the shaft loses its vitality and has to be separated in the manner already described, whilst an involucrum forms around it from the periosteum (Figs 352 and 355) If a mixed infection has not occurred, no fever or bad constitutional symptoms need be expected during this later stage Pathological fracture sometimes occurs as a complication if undue strain is placed on a limb which has been weakened by osteomyelitis

When the medulla itself is more especially involved, the symptoms of pyæmia or of severe toxæmia become very prominent, and the child may die from this cause before the local mischief has been able to advance very considerably The pain will continue to be of a severe character, although the patient's perceptions may be so blunted by the toxic condition that he becomes more or less unconscious The swelling of the limb is not so great as in the former type, but the mischief may be very extensive, and although there is no great collection of pus beneath the periosteum, yet it may be stripped up along the whole length of the shaft, which may even be detached from the epiphysis at each end Should the child not die of toxæmia, extensive destruction of bone is certain to result

In infants and very young children, especially if the subjects of inherited syphilis, the disease early spreads through the non-vascular cartilage of the epiphysis to the neighbouring joint, and the symptoms

of acute suppurative arthritis supervene The head of the humerus and the upper and lower ends of the femur are the parts most commonly involved in this way In some of these cases the ligaments are so seriously weakened and relaxed that a loose flail-joint results, and pathological dislocation may result

Differential Diagnosis —Certain conditions may cause difficulty

(1) *Acute Suppurative Arthritis* Here the point of maximum tenderness is not placed over the bone but in the joint The slightest movement of the joint, which is held in a position to give maximum room



FIG 356 —KOHLER'S DISEASE

Note the marked increase in density and diminution in size of the scaphoid

for the effusion, gives rise to much greater pain than in osteomyelitis The effusion is usually greater than that accompanying osteomyelitis, and if in doubt aspiration will reveal its nature

(2) *Acute Rheumatism* Here more than one joint may be affected, and the pain and toxæmia are rarely as acute as in osteomyelitis Signs in the heart aid the diagnosis

(3) *Erythremia crurum puellinum frigida* A condition in which bluish-red swellings are present, usually over the calves of young females, may sometimes cause difficulty Multiplicity of the lesions is usually present and toxic signs are minimal

(4) *Cellulitis* The inflammation here is superficial and the thickening does not extend deeply Passive movement of the joint causes little pain

(5) *Ewing's Sarcoma of Bone* is often recognized only by the X-ray

appearance or by the material removed at operation, as up to this stage it resembles osteomyelitis so closely

Schlatter's Disease is probably a low-grade subacute infection following on injury involving the upper end of the tibia in young people It is probably due to a slight injury directed to the lower tongue-shaped prolongation of the upper epiphysis, which forms the tubercle of the tibia, and is followed by a subacute inflammation of the epiphyseal line, which does not result in suppuration The child complains of a tender swelling in this region without any affection of the joint, and walks with a limp Radiographic examination suggests displacement forwards of the epiphysis, but there is no mobility Treatment consists in rest and protection of the part from injury, and in time the condition gets well

Kohler's Disease is a similar affection limited to the scaphoid bone (tarsal), which is somewhat enlarged and sensitive to pressure In the X-ray picture (Fig 356) the bone or its ossified centre appears to be abnormally dense, shortened antero-posteriorly, and correspondingly broader The condition usually appears in adolescents, and is likely to be mistaken for static flat-foot, it causes a limp It may be due to injury, but the symptoms are transitory, and a return to a practically normal condition under the protection assured by a flat-foot support is the rule in a year or more



FIG 357.—SKIAGRAM OF A CASE OF KIENBOCK'S DISEASE

Kienbock's Disease also comes under this heading it is a quiet sclerosing osteitis of the carpal semilunar, and the X-ray appearance is very similar to that of the tarsal scaphoid in Kohler's disease (Fig 357) There can be no doubt that in a certain number of cases traumatism plays an important part, and it sometimes follows a typical crush fracture of the bone

Apophysitis of the Os Calcis is a condition similar to Schlatter's disease There is an epiphysis over the tuberosity of the os calcis, which commences to ossify between the seventh and ninth years, and fuses with the bone between the sixteenth and twentieth years Slight injury may cause enlargement of the heel, which on X-ray examination may show apophysitis The epiphysis may be fragmented, and the clear area between the epiphysis and the body of the os calcis may be broader than normal (Fig 358) On each side of this area the bone is irregular, as if ossification had been interfered with Treatment consists in rest of the part, and protection from further injury

Freiberg's Disease—This is an uncommon affection of the epiphysis of the head of the second metatarsal bone, it is probably an example

of *osteochondritis juvenilis* The condition is probably caused by trauma, and as the second metatarsal is the longest, it is perhaps subject to more trauma than the other metatarsals The X-ray picture is quite typical, the rounded head of the bone becomes flattened and quadrangular in shape The symptoms are pain in the foot and tenderness over the head of the metatarsal

With regard to treatment a metatarsal bar may give relief, but in most cases a cure can be effected only by excision of the enlarged metatarsal head



FIG 358—APOPHYSITIS OF THE OS CALCIS

This condition is analogous to Perthes and Kohler's disease Note the condensation and fragmentation of the calcaneal epiphysis, also the cloudiness and irregularity of the posterior border of the adjacent os calcis, which in some cases is much more marked

The **Prognosis** of the acute form of osteomyelitis is always grave Life may be threatened by pyæmia or toxæmia in the early stages, whilst later hectic fever, amyloid disease, and exhaustion may terminate the case if a mixed infection has occurred

The utility of the limb may be unimpaired if the disease has not been too extensive, and if prompt treatment has been adopted, but if life is threatened by toxæmia, or if neighbouring joints suppurate, or if the osteogenetic powers of the periosteum have been destroyed by the acuteness of the process, amputation may be required

Treatment.—Prompt surgical interference must be adopted in order, if possible, to cut short the malady As soon as the local pain and high fever give evidence that this affection is present, a free incision should be made in the long axis of the limb through the periosteum, whether pus can be detected or not The surgeon will then proceed to investigate carefully the condition of the bones by inspection and the use of the finger and probe As a rule, he will find himself in the neighbourhood of the epiphyseal cartilage, and if the case has been taken in hand early it is possible that the mischief will be quite limited, all that is then required is to scrape or gouge away the softened and hyperæmic bone at the end of the diaphysis, together with any necrotic tissue which may be present, taking the greatest care not to perforate the epiphyseal cartilage The cavity thus formed is drained or packed with gauze, infiltrated with bipp, and in all probability recovery will rapidly ensue

If the case has gone further, the periosteum will be found stripped from the bone for a varying distance, although but little pus may be present beneath it If pus is present, this is an indication that there is drainage from the medullary cavity, and all that is required is free incision of the periosteum and exposure of the abscess cavity to the surface to ensure escape of the pus

When the periosteum is hyperæmic and swollen, yet no pus is present beneath it, then in these cases it is essential to open the medullary cavity to allow of free escape of the dammed-up pus Until recently it was the custom to gouge away large areas of the shaft and form a gutter, exposing freely the medullary cavity It is, however, difficult to determine to what extent the medullary cavity is infected, and it is very easy to open up non-infected areas and thus spread the infection It is most desirable, therefore, to establish communications between the medullary cavity and the surface by drilling the bone with several drill holes, or trephining it with a conical trephine The opening thus made is ample to allow of escape of pus and allay the toxæmia, and the boundaries of the necrosis will eventually demarcate themselves This conservative operation has a far lower mortality than the more radical one When grave constitutional phenomena are present, associated with loosening of the epiphysis, it may be necessary to amputate in order to prevent death from toxæmia

If the periosteum has been extensively involved, a large amount of bone, possibly the whole diaphysis, is denuded, and perhaps both epiphyses are loosened The dead diaphysis should be removed at once if the leg or forearm is involved, as there is always a second bone to maintain the length of the limb, but for the femur and humerus its removal should be delayed—immediate removal would lead to hopeless shortening and crippling

At the termination of this operation the best treatment is to pack the wound with gauze soaked in sterile vaseline, perhaps putting a suture or two in the ends of the incision, and then to encase the limb in plaster of Paris A window may be cut over the wound, but the dressings should not be disturbed unless some indication, such as a rise in temperature, points to their replacement, for several weeks At

the end of this time, although the wound smells foul, under the dressings will be found healthy granulations The procedure is then repeated Other methods of treatment whereby the wound is repeatedly dressed or continuously irrigated with Carrel-Dakin solution are not so satisfactory

When the sequestrum is free—that is, in about two or three months—*sequestrectomy* will be required, it consists in reflecting the periosteum from the new casing, and in enlarging or uniting one or more of the cloacæ, so as to allow the sequestrum to be withdrawn In some cases it is desirable to approach the sequestral cavity by some safer route than that suggested by the sinus, *e g* when the necrosis involves the lower end of the femur, it is often wise to cut down on it from the outer side, although the sinuses are central It is not always easy to remove the sequestrum *en bloc*, and it may be necessary to divide it, the greatest care must be taken not to leave any portion behind, as the wound cannot heal in this case The empty cavity should be dealt with by one of the methods detailed below, or alternatively the method described in the treatment of the acute case can be adopted Occasionally removal of the sequestrum is almost impracticable, and under such circumstances *amputation* may be preferable This summary proceeding may also be needed in the course of this disease on account of pyæmia, defective repair, exhaustion from chronic toxæmia, or suppuration in a neighbouring joint

Osteomyelitis of the flat bones involves opening freely into the cancellous tissue by gouge or trephine, and scraping away all the bone which is diseased or infiltrated with pus In the cranium the inner table should not be perforated unless the surgeon suspects the existence of subcranial suppuration

The **closure of a cavity left by the removal of a sequestrum** (or of a growth from the interior of a bone or of a tuberculous focus) is not always simple, inasmuch as the walls consist of osseous tissue which is not too well supplied with blood, and which becomes less vascular as the condition becomes more chronic The shape of the cavity also influences the rapidity of the healing process

The ideal cavity to leave after the removal of a sequestrum is a shallow crater, over the margins of which the soft tissues can be adapted After removal of the sequestrum and of that portion of the involucrum which overhangs the cavity, bleeding is checked by the use of swabs wrung out of hot saline, the cavity is then mopped over with absolute alcohol or ether, carefully ' bipped,' and then the soft tissues are drawn together over the hollow so as to close it entirely, or the wound is packed with ' bipped ' gauze, which may usually be left *in situ* for ten days In some cases it may be possible to detach one or both bony sides of the cavity and press them inwards so as to reduce its size Bone grafts have also been utilized, *e g* a phalanx clipped up into small fragments, and fat grafts, but the best method of filling up such a cavity is by means of a pedunculated muscle graft turned in from the neighbourhood, *e g* from the gastrocnemius or soleus for cavities in the tibia

Sinuses penetrating through the whole thickness of a bone are

most difficult to heal, inasmuch as the bony walls cannot fall together In such cases the total removal of one side of the tunnel may suffice to permit the soft tissues to fall in and close up the space, but if this is not possible, then the cavity must be cleared and cleansed, and some grafting process (bone or muscle) adopted

At all stages of the disease thought must be given to the possibility of such complications as embolic infection of other bones, empyema, pericarditis, brain abscess, and infective arthritis, all of which must be treated as they arise

3 The **Acute Traumatic Osteomyelitis** which arises as a result of infection from without, *e g* in cases of compound fractures, and after amputation, excision, or even osteotomy, requires a separate description The clinical history of a case involving the shaft of a long bone is as follows The patient during an attack of septic traumatic fever due to an injury or operation has one or more rigors, which suggest the existence of pyæmia, and is suddenly seized with severe pain in the limb, which becomes intensely sensitive On examining the wound, the soft parts are found to be unhealthy and infiltrated, the lower end of the bone is bare and yellow, and from the interior a stinking mass of gangrenous medullary tissue sometimes protrudes Should early and efficient treatment not be undertaken, the patient runs a considerable risk of succumbing to acute pyæmia or toxæmia, whilst a varying amount of the interior of the bone dies (*central or tubular necrosis*), and a small segment of its whole thickness below, so that the sequestrum which ultimately separates is annular and conical (Fig 359) Should the patient survive, the necrotic tissue gradually separates, and during this process a mass of new bone is formed from the under surface of the periosteum, so that the shaft becomes much thickened externally



FIG 359 —TUBULAR OR CONICAL SEQUESTRUM FROM ACUTE OSTEOMYELITIS OF FEMUR AFTER AMPUTATION

Treatment.—The wound is thoroughly opened up as early as possible, flushed out, and the sloughing medullary tissue scraped from the interior of the bone, which is subsequently disinfected with pure carbolic acid, a drainage wick of gauze or rubber glove being placed in it for a few days A certain amount of necrosis follows, but without high fever or toxæmia Should this treatment fail, amputation will be required, or complete excision of the affected segment of bone

4. **Acute Osteomyelitis of Cancellous Tissue** develops after an infected wound of the short bones, or of the cancellous extremities of long bones, it may also be caused primarily by auto-infection, or may be secondary to acute infective arthritis, or the result of a pyæmic embolus The local and general phenomena are very similar to those detailed above, except that no large sequestra are formed, the dead bone coming away in spicules (one form of

caries necrotica), whilst the pain and fever are less severe, and there is less likelihood of the development of pyæmia *Treatment* consists in opening up the infected area and removing all diseased tissue, the cavity thus formed must be efficiently drained, if need be through a counter-opening, and may advisably be packed with 'bipped' gauze The general health must be attended to, and care taken to prevent or limit deformity

5 **Typhoid Osteitis.**—Affections of the osseous system are not uncommon in typhoid fever, and usually come on during the early stages of convalescence The tibia and ribs are most often affected, and in a large percentage of cases typhoid bacilli, with or without pyogenic cocci, will be found The trouble commences either as a periostitis or osteomyelitis, subacute in character, often improving temporarily, and then relapsing, it is curious to note how long the organisms may lie latent in the tissues before causing an abscess In time an abscess usually develops, together with some amount of necrosis or caries Sometimes an abscess within the bone communicates through a small sinus with one beneath the periosteum, constituting the so-called 'collar-stud' abscess On its first appearance the affected limb should be elevated and fomented, and frequently the more acute symptoms will yield, but the part often remains enlarged, swollen, and tender, and exacerbations of pain are not unlikely to develop from time to time, culminating sooner or later in abscess formation When suppuration has occurred, the parts must be freely incised, diseased bone removed, granulation tissue scraped away, and the parts disinfected with 'bipp' The wounds are usually found to be extremely chronic and indolent, and may require scraping several times

Acute Epiphysitis is a condition occurring in young children and accompanied almost invariably by a fatal issue It is an acute infection of the epiphysis, usually by the streptococcus, which gains entry through the circulus vasculosus of Hunter, an anastomosis of vessels around the synovial reflection on to the bone The child is acutely ill, often moribund, from toxæmia There is a large effusion into the joint, which by aspiration can be shown to be teeming with organisms

Treatment consists in draining the joint, but where the toxæmia is advanced amputation is probably the best treatment

Chronic Inflammation of Bone.

Chronic Osteo-periostitis is a chronic inflammatory condition of the bone, which results in overgrowth, thickening, and condensation

Varieties.—(*a*) It may arise as a *localized* chronic periostitis, traumatic, toxic, rheumatic, or syphilitic in origin, or due to the close proximity of a chronic ulcer It is characterized by a formation of new bone beneath the periosteum, the so-called *node* (Fig 360), the cancelli of which are arranged at right angles to the surface At first this new material is soft and spongy, but it rapidly becomes hard and sclerosed, and a similar condition affects the subjacent compact structure, which is thickened and indurated by a new formation

around the Haversian canals If the irritation persists, as in the case of a chronic ulcer, this condition may run on into the following variety

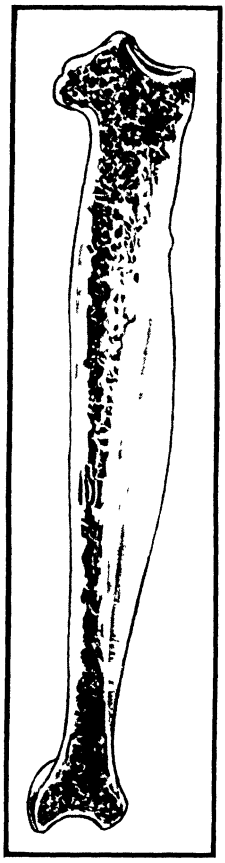


FIG 360 — CHRONIC OSTEO-PERIOSTITIS OF TIBIA, SHOWING FUSIFORM SWELLING ON THE FRONT OF THE BONE CONSISTING OF DENSE OSSEOUS TISSUE AND THE MEDULLARY CAVITY ENCROACHED UPON (MUSEUM OF ROYAL COLLEGE OF SURGEONS)

(*b*) The *diffuse* form of chronic osteo-periostitis usually originates in some deep-seated or central affection, tuberculous or syphilitic in nature, and often involves the whole bone, although sometimes limited to one or other end If tuberculous, there may be a small chronic abscess or some central necrosis, and around this the bone becomes thick and indurated In the later stages a considerable new formation may occur beneath the periosteum, and the medullary canal becomes encroached on or obliterated If syphilitic in origin, it may be due to a central gumma, or to a general condition of sclerosis, developing without any localized focus

The **Symptoms** consist of deep aching pain in the limb, worse in bed, with perhaps tenderness over some particular spot, especially in cases where an encysted abscess exists in the head of a bone, such as the tibia On examination the bone is felt to be thickened, and its surface more or less nodulated If the disease is limited and superficial, a distinct node may be felt, consisting of a hard, fusiform, and tender swelling Where the enlargement is more general there is less tenderness, though the pain is constant

The **Diagnosis** of such cases is not always easy, the enlargement of the bone being sometimes mistaken for the *early stage of a malignant tumour* The rate of growth will be of little assistance, since it is very variable, but a tumour may have more defined limits, and its tension is often not the same throughout Radiography is valuable in this direction, since in simple chronic periostitis the bone is solid and throws a continuous and well-defined shadow, while in malignant disease a certain amount of soft tissue is always present, either centrally or peripherally, easily penetrated by the rays, and hence leaving gaps in the shadow If, in spite of such assistance, the case is still doubtful, an exploratory incision will be required

The **Treatment** consists in resting the limb, applying counter-irritation, *e g* iodine paint or the actual cautery, and giving iodide of potassium internally If relief is not thereby obtained, it will be necessary to cut down over the whole length of the thickened bone through the periosteum, which is stripped aside, and, if merely a nodular enlargement is present, to chisel away

the new formation When the whole thickness of the bone is involved, a gutter or trench must be made by gouge and mallet, extending into the medullary cavity, and its length corresponding to the enlargement The soft parts are loosely drawn together, the hollow will fill with blood-clot, which is allowed to organize If enough bone has been removed, most satisfactory results follow, but in some aggravated conditions which have lasted for many years amputation is required

Brodie's Abscess is a condition in which an abscess forms in the bone, usually close to the epiphysis, and was originally described by Sir Benjamin Brodie as tuberculous in origin Although undoubtedly some cases are tuberculous, the majority are staphylococcal in nature, whilst in a few cases a breaking-down gumma is responsible The abscess cavity, from which often no organisms can be grown, is surrounded by an area of dense bone, densest where the infecting agent is the spirochæte, and least dense where Koch's bacillus is responsible Usually these abscesses are slowly progressive, although occasionally they may flare up acutely, and in other cases they may become absorbed They give rise to rather indefinite pain in the region of the affected part of the bone, often worse at night, together with perhaps some periosteal thickening and muscular wasting Some effusion in the neighbouring joint may be present (Figs 353 and 354)

Treatment—All these cases should be subjected to operation, with scraping of the abscess cavity and, if necessary, packing with vaseline gauze, as there is always the danger of the infection bursting into the joint

Tuberculous Disease of Bone

Tuberculous disease of bone is secondary to some other tuberculous infection in the body, such as a focus in the mediastinal or abdominal lymphatic glands It is not commonly associated with pulmonary tuberculosis, but when both are present the outlook is much more serious The infection is blood-borne, and the tuberculous emboli are held up in the end-arteries on the metaphyseal side of the epiphysis or alternatively enter the epiphysis itself through the vessels derived from the circulus vasculosus of Hunter Probably some previous trauma has produced a small hæmatoma which provides a suitable nidus for the growth of the tubercle bacilli Infection may also result through the vessels running from the periosteum into the shaft of the bone The normal reaction of the tuberculous infection is to produce a typical tuberculous granulation tissue which invades the cancellous bone and the Haversian systems with resulting absorption of the bone, a process known as rarefaction Sometimes instead of the slow process of absorption the infected area may break down to form tuberculous pus with the production of one type of Brodie's abscess As has been mentioned previously, this abscess is surrounded by an area of bone which has undergone some degree of sclerosis This process of the formation of a tuberculous abscess in bone is referred to as *caries suppurativa* Sometimes the absorption of bone does not keep side by side with its destruction, and partly on account of an

endarteritis obliterans which affects the vessels Small areas of bone form sequestra, a process known as *caries necrotica* These sequestra are very different from the hard white sequestra associated with pyogenic infection, being soft and friable, yellowish in colour, light in weight, and often incompletely separated from the surrounding bone In the small long bones, the vertebræ, and those of the tarsus and carpus, on account of the rapid splitting up of the nutrient vessels, the whole of the bone becomes involved As in other bones where the periosteum is involved, there is often some periosteal reaction sufficient in *tuberculous dactylitis*, as it is called, to produce an ever-expanding bone which is being continually eroded from the centre Rarely tuberculosis of bone may give rise to a generalized sclerosis of bone closely resembling that commonly associated with syphilis If left without any treatment the tuberculous process extends in all directions outwards to involve the periosteum, the muscles, and eventually the skin with inevitable secondary infection, downwards into the medullary cavity, and upwards into the epiphysis, causing separation and secondary involvement of the joint Spread outwards may also give rise to joint involvement if the epiphysis is intra-articular, as in the hip-joint The disease is most commonly seen in children, less commonly in old people, but may occur at any period of life

1 In **Tuberculous Periostitis** a specific infiltration of the periosteum is met with, consisting of a deposit, partly in that membrane and partly under it, of pulpy granulation tissue containing the characteristic miliary tubercles As in tuberculous disease elsewhere, caseation and suppuration are likely to follow, leading to the formation of abscesses, which are primarily subperiosteal and filled with curdy pus, these in time find their way to the surface, either directly or by more or less tortuous channels, and leave sinuses, extending down to the diseased area The effect on the bone may be insignificant if the part affected is dense, consisting merely in some slight superficial erosion, occasionally, however, the disease may spread along the periosteum, and involve a neighbouring epiphysis or joint If the compact layer is *thin*, as in the sternum, ribs, or bodies of the vertebræ, the underlying cancellous tissue is almost certain to be secondarily affected, and caries will result

Clinical History —In a superficial bone a doughy or pulpy swelling forms, which is slightly tender on pressure It takes weeks or months to develop, and on radiography the underlying osseous tissue may appear quite normal in texture In the later stages, when caseation or suppuration is present, the swelling often becomes more defined and somewhat resembles an ordinary node, but is more irregular in shape, of somewhat unequal consistency, and on firm pressure small portions may be felt to give way If an abscess forms, the skin becomes reddened, the swelling is elastic to the touch, and the pain greater, but it diminishes as soon as tension is relieved by discharge of the pus A sinus, however, forms, and a probe passed down impinges on soft carious bone (Fig 361) The admission of pyogenic infection increases the trouble

Treatment—In the early stages constitutional treatment may suffice, together with rest and carefully-adjusted pressure, as by strapping with Scott's dressing, or Bier's induced hyperæmia, where applicable The condition, however, demands incision if a neighbouring joint is threatened, or when suppuration has occurred Free removal of all the granulation tissue and softened bone with a Volkmann's spoon is required, followed by disinfection of the cavity with alcohol and 'bipp,' and, if possible, closure of the wound without drainage If a rib is involved, it is wiser to remove entirely the affected portion of bone

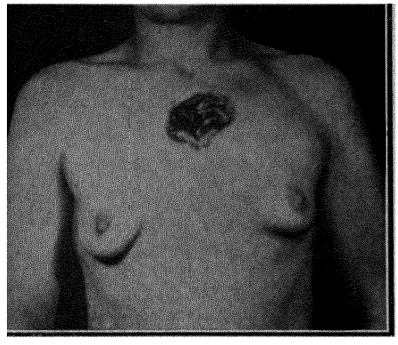


FIG 361—TUBERCULOUS DISEASE OF THE STERNUM [1]

An abscess formed and discharged leaving a large ulcer

2 **Tuberculous Osteitis** arises in cancellous tissue, and usually in the epiphyses, or under the articular cartilage The child complains of pain in the affected bone, often worse after exercise, but beyond this, together with some slight limp and a generally debilitated condition of the child, little else is noticed by the parents On examination some wasting of the muscles will be observed, and there may be an increase in the temperature of the skin over the area of affected bone Tenderness can often be elicited, and some effusion into the neighbouring joint may be present All cases must be confirmed by X-rays, which will show the typical rarefied areas in the neighbourhood of the epiphysis In the differential diagnosis, subacute osteomyelitis, osteoclastoma, and osteitis fibrosa must be considered

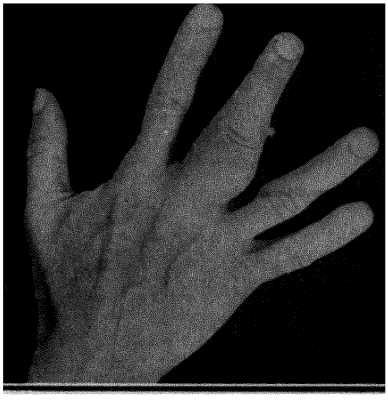


FIG 362—TUBERCULOUS DACTYLITIS

The disease started in the proximal phalanx and has spread to the periosteum

Treatment—This consists, in addition to sanatorium regime, in prolonged immobilization of the affected limb, fixing the joints above and below the lesion to produce effective rest For this purpose splinting with plaster of Paris is the most desirable the cast can remain on for several weeks before it is changed The splinting must be maintained for many months, for at least six months after all pain has disappeared and until the X-rays show a return to normal

bony structure In the case of the leg a walking caliper is worn for another year If the pain gets worse and in spite of immobilization the X-rays show a spread of disease, operative interference must be considered on account of the danger of involvement of the joint This will consist of opening up the bone, curetting it, and swabbing it out with pure carbolic, the immobilization then being resumed If a case of tuberculous osteitis is seen late, where the process has spread outside the bone to involve the surrounding structures and to produce sinuses which have become secondarily infected, amputation may be required Where a definite Brodie's abscess has formed, operation is indicated to evacuate the tuberculous pus Prolonged rest in these cases, although giving rise to increasing demarcation of the abscess, will not yield a cure, and the danger of their extension into the joint is too severe a risk to take (Figs 364 and 365)

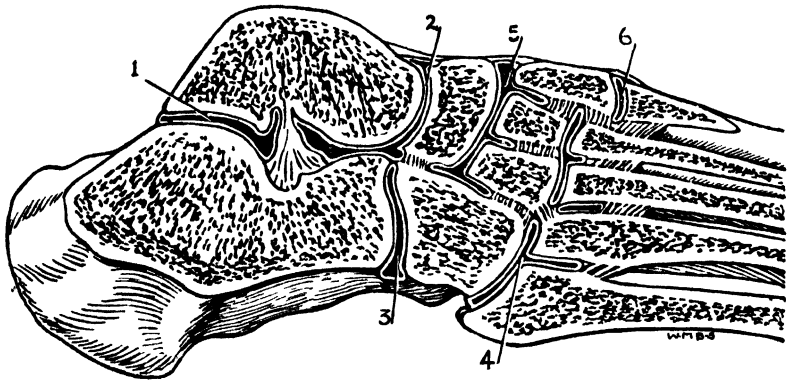


FIG 363 —ARRANGEMENT OF SYNOVIAL MEMBRANES OF FOOT

1, Posterior calcaneo-astragaloid, behind the interosseous ligament, 2, anterior calcaneo-astragaloid and astragalo-scaphoid, 3, calcaneo-cuboid, 4, cubo-metatarsal, 5, the large common sac between scaphoid and cuneiform, between the three cuneiform bones, and between the cuneiform and second and third metatarsals 6, between the internal cuneiform and first metatarsal

3 **Tuberculous Dactylitis—Clinical History.**—The affected segment of the finger becomes slowly enlarged, bulbous, and painful, the pain being, however, slight in amount, though sometimes worse at night At first the finger looks white, and the skin is smooth and shiny, but after a time one spot rapidly increases in size, becoming red and tender, and finally an abscess forms, which bursts or is opened, leaving a sinus, down which a probe can be passed into the carious interior of the bone Occasionally contiguous joints are involved in this process, whilst the tendon sheaths are also liable to be affected, a large portion of the swelling is often due to periosteal infiltration (Fig 362) In some cases the bone appears to be expanded, but the term *expansion* is scarcely correct, inasmuch as the enlargement is due to absorption on the inner aspect, whilst there is a new formation of bone under the peri-

osteum Natural cure without suppuration occurs when the child is placed under suitable hygienic conditions, but even then the growth of the phalanx may be hindered, and the finger remains shortened

The **Treatment** of tuberculous dactylitis must be conducted along the lines laid down for tuberculosis generally on p 175 The child is transferred to some healthy place where treatment of a sanatorium type is possible, and there it must remain, perhaps for years, until the trouble comes to an end, educational facilities must therefore be included in the programme The local treatment consists in putting the hand to rest on a splint, and possibly applying Scott's dressing to the affected finger There is but little call for operative treatment under such circumstances If an abscess forms, it should be aspirated at an early date, so as to avoid the risk of sinus formation In the worst cases where pyococcal troubles are also present, amputation may be required

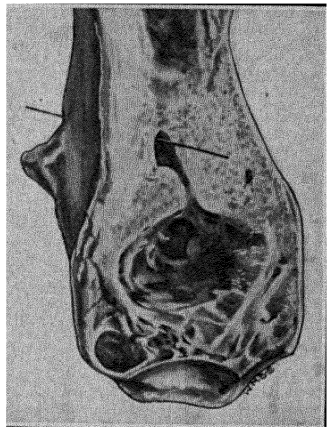


FIG 364 —CHRONIC ABSCESS IN THE LOWER END OF THE TIBIA (KING S COLLEGE HOSPITAL MUSEUM)

Any of the *bones of the tarsus* may be involved in exactly the same manner, the clinical history and treatment being identical, although articular lesions are more common than when the disease is limited to the phalanges The affected portion of the foot becomes swollen and shiny, since the overlying periosteum is often involved in the process, and it is sometimes difficult to determine whether the lesion is limited to the bones or involves the joints also In the early stages one part of the foot may be more swollen than another, according to the location of the trouble The os calcis is most often affected, and afterwards, in order of frequency, come the first metatarsal, astragalus (the head), and scaphoid When it starts in the astragalus, the swelling occurs below the level of the ankle-joint in front of or behind the malleoli, whilst pressure over the head of the bone gives rise to pain The foot is usually in a position of equinus, but not to such a marked degree as when the ankle-joint itself is affected, the subastragaloid movements (inversion and eversion, abduction and adduction) are also considerably limited, or may be absent An examination of the accompanying illustration (Fig 363) will explain the fact that tuberculous disease starting in the astragalus is very likely to involve the ankle-joint, or to spread to the os calcis or scaphoid Disease of the os calcis leads to more limited swelling of the back of the foot on one or both sides of the heel, the movements of the ankle will not be impaired, although walking is painful, and hence the patient limps, treading only on the toes Further forwards, tuber-

culous disease is most likely to start in or around the scaphoid, the bulbous swelling of the foot being then shifted anteriorly, and the movements of the ankle remaining unimpaired Owing to the arrangement of the synovial membranes, the prognosis is much worse when the disease attacks the inner half of the foot, comprising the astragalus, scaphoid, cuneiform, and three inner metatarsal bones, than when it affects the outer segment, consisting of the cuboid and two outer metatarsals, which are excluded from the general synovial membrane, and are thus more amenable to treatment

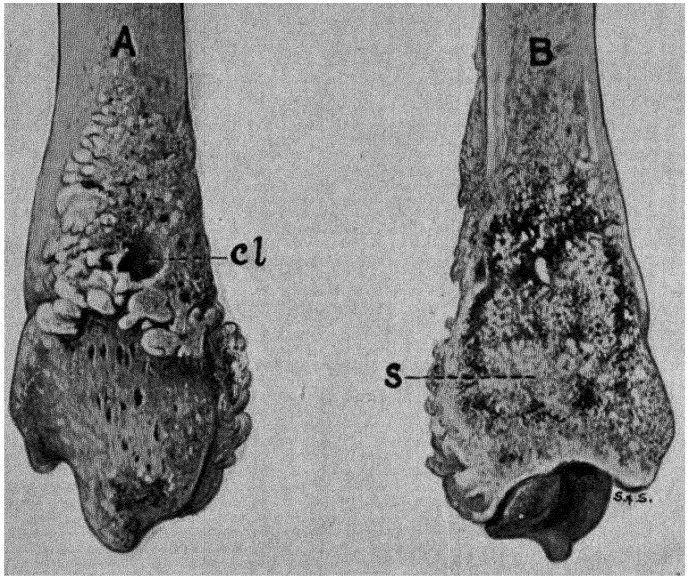


FIG 365 —LOWER END OF TIBIA AFFECTED WITH TUBERCULOUS DISEASE (KING'S COLLEGE HOSPITAL MUSEUM)

In A, a subperiosteal deposit of new bone is seen surrounding an opening (*cl*) which leads into the interior of the bone In B, the interior of the same bone is seen and shows a sequestrum (S) just above the epiphyseal line The ankle-joint is healthy

The **Treatment** consists in the usual local and constitutional measures adopted in tuberculous disease (p 175) In the early stages the foot and ankle are immobilized, and preferably in plaster of Paris, and the foot is not allowed to be used until all pain has ceased Older patients are fitted with a Thomas's knee-splint and a patten, and allowed to get about on crutches

Should the disease persist, or suppuration recur after aspiration, operation may be required If the *os calcis* alone is involved, it will suffice to open it from one or both sides, to scrape out and disinfect its interior, with subsequent closure of the wound If the disease

mainly affects the *astragalus*, it may suffice to remove it entirely, neighbouring articulations being curetted, but probably the disease will have spread so far that Syme's amputation will be required Disease of the *cuboid* and outer half of the foot in front of the os calcis can often be dealt with efficiently by scraping, but when the common synovial membrane on the *inner side* is involved, and hygienic treatment fails, amputation will probably be needed

For tuberculous osteomyelitis of ribs, see p 685

Syphilitic Diseases of Bone.

In the **Secondary Stage** flying pains about the bones (sometimes termed *osteocopic*) are often complained of, they are, however, of but little importance, and disappear rapidly as the patient gets under the influence of treatment In the late secondary or early tertiary periods a *periosteal node* is often met with, as a result of chronic periostitis It usually affects only one bone, and most commonly the tibia, and consists of infiltration and thickening of the periosteum, which may entirely disappear or be followed by a formation of new bone, which is at first spongy and soft, but after a while becomes hard and sclerosed When this has once occurred, absorption of the newly-formed bone does not readily follow, even under treatment, the part remaining permanently thickened It is recognized clinically as a fusiform swelling, a little tender on pressure, and the seat of deep aching pain, usually worse at night It must be understood that the pain is not so much associated with the onset of night as with the increased warmth of the limbs when in bed, indeed, patients with syphilitic tibiæ frequently sleep with their legs exposed Night-watchmen and others, on the contrary, complain of pain during the day, when they take their rest Suppuration does not occur, and constitutional rather than local treatment is required

In the **Tertiary Period** the bones may participate in the changes which involve any and every tissue of the body The following lesions are described, but are nowadays rarely seen

(*a*) The formation of *subperiosteal gummata*, either localized or diffuse, probably resulting in *caries* of the subjacent bone, if the affection is limited, only a small portion may be thus involved, but where it is widely diffused, an extensive surface of the bone may become eroded and irregular This process is sometimes accompanied by a development of new bone under the adjacent periosteum, and even by sclerosis and necrosis The calvarium is the part most frequently involved, and as but little new bone forms in this situation the skull often presents a curiously pitted or worm-eaten appearance (Fig 366) The overlying scalp is usually invaded and destroyed by the gummatous process, permitting the entrance of pyococci, deep and sometimes extensive wounds result, discharging foul pus, and at the bottom of which bare and even dead bone may be felt

(*b*) At the same time a condition of *sclerosis* may develop in the underlying or surrounding parts, and this to such a degree as seriously to compress and constrict the vessels in the Haversian canals Moreover, an obliterative endarteritis is almost always present, and these

factors, combined with the separation of the periosteum and the influence of the mercury administered for therapeutic purposes, so interfere with the vitality of the bone that, should pyococci be admitted, necrosis is almost certain to ensue

The effects produced vary considerably in different cases, and especially with the situation When the *calvarium* is attacked, pyogenic infection often supervenes, owing to the thinness of the scalp and the depth to which the hair follicles penetrate, and consequently necrosis is common The process in such a case is probably as follows The pericranium corresponding to the necrotic area becomes gummatous, and at the same time the subjacent bone undergoes sclerosis Sooner or later the gummata burst or are opened, pyogenic

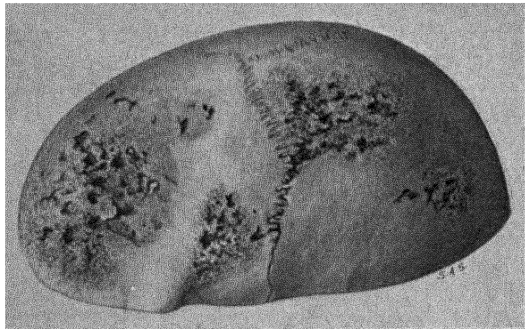


FIG 366 SYPHILITIC CARIES OF SKULL FROM DIFFUSE GUMMATOUS DISEASE (FROM KING'S COLLEGE HOSPITAL MUSEUM)

infection occurs, and the scalp tissues are stripped off the calvarium to the limits of the disease, necrosis resulting in the sclerosed area of bone A line of rarefaction subsequently forms around the sequestrum in consequence of Nature's attempts to separate it The later stages of the disease are marked by extreme chronicity, the sequestrum lying bare in the wound perhaps for years without being separated, owing to the slight degree of vascularity and the extreme condensation of the surrounding parts It is quite unusual at the present day to see cases of this nature In the *shafts of long bones*, where the compact tissue is thick and resistant, there may be extensive periosteal disease, with but little affection of the underlying parts, but if this compact layer is thin, and especially when the cancellous ends are involved, a considerable amount of destruction from caries may result, though if pyococci are not admitted there will be an entire absence of necrosis

The *sternum* is not uncommonly affected by syphilitic disease, which manifests itself as a gumma, which breaks down and suppurates, but does not often cause much bone destruction The *nasal bones* and *hard palate* are frequently the site of subperiosteal gummatous formation, resulting in suppuration and necrosis, a foul discharge from the nose results in the former case, which may be followed by destruction of the septum nasi and permanent deformity The palatal trouble often results in perforation

In the **Treatment** constitutional remedies must be employed, and will be valuable if suppuration and necrosis have not occurred They may have but little effect, however, if pyogenic infection has supervened, apart from measures directed to providing effective drainage and removal of the dead bone In the calvarium, however, no attempt should be made to take away the dead bone unless it is loose

(*c*) Occasionally a *gummatous osteomyelitis* is met with, in which a gumma forms in the interior of a bone It results in the so-called expansion of bone and secondary thickening, *i e* a chronic osteoperiostitis, limited usually to one end of the bone at first, but subsequently affecting the whole shaft It has often been mistaken for malignant disease, and amputation considered or undertaken The greater rapidity of growth in the syphilitic cases, and the evidences of tertiary lesions elsewhere, or of a syphilitic history, and the existence of a positive Wassermann reaction, will often guide the surgeon to a right conclusion, whilst radiography is also helpful, but if there is any doubt an exploratory incision and a microscopic examination of the diseased tissues should always be made before amputation is undertaken

In **Inherited Syphilis** any of the above manifestations may be seen, but with more or less special features added, and, in addition to these, certain forms which do not occur in the acquired type of the disease have been described

1 A new formation of bone beneath the periosteum is perhaps the most frequent result, and this occurs with but little pain Perhaps the most common situation of this lesion in infants is the calvarium, where bony masses known as *Parrot's nodes* form around the anterior fontanelle, causing the top of the skull to resemble a ' hot-cross bun ' in shape In the early stages the bone is soft and spongy, and on post-mortem examination is dark red or maroon in colour If the process is not checked by suitable antisyphilitic treatment, the newly-formed osseous tissue becomes dense and sclerosed, and the deformity may then persist through life (Fig 48, p 157) Any part of the calvarium may, however, be affected, and the change is not necessarily limited to the first years of life

2 A somewhat similar condition is met with in the shafts of long bones, due to the deposition of alternating lamellæ of soft and hard bone outside the ordinary compact tissue and beneath the periosteum

3 *Syphilitic epiphysitis* (or, as it is termed, syphilitic *osteochondritis*) is a lesion characterized by enlargement of the ends of the bones, as in rickets, but coming on within the first year after birth The enlargement is mainly situated in the epiphysis, but also extends some way along the shaft, thus contrasting forcibly with rickets Occasionally only one side of the epiphysis is affected The change commences in the zone of calcified cartilage nearest the diaphysis, which becomes friable, opaque, and irregular, and as the condition progresses it may be transformed into granulation tissue, so that separation of the epiphysis follows. Pyogenic infection may follow, resulting in suppuration and necrosis of the epiphysis or acute arthritis, or the limb hangs powerless in a condition known as *syphilitic pseudo-paralysis* The disease is usually symmetrical, and often multiple,

and situated in much the same positions as rachitic affections, the knees, elbows, and wrists being perhaps most often affected It may terminate in the early stages, and be followed by organization of the granulation tissue, the ultimate result being cessation of growth in the bone

4 A symmetrical overgrowth of the tibia, perhaps combined with an anterior curvature, also occurs in syphilitic children, resulting in permanent elongation of the legs (p 511)

5 *Craniotabes* consists of a localized absorption of the osseous tissue of the cranium, leaving small areas where the bone is thinned or absent, so that on pressure a sensation of crackling, like that of parchment, is imparted to the finger It occurs most frequently in the parietal bone, and in the majority of cases within the first six months of life, a fact that throws considerable doubt on the idea that it is due to rickets

The **Treatment** of syphilitic lesions in children must be carried out in accordance with general principles, and mainly by the administration of suitable drugs

Rickets.

Rickets is a disease occurring in children and manifesting itself mainly in lesions connected with the bones It usually commences within the first three years of life, but sometimes appears later

Causes.—Much work has been undertaken during recent years to solve the ætiological problem of rickets, and it now seems certain that at least three elements combine in order to bring about the disease (1) Deficiency of the *antirachitic vitamin D* in the diet, it is present in good milk, eggs, and butter, but apparently the amount in milk varies with the diet and management of the cow, being more abundant when the animal receives fresh green food and lives in the sunshine Cod-liver oil contains the largest amount of antirachitic vitamin of any known substance (2) *Sunlight*, and especially the ultra-violet rays in the spectrum, are essential if healthy bone formation is to occur The abundance of sunshine of the tropics explains the rarity of rickets in these regions, and the nature of the food available in the Arctic circle, largely blubber, provides the antirachitic factor which balances the lack of sunshine there experienced (3) A sufficiency of both *calcium and phosphorus* must be present in the food if healthy bone is to be formed Good milk contains an abundance of these in a suitable form, but cannot prevent rickets apart from other factors When the diet consists largely of cereals or carbohydrates, defective intake of Ca and P may have a distinct causative influence

Rickets is therefore a deficiency disease, induced chiefly by improper or insufficient food, especially by the too early administration of starchy materials and the want of suitable fats, whilst uncleanliness and the absence of sunlight and fresh air predispose to it The crowded streets and houses of the poorer sections of our great cities are obviously magnificent factories of this disease Syphilis has no direct causative connection with rickets

The Symptoms may be divided into the early or general, and the later or osseous The *general* symptoms commence with the child

becoming feeble and fretful, losing its power of walking if this has been attained, and its muscles generally are hypotonic The child may be fat and flabby, or thin and emaciated, the mucous membranes are pale, and vomiting and diarrhœa are constantly present, the motions being often green, slimy, and very offensive The spleen is enlarged, the abdomen tumid, and profuse sweating of the head is very characteristic

The commencement of the *osseous changes* is usually indicated by increasing irritability and restlessness, the child tossing off his bedclothes at night, and crying out when handled or touched The articular ends of the long bones become enlarged, as also the junction of the costal cartilages with the ribs Sooner or later the shafts of the long bones soften, and may bend in various directions, and thus many *deformities* may be produced

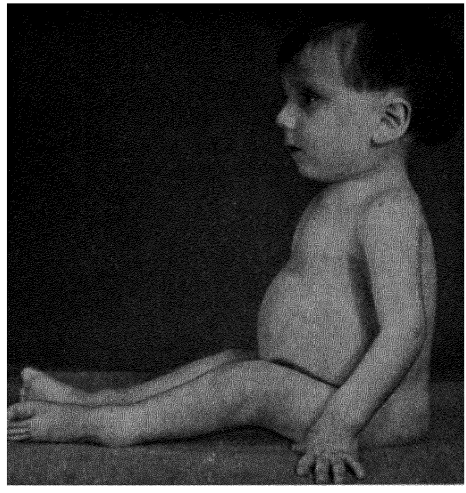


FIG 367 —CHILD WITH WELL-DEVELOPED RICKETS

The enlargement of the epiphyses of the radius and tibia is well seen

The *head* usually becomes flattened anteroposteriorly, so that the forehead appears square in shape and enlarged, whilst frontal bosses may develop on either side, due to new formation of bone under the periosteum, it is a question, however, whether these are not syphilitic rather than rachitic in origin The fontanelles remain open much longer than usual, and craniotabes is said to occur The teeth do not erupt till late, and are stunted, defective in enamel, and easily eroded, so that the ends of the incisors are often concave, they must not be mistaken for syphilitic teeth, since the concavity is a small arc of a large circle, while the typical notch of syphilis is a large segment of a small circle

The *spine* may be affected by kyphosis (p 491), or less frequently by scoliosis (p 486), the kyphotic curve results when the patient is allowed to lie too much in bed with the head on a high pillow, or if the child is carried about with a curved back, scoliosis more often occurs when the patient is able to walk (Fig 367) Occasionally a kypho-scoliosis is produced as a result of the child being carried about sitting on a nurse's arm with the pelvis tilted

Changes in the *thorax* are produced by enlargement of the costochondral junctions (*beaded ribs*), which, when present on either side of the sternum, produce what is known as the *rickety rosary* The swelling is more marked on the pleural aspect than on the outer side

of the bone If there is any obstruction to the entrance of air into the lungs, as from tracheitis or bronchitis, the atmospheric pressure may cause the softened bone and cartilage to sink inwards, and as a result of this the sternum may be pushed forwards (*pigeon breast*), whilst the curvature of the ribs at the angle is increased A very characteristic feature of the rickety change consists in the lateral groove thus produced on each side of the sternum, which may meet with a transverse depression below, caused by the projection of the lower floating ribs by the tumid abdomen

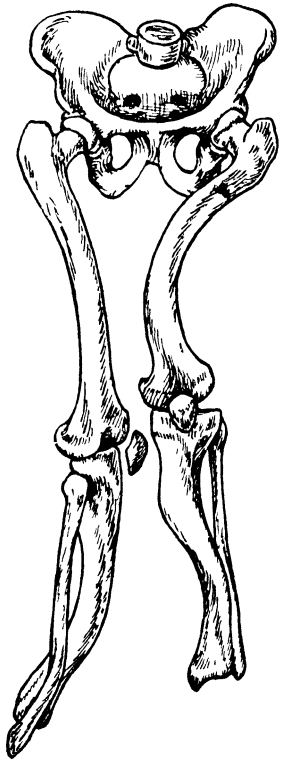


FIG 368 —PELVIS AND LEG BONES IN RICKETS (FROM COLLEGE OF SURGEONS MUSEUM)

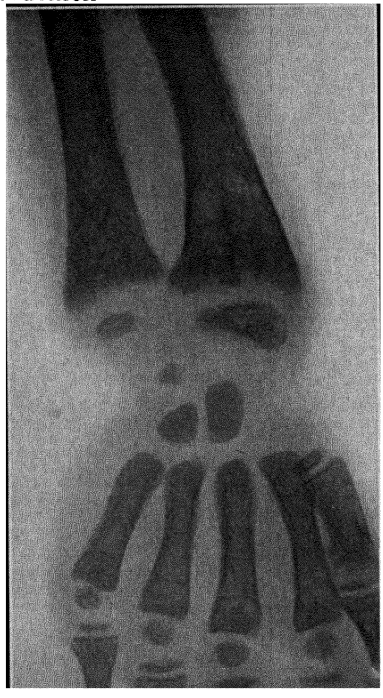


FIG 369 —X-RAY OF WRIST OF CHILD WITH RICKETS

The *pelvis* is flattened antero-posteriorly, or more rarely is triradiate, the former condition being produced when the patient lies habitually on his back, the latter occurring only when walking is permitted, the acetabula being then pressed inwards and backwards by the heads of the femora

The deformity of the *long bones* (Figs 368 and 370) usually consists in an increase of their natural curves, especially at points where powerful muscles are attached The femora are curved forwards

and outwards, and the tibiæ in a similar direction, although not uncommonly the lower end of the tibia is bent inwards Genu valgum or varum may also result from these changes (pp 507 and 509)

When the acute stage of rickets has passed away, any deformities present become fixed by the complete ossification of the softened bony tissues As a rule the density of such deformed bones is increased, whilst their natural shape is altered by deposits of new subperiosteal bone or struts in the concavities, so that on section they are usually more or less flattened from side to side, and the medullary canal appears to be displaced towards the convexity Growth is often checked by this disease, and thus the individual becomes stunted and dwarf-like



FIG 370 —SECTION THROUGH LOWER END OF RICKETY FEMUR, SHOWING EXAGGERATED DEPTH AND IRREGULAR BORDERS OF THE PROLIFERATING EPIPHYSEAL CARTILAGE (COLLEGE OF SURGEONS MUSEUM)

Pathologically the chief changes in rickets are found in the neighbourhood of the epiphyses Ordinarily, the epiphyseal cartilage is a lamella about a line in thickness, bounded on either side by a zone of calcified tissue, containing regular alveolar spaces filled with vascular medulla, and lined by osteoblasts, passing gradually into normal cancellous bone In rickets the epiphyseal cartilage is not only circumferentially enlarged, but also thickened and irregular (Fig 370), outgrowths of cartilage projecting on either side into the calcified tissue, which is more abundant and more open in texture than usual, whilst it passes irregularly into the cancellous bone Thus, there is an increased preparation for the formation of bone, but the ossifying process is inefficiently carried out X-ray examination shows the typical deformity at the end of the bones (Fig 369) In addition to this, the Haversian canal systems and the medullary spaces in the diaphyses are enlarged, so that the bones become weaker and less rigid from the insufficient amount of lime salts present, and thus readily bend under the weight of the body or from muscular action Less frequently the subperiosteal compact bone becomes similarly rarefied When the disease comes to an end the deformities may persist, but the bone, now effectively ossified, becomes harder and stronger than usual

In the **Treatment** of rickets the most essential feature in the early stages is the correction of all errors in the personal hygiene The diet should consist of good cow's milk, diluted if need be, and with lime-water added, whilst the juice expressed from raw beef, or one of the many meat juices now sold, may also be administered The

condition of the bowels must be attended to, and the child placed in as good surroundings as possible Cod-liver oil is the all-essential medicine, containing an abundance of the necessary antirachitic vitamin, it may be administered in combination with Parrish's food (syr ferri phos co) Exposure to sunshine is perhaps best delayed until the general symptoms of the acute stage have passed, if it be not obtainable, the ultra-violet rays of the arc lamp should be substituted Deformities should be prevented by keeping the child in the recumbent posture, and not allowing it to crawl or run about The early stages of deformity can often be corrected by daily manipulation of the affected bones, for the legs, it may suffice to keep the child off its feet, as by a splint which extends from the thighs 6 inches below the soles, a certain amount of pressure can also be exercised by this appliance Osteotomy, or even resection of portions of bone, is required in the severer cases where the deformity persists, and the bony changes have become consolidated (see p 511)

Adolescent Rickets comes on about puberty, and is usually independent of an early rachitic history, although in a few cases it may be looked on as a recrudescence of the infantile ailment Imperfect nutrition is probably a less important ætiological factor than in infancy, but strain, mental or physical, combined with defective hygiene, has been present in most instances The chief changes are to be found in the shafts of the long bones of the legs, which become bent from the superjacent weight of the body Deformities in the upper extremities are less frequent Enlargement of the epiphyses is also observed There is usually no sweating of the head, but the patient is pale, and complains of fatigue and languor, but not of pain The softened bones bend, and no buttresses or struts are formed in the concavities, hence the deformities produced are often serious, and the course of the case is slow *Treatment* is undertaken along the same lines as for the infantile variety, cod-liver oil and sunshine being the two essentials, undue mechanical strain must be avoided, and, if need be, the patient is kept at rest Deformities are dealt with by the use of orthopædic appliances or by osteotomy

Infantile Scurvy (*syn* **Barlow's Disease, Scurvy, Rickets, Hæmorrhagic Rickets**).—This condition, first accurately described by Sir Thomas Barlow, presents the symptoms of scurvy in a rachitic child, and in its manifestations either one or the other set of phenomena may predominate It is usually seen in the children of well-to-do people from four to eighteen months old, and apparently arises from defective nutrition, especially from the prolonged administration of peptonized or prepared foods, or even possibly of sterilized milk In the slighter cases there may be but little evidence of the scorbutic condition, beyond the fact that in a rickety child there is some tendency for the gums to bleed, or a little hæmaturia, but in those that are more marked the rickety signs are of little importance compared with those due to hæmorrhagic extravasations The disease often comes on suddenly with some amount of pyrexia, rarely exceeding 102° F, but the child is evidently ill, and perhaps complains of tenderness of the limbs, which may be kept so quiet as to suggest that they are paralyzed This is followed by the appearance of swellings of some

size, due to sub-periosteal extravasations, the skin over the affected parts being at first shiny and œdematous, but subsequently becoming stained by the blood-pigment The femur and tibia are most often affected in this way, and the epiphyses occasionally become detached, or even spontaneous fractures may occur Bleeding may also take place beneath the conjunctiva or in the orbit, leading to protrusion of the eyeball, whilst there may be blood-stained diarrhœa, hæmaturia, or epistaxis

The disease, when recognized, is readily amenable to *treatment*, but should its nature be overlooked, the child is likely to become emaciated and die Attention to the diet is the main point to be attended to, for when fresh milk, lime-juice, or vegetables are given, the symptoms soon disappear The affected limbs must be kept at rest, and cooling lotions applied, whilst splints are required when epiphyses are separated or fractures have occurred

Achondroplasia (Chondrodystrophia fœtalis) is a curious congenital condition, somewhat resembling rickets, in which the growth of those bones developing from cartilage is cut short and interfered with by virtue of premature synostosis with the epiphysis The growth of the long bones of the arms and legs is grossly affected, so that the limbs are short and stunted, and the stature correspondingly diminished, although the epiphyses are normal The bones generally are not bent or curved abnormally, though there is probably some change of the neck or shaft of the femur, resulting in lordosis, which is very marked when the patient stands The fingers taper to their tips, and are separated one from another in 'spoke-like' fashion. The bones at the base of the skull, being of cartilaginous origin, undergo premature synostosis, whilst the upper half of the skull, being derived from membrane and therefore developing naturally, looks unusually large, the face is small, and the bridge of the nose depressed as in congenital syphilis, on account of the premature ossification of the scaphoid The children, if they live, are usually efficient in their mental development, and the thyroid body normal No known treatment is of any value

Renal Dwarfism was first described by Barber in 1913, and is of interest to the surgeon owing to the fact that in about 70 per cent of cases there are bony deformities The disease is characterized by severe chronic interstitial nephritis associated with deformities of the limb bones, which make their appearance from the eleventh to the fourteenth years The changes in the bones resemble those of rickets, but the X-ray appearances are distinctive and characteristic Skiagrams show a much greater regularity of the epiphyseal line as compared with rickets, although the detail is frequently blurred owing to osteoporosis The deformity is not due to bending the shaft of the bone, but to displacement at the epiphyseal line

Renal Rickets is sometimes seen as a complication of congenital cystic disease of the kidneys (Fig 371)

Osteogenesis imperfecta (or **idiopathic psathyrosis**) is a rare *congenital* condition, characterized by a defective development of osseous tissue from cartilage, so that the bones are brittle or soft, and thus are easily

bent or broken, constituting a condition of *fragilitas ossium* Nothing is known as to ætiology, except that there is a strong hereditary tendency It is possibly due to some change in the parathyroid glands, which apparently control the calcium metabolism Not a few of the subjects are stillborn, with broken or deformed limbs, whilst many die within the first year of life Cases in which fractures occur more or less spontaneously and frequently in older life are probably due to some other condition, such as osteomalacia If the child lives, one fracture occurs after another and the limbs may become terribly deformed, although with care they usually unite well In addition to the deformities due to the malunion of fractures, the bones are usually bent and distorted, and thus the case may be confused with rickets or osteomalacia The cranial bones sometimes participate in the process, and are deformed, the sclerotics are of a bright blue colour The actual anatomical changes in the bones consist in the persistence of cartilage cells in their capsules and calcification of the trabeculæ between, very little bone being formed, and that of a defective type The administration of parathyroid extract is justifiable, and calcium salts may be useful, otherwise, all that can be done is to protect the patient from mechanical injuries and treat the fractures as they occur

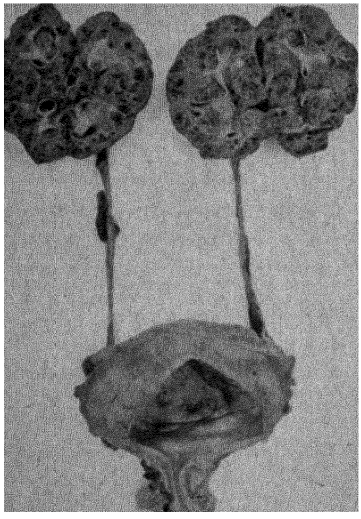


FIG 371.—CONGENITAL CYSTIC DISEASE OF THE KIDNEYS IN A CHILD SUFFERING FROM RENAL RICKETS

Mollities Ossium (*syn* **Osteomalacia**) is an *acquired* disease of somewhat unusual occurrence, characterized by the absorption of the osseous substance of the bones, as a result of which softening and rarefaction are produced, followed by bending or spontaneous fracture

The complaint is almost limited to the female sex (only 8 per cent of the cases reported are in males), and often commences during pregnancy, it is said to be sometimes connected with a rheumatic tendency Any part of the skeleton may be affected, in females the change usually attacks the pelvis, spinal column and ribs first, and the limbs later, in men the process starts in the long bones

Pathologically, the change consists in a replacement of the medullary substance by a soft fibro-cellular tissue, which is exceedingly vascular, and into which hæmorrhage often occurs, the resulting material looks in the fresh state somewhat like splenic pulp The bony cancelli are absorbed, as also the greater part of the compact tissue, with the exception of a thin layer situated beneath the periosteum, in a well-

marked case the mineral salts may be diminished to about one-sixth of their normal amount, but the relative proportion of phosphate of lime to the carbonate is not changed Part of the bone substance remains for a time in a decalcified state, with the corpuscles evident, but in a condition of fatty degeneration Possibly some acid, *e g* lactic acid, is the active agent in dissolving the earthy salts, which escape partly in the urine, partly in the fæces The disease is undoubtedly due to a deficiency in the circulating blood calcium, a deficiency which the body attempts to make good by the mobilization of the bone calcium The deficiency may be due to a deficient intake or a period of relatively deficient intake such as may occur during pregnancy, where the demands for calcium in the milk and in the skeleton of the fœtus are great Deficient absorption, as occurs in cases of idiopathic steatorrhœa, may give rise to this condition Lack of vitamin D, which is intimately concerned with the absorption of calcium, is also a potent factor in this disease



FIG 372 —PAGET'S DISEASE OF THE TIBIA

Note the broad, hazy trabeculæ alternating with areas of rarefaction, which tend to be pointed at their extremities, together with the bowing of the bone

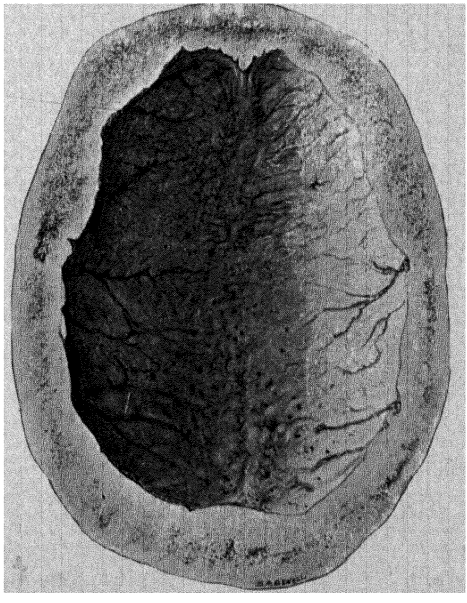


FIG 373 —CALVARIUM IN OSTEITIS DEFORMANS (ROYAL COLLEGE OF SURGEONS MUSEUM)

Clinically, the onset is somewhat indefinite, the only complaint being of pain in various parts of the body, whilst the patient becomes

emaciated and exhausted Sooner or later skeletal changes ensue and demonstrate the character of the disease In women the mischief usually commences in the pelvis, which becomes flattened at first, and subsequently triradiate, owing to the acetabula being pressed inwards and backwards by the weight of the body, and in pregnant women this may cause so much deformity as to necessitate Cæsarean section The spine becomes curved, whilst the limbs bend and break, in the latter case sometimes no attempt at repair is made, or healing may occur with deformity Death may result from exhaustion, or from obstruction to parturition, or the patient may live more or less bedridden for years, the limbs becoming useless, shortened, and perhaps contorted in a strange and abnormal fashion In women the disease may cease to progress, or even recovery may occur at the menopause

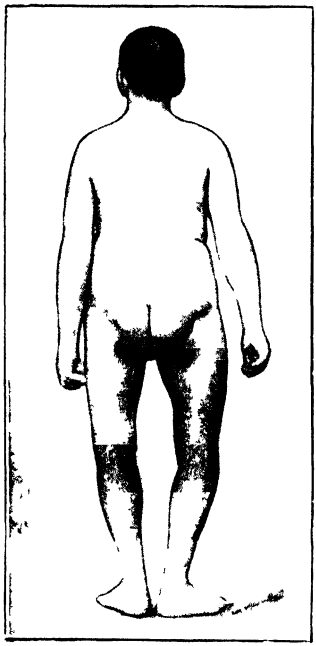


Fig 374.—Early Stage of Osteitis Deformans

Treatment consists of the administration of a diet containing requisite quantities of calcium together with vitamin D and the exposure of the body to sunlight or ultra-violet radiation During treatment and until a cure is effected the stresses to which the bones are subjected should be reduced to a minimum in order to avoid deformity

Osteitis deformans is an inflammatory disease of the osseous skeleton, first described by Sir James Paget in 1876 The onset is insidious, and the progress very slow It is characterized by a painful overgrowth of the long bones, spine, cranium, and pelvis, which are also softened, so that those which bear the weight of the body become curved It may commence in one bone alone, and then usually the tibia or femur, but more often many bones are affected at the same time (Fig 372) Attention may be drawn to the condition, either by the pain, which the patient at first considers to be rheumatic, or by the general enlargement and bending of the bones, or by the increased size of the head, necessitating the use of larger hats The cranial overgrowth is eccentric in character, and the calvarium may become very thick (Figs 373 and 375), the facial skeleton, however, is not much affected (Fig 376) The spine becomes markedly kyphotic (Fig 374), the dorsal curve being increased, and the lumbar concavity obliterated, it is nearly rigid from ankylosis of the vertebræ, and may be very painful In the later stages the head is carried forwards by the bent spine, the height is diminished, the shoulders are round, and the chest sunken towards the pelvis, the gait is slow and awkward

The disease usually attacks middle-aged men, its progress is exceedingly slow, the patient often living to an advanced age, or dying from some intercurrent malady Some cases have terminated in sarcoma or endothelioma of the bones The structure of the osseous tissue is suggestive of inflammatory rather than degenerative changes There is an invasion of the compact and cancellous bone by a very vascular connective tissue with subsequent loss of demarcation between these two layers of the bone It is during this process that fractures of the bone may occur Later osteogenic activity supervenes, and there

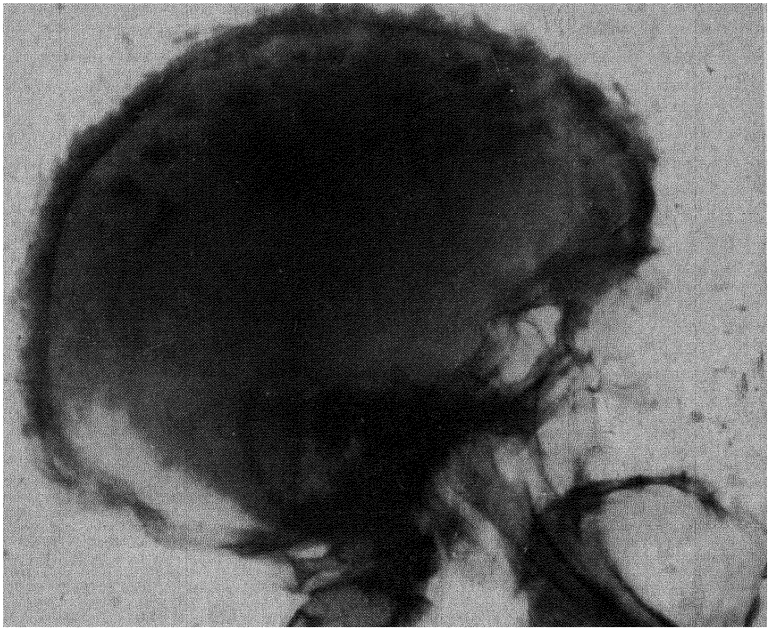


FIG 375 —SKIAGRAM OF SKULL IN OSTEITIS DEFORMANS

occurs the formation of many bony trabeculæ partly obliterating the medullary cavity and giving rise to a bone with an immensely thickened cortex

Differential Diagnosis —From *arthritis deformans*, which it resembles by the attitude and gait of the patient, it is known by the absence of articular lesions, especially in the fingers, and the enlargement of the bone, notably of the cranium From *acromegaly* it is distinguished by the absence of enlargement of the hands, feet, and lower jaw

Treatment is purely symptomatic, no remedy at present known having any control over the disease

Generalized Osteitis Fibrosa (von Recklinghausen's disease) is a condition associated with a disturbance of the calcium metabolism

of the body dependent upon over-activity of the parathyroid The disease is more common in women, occurring most frequently about the age of forty to fifty, and is usually accompanied by severe pain in the affected bones with associated general malaise and debility Sometimes the patient may attend with a fracture sustained as a result of some quite trivial violence, at others a tumour may be noticed, often in the jaw, and sometimes hæmaturia may bring the patient to the doctor In this disease there is a steady absorption and softening of the bone and replacement by vascular connective tissue, with the result that fractures and other deformities occur as a result of the stresses to which these weakened bones are subjected In this mass of fibrous tissue there are scattered small islands where calcification and ossification have taken place so that the bone cuts with a gritty sensation Cysts varying in size from a small pea to a plum are common throughout the bones affected and are filled with a reddish-brown fluid probably representing degenerated fibrous tissue Giant-cells are seen scattered in areas throughout the general granulation tissue of the bone Examination of the blood calcium shows this to be raised to anything up to 23 mgm per 100 c c , this being quickly reduced to normal with an accompanying return to a normal condition of the bones on removal of the parathyroid adenoma always present in this condition

A single cystic degeneration sometimes occurs, usually in young people, and most commonly in the upper end of the femur or humerus It is known as *focal osteitis fibrosa cystica* and is associated with no enlargement of the parathyroid or disturbance with calcium metabolism The cyst is lined with reddish granulation tissue and contains numerous giant-cells Fracture of the affected bone is often the initial symptom **Treatment** consists in exploration of the cyst, curetting it and packing the cavity with masses of bone chips This is followed by a period of suitable immobilization

Acromegaly is a rare condition, the characteristics of which were first described by Dr Pierre Marie in 1885 It is a general affection involving mainly the osseous system, commencing usually in young adults, and, after lasting for a long time, killing the patient by syncope or cerebral compression, if some intercurrent malady does not destroy him

It is characterized by a very definite enlargement of the hands and feet, which are, however, not lengthened, so that the hands have been compared to battledores and the fingers to sausages The bones themselves are enlarged, and the soft structures on the palmar aspects project as pads The nails and skin are unchanged, whilst the other segments, both of the upper and lower limbs, are usually unaffected, though sometimes considerable overgrowth in length occurs, in fact, many of the so-called giants who have been exhibited are typical illustrations of acromegaly Both the upper and lower jaws are thickened and prominent (Fig 377), whilst the lower lip is enlarged and overhanging The orbital ridges project, and the forehead is usually low, the nose and tip of the tongue are also more or less enlarged The spine is kyphotic in the dorsal region, with a slight

lumbar lordosis The ribs and sternum project anteriorly

The patient usually suffers from headache, lassitude, and great fatigue, wandering pains about the body, and excessive appetite and thirst, amenorrhœa is a marked symptom in women, whilst men suffer from a loss of virile power The urine is abundant, but of a low specific gravity Vision is usually diminished, and optic neuritis has been observed in some cases

Morbid Anatomy —The cause of acromegaly appears to be overgrowth of the anterior half of the pituitary body, and excessive absorption of its secretion

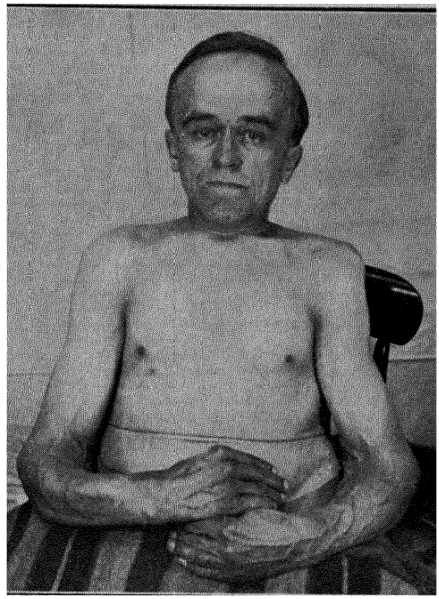


FIG 376 —OSTEITIS DEFORMANS IN LATE STAGE

Note size of the skull and curvature of humerus and of bones of forearms

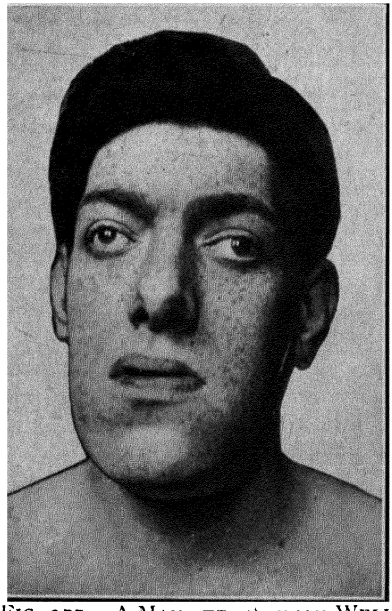


FIG 377 —A MAN ÆT 28 WITH WELL MARKED ACROMEGALY

Note the great enlargement of the lower jaw and the left external squint

(hyper-pituitarism) The sella turcica is expanded, and this can be recognized by X-rays The changes in the bones are merely those of overgrowth

Diagnosis —The disease has been mistaken for *myxœdema*, but there is not much difficulty in distinguishing the two if it be remembered that, in the latter condition, the skin is not mobile over the thickened subcutaneous tissue, that the face is broad, pasty, and puffy, and that masses of gelatinous tissue are found above the clavicle, whilst in acromegaly the face is elongated and the skin and subcutaneous tissues normal The mental condition and speech of a patient suffering from myxœdema are

widely different from those in acromegaly, whilst in the former the thyroid body is either absent or diseased, and in the latter skeletal changes are present From *chronic osteoarthritis* affecting the hands the diagnosis is easy, in that there are usually no signs of articular disease, and much less pain From *osteitis deformans* the distinguishing features have already been indicated

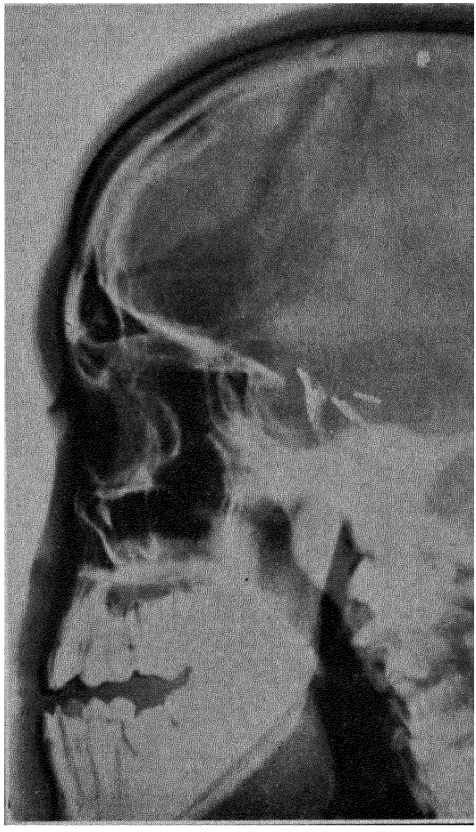


FIG 378 — SKIAGRAM OF SKULL OF ACROMEGALIC PATIENT SHOWING POSITION OF RADON SEEDS WHICH WERE INSERTED INTO THE PITUITARY BODY THROUGH AN OSTEOPLASTIC FRONTAL FLAP

Treatment is merely symptomatic, antipyrin being useful in relieving the headache, as also valerianate of caffeine Possibly thyroid extract may be of some use in combating the functional phenomena, though it will not influence the skeletal changes Attempts have been made to remove the growth by operation with success

In some cases, where increased intracranial pressure is observed, the introduction of radon seeds into the pituitary through a frontal osteoplastic approach may be very beneficial (Fig 378)

In advanced acromegalics the lower jaw may be so enlarged that the patients' bite may be well out of alinement (Fig 379) In these cases a wedge-shaped resection of the middle of the lower jaw should be performed on both sides, and gives excellent results The idea that fracture through the jaw of an acromegalic never unites is mythical

Hypertrophic Osteo-Arthropathy —It has long been known that clubbing of the terminal phalanges is associated with chronic pulmonary and cardiac disease (Fig 381), and it is probable that such is the earliest stage of this more generalized affection, first described by Pierre Marie In it the ends of the fingers and toes are enlarged and bulbous, with the nails curved over towards the palm or sole, in the early stages the change may be limited to the soft tissues, but radio-

graphy has demonstrated that in the later there is a well-marked new formation of bone along the shafts of the phlaanges, and also of

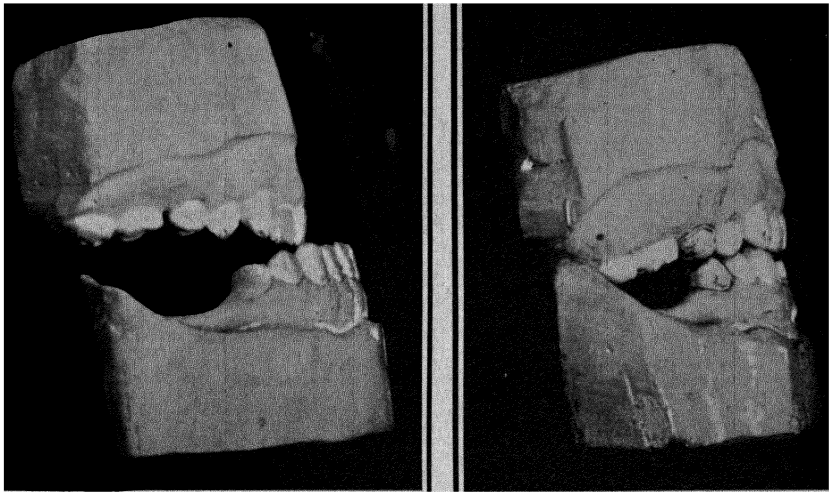


FIG 379 FIG 380

FIGS 379 AND 380.—THE BITE OF ACROMEGALIC PATIENT BEFORE AND AFTER A WEDGE RESECTION OF THE HORIZONTAL RAMUS OF THE LOWER JAW

the metatarsal and metacarpal bones There is a considerable swelling of the bones just above the wrists and ankles, extending some way

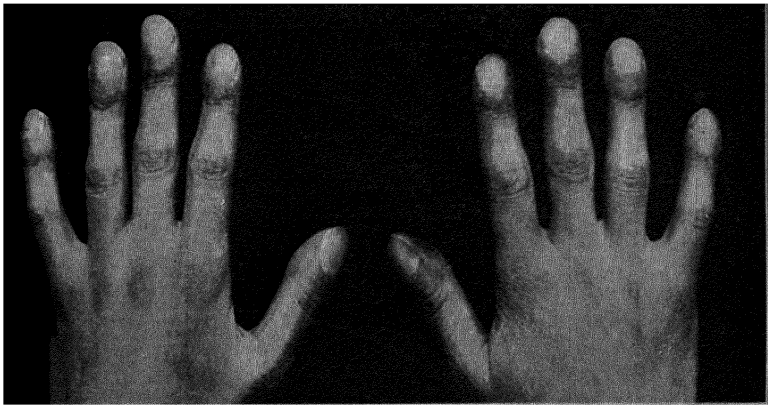


FIG 381.—CLUBBED FINGERS DUE TO CHRONIC EMPYEMA

along the shafts, and similar bony enlargements sometimes occur elsewhere, they are due to a diffuse osteo-periostitis The spine is kyphotic

in the upper dorsal region, but with well-marked lordosis below It is thus seen that the changes are somewhat like those of acromegaly, from which they are distinguished by (*a*) the implication chiefly of the fingers and toes, and particularly of the terminal phalanges, whilst in acromegaly the enlargement of the different portions of the hands and feet is general, (*b*) the nails are not affected in acromegaly, (*c*) the joints are but little involved in acromegaly, and (*d*) the enlargements of face, tongue, jaw, etc , so marked in acromegaly, are absent in osteo-arthropathy These phenomena probably result from chronic toxic absorption, since the condition arises in such diseases as chronic bronchitis, bronchiectasis, and chronic empyema, where suppuration has existed for some time It is, however, sometimes associated with lesions other than pulmonary, *e g* chronic jaundice, syphilis, and influenza, and has even been found in otherwise apparently healthy individuals Little can be done in the way of treatment, except to deal with the cause, if obvious

Tumours of Bone.

The characters of the osteomata, chrondromata, and fibromata of bone have been described in Chapter VII , and various solid and cystic tumours connected with the teeth are dealt with elsewhere

Myeloma (Osteoclastoma or Giant-Cell Tumour) (Fig 382 and Plate VIII) is practically a benign tumour, rarely giving rise to secondary deposits either in lymphatic glands or viscera, and its growth within the bone is strictly limited, with no tendency to diffusion along the medulla, occasionally a layer of condensed bone demonstrable by radiography forms an effective barrier in this direction It most commonly affects persons between twenty and forty years of age For its pathological features (Fig 383), see p 201 The sites of election for myeloid tumours are the growing ends of the long bones, especially the lower ends of the femur and radius, and the upper ends of the humerus, tibia, and fibula, whilst they also occur in the diploe and lower jaw, and constitute one form of epulis The development of the tumour leads to the so-called *expansion* of the bone, in which the osseous tissue is absorbed from the inner aspect, and new bone is laid down externally, the outer layers, however, gradually become thinned, so that after a time the osseous lamina can be pressed inwards, giving rise to a feeling known as 'eggshell crackling', and finally the tumour projects through the bony wall This expansion may be central, and the bone end thus becomes more or less globular, or it may be eccentric, and then the growth projects merely on one side Sooner or later spontaneous fracture is likely to occur Neighbouring joints usually escape, but in old-standing cases the growth may project around the articular cartilage and somewhat impair the movements, there may, however, be some serous effusion in the cavity The **Symptoms** may be so slight at the commencement that nothing is noted until fracture has taken place, but sometimes pain similar to that of a chronic osteoperiostitis draws attention to the enlargement of the bone Radiographic examination reveals a well-defined area of bone, which is



Osteoclastoma of the lower end of the Tibia

(Museum, Royal College of Surgeons)

[*To face page* 676

unduly translucent, but with the characteristic 'stippling' due to the presence of calcareous foci scattered through the growth The

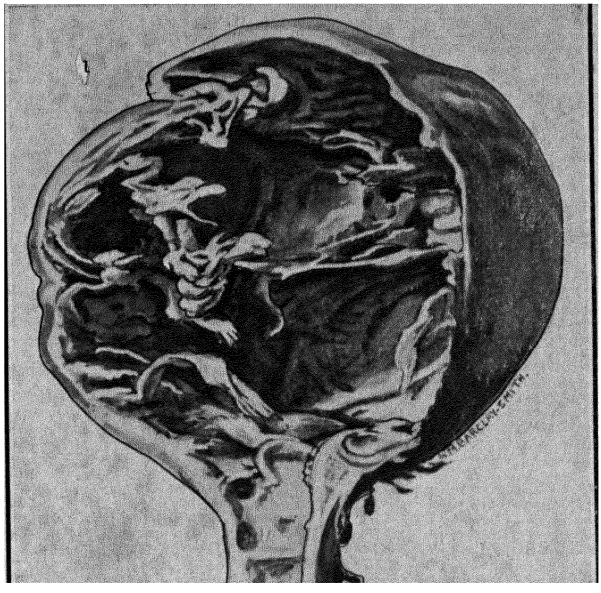


FIG 382.—MYELOMA (OSTEOCLASTOMA) OF HEAD OF TIBIA

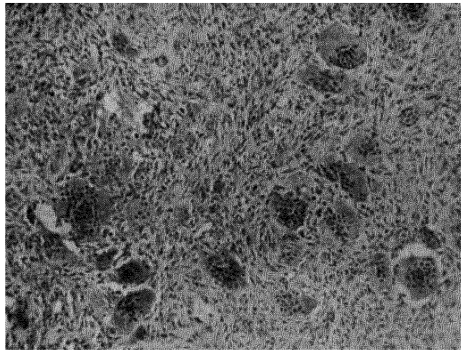


FIG 383.—MICROPHOTOGRAPH OF A SECTION OF AN OSTEOCLASTOMA OF THE RADIUS

The giant cells can be easily seen

accurate limitation of the growth, and its demarcation from the medullary cavity, are important diagnostic signs

Treatment is governed by the assurance that a myeloma is non-malignant, and hence may be dealt with in a conservative manner

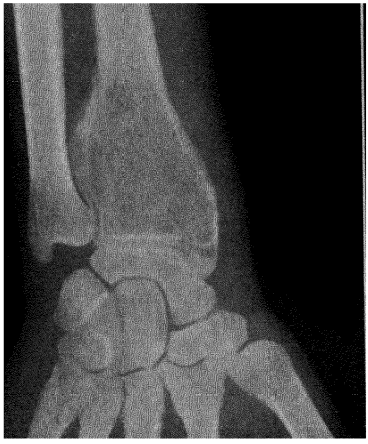


FIG 384.—MYELOMA OF LOWER END OF THE RADIUS

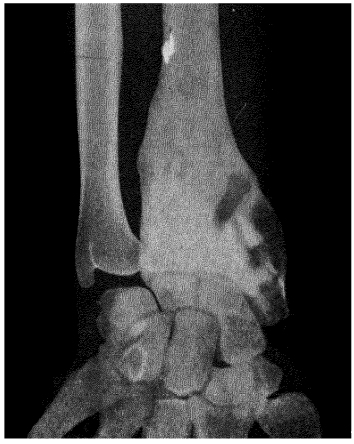


FIG 385.—THE SAME CASE AS FIG 384 AFTER CURETTING AND THE INTRODUCTION OF BONE CHIPS



FIG 386.—MULTIPLE MYELOMATOSIS OF THE SKULL

by a localized removal of the growth, amputation being reserved for the more advanced cases and for those where a local removal would

leave a more or less useless limb In quite the early stages it suffices cleanly to excise the growth, or if that is impracticable, to incise and scrape it away with a sharp spoon, closing the wound without drainage, possibly after filling it with bone chips (Figs 384 and 385) Subsequent exposure of the part to radium or X-rays is desirable in order to complete the destruction of the growth In a later stage the affected portion of the bone may be completely removed, and if necessary the gap bridged by bone-grafting Thus a myeloid tumour of the upper end of the fibula can be excised, care being taken of the external popliteal nerve and its branches, but if the upper end of the tibia or lower end of the femur is involved to the extent of destroying most of the bony substance, amputation may be required



FIG 387 —MULTIPLE MYELOMATOSIS OF THE SKULL

Multiple Myelomatosis —This is a somewhat rare condition, occurring usually between the ages of forty and sixty, and may be classified as a primary malignant tumour of the bone-marrow It originates particularly in the bones which normally contain red marrow, and so is most frequently found in the vertebræ, sternum, and the ribs The pelvic bones and the skull, however, are not uncommonly affected The multiple tumours are independent growths, commencing simultaneously in a number of different bones, and begin as small nodules which vary in size from that of a pea to that of a hen's egg The bone is gradually destroyed, and its place is taken by a soft greyish-red mass The cells composing this mass consist of primitive types arising from the same cells as those found in the blood In some cases the cells of this disease resemble plasma cells, and in the very rare examples where a single focus of this disease has been recorded without any disease whatever of other bones, it is this cell type that has been present In the skull (Figs 386 and 387) the growths appear as multiple clear areas of varying size The disease first manifests itself by pain, and men are more often affected than women The pain, usually in the back, becomes persistent, and kyphosis may develop and slight fever may occur Bence-Jones proteosuria may be present Secondary anæmia soon appears, and the patient dies of general cachexia with secondary metastatic deposits scattered throughout

the viscera The actual diagnosis is confirmed by the X-ray appearances in the bones

Treatment in the past was regarded as useless, but with modern deep X-ray therapy better results are being obtained

Sarcoma of Bone—It has been customary in the past to describe types of sarcoma of bone as endosteal or periosteal, according to which part of the bone development primarily arises Other types described were based on the predominant groundwork of the tumour, so that such types as osteo-sarcoma, chondro-sarcoma, myxo-sarcoma,

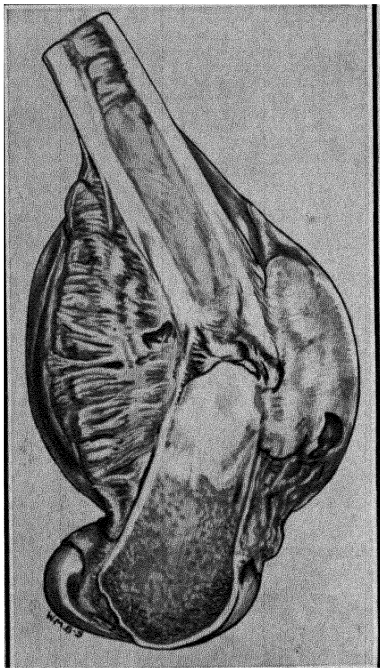


FIG 388—OSTEOGENIC SARCOMA DISSEMINATING ITSELF IN THE MEDULLARY CAVITY AND CAUSING A FRACTURE (KING'S COLLEGE HOSPITAL MUSEUM)

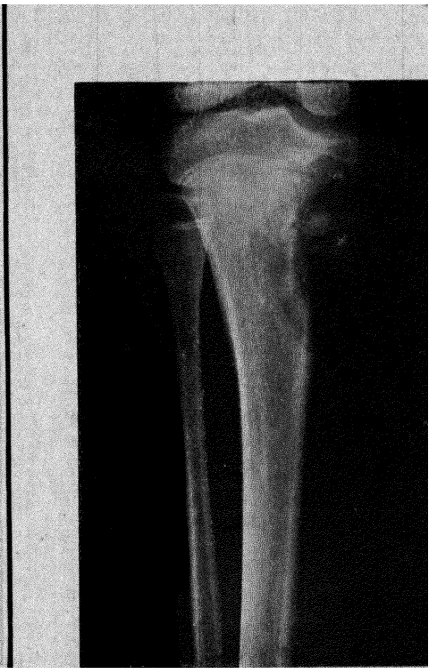


FIG 389—SARCOMA OF TIBIA OF THE OSTEOLYTIC TYPE

fibro-sarcoma of bone were all mentioned Such a classification is now regarded as false, because in most cases it is impossible to tell exactly in what part of the bone the tumour arose, as all parts are equally invaded, and even though one may have arisen from the cancellous and another from the compact bone the ultimate picture is alike and indistinguishable Moreover, according to the various degenerations and changes that the matrix of the tumour undergoes so the differences, erroneously referred to as different types in the older classification, arise It is better to refer to these sarcomas of bone as *osteogenic*

sarcomas, implying not that bone formation is an essential character, but that they arise from cells capable of forming bone One type of sarcoma must, however, be clearly separated from this group, and that is a simple *fibro-sarcoma* arising from the fibrous tissue layers of the periosteum, a tumour related only to bone by virtue of its position Any rarefaction of the shaft occurs by virtue of pressure or secondary involvement, and any periosteal reaction occurs as a result of irrita-

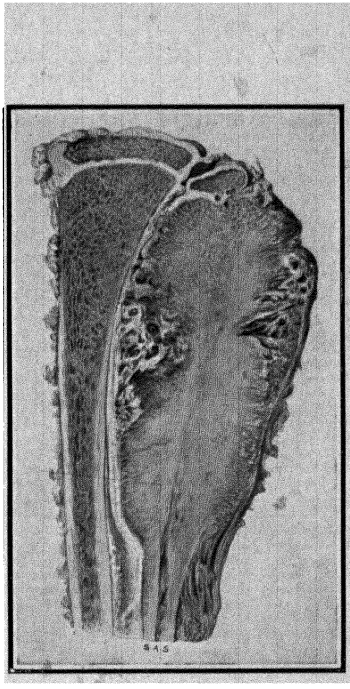


FIG 390 —OSTEOGENIC SARCOMA OF FIBULA (KING'S COLLEGE HOSPITAL MUSEUM)

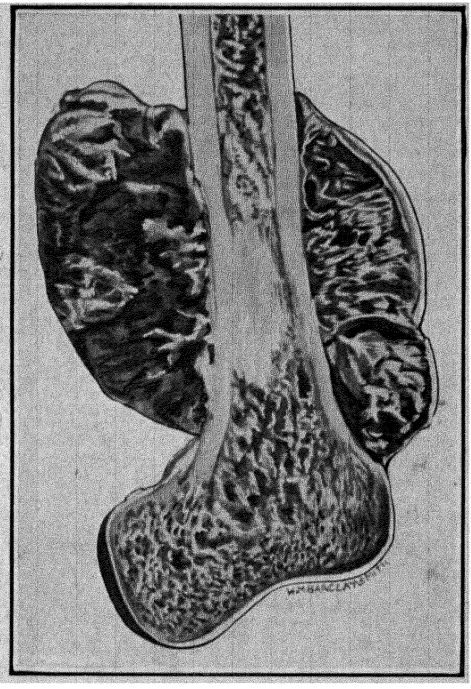


FIG 391 —OSTEOGENIC SARCOMA OF LOWER END OF FEMUR INVADING BONE (KING'S COLLEGE HOSPITAL MUSEUM)

tion of the periosteum by fibro-sarcoma, not because the tumour is osteogenic

The disease is one that affects most commonly adolescents of about fifteen years It occurs in the metaphyseal region, the bones most commonly affected being the adjacent ends of the femur and tibia, the upper end of the humerus, and most rarely the radius, ulna, or scapula (Figs 388, 389, 390, 391) Pathologically there is an invasion of all layers of the bone by the growth, the epiphyseal cartilage, however, and the periosteum to a lesser extent serving as barriers to the extension of the neoplasm The tumour mass is richly supplied with blood-vessels, and hæmorrhage may occur into its substance with the formation of hæmorrhagic cysts Sometimes the vascular supply is so abundant that pulsation occurs, giving rise to the so-

called 'malignant bone aneurism' (Fig 392) In other cases the tumour is relatively avascular The characteristic cell type of the tumour is usually a spindle-shaped cell, though round cells with hyperchromatic nuclei, and, in areas where much bone destruction is occurring, multinucleate osteoclasts, are common The matrix, as we have seen, varies from tumour to tumour and may be osteoid, cartilaginous, fibrous, or myxomatous At first the periosteum is merely raised up from the bone by the expanding tumour, but eventually this gives way and rapid permeation of the superficial tissues then occurs At the junction of the raised with the normal periosteum radially placed striæ of ossification often form (Figs 390 and 392), which are easily recognizable with the X-rays (Fig 393) The tumour spreads partly by lymphatic invasion, but more extensively through emboli which become detached from areas of the growth invading the blood-vessels Secondary deposits in the lungs should therefore be looked for in every case The patient usually gives a history of relevant trauma some months or so before the onset of pain in the affected area, and this may be of especial severity at night and bring the patient to the doctor If this is tolerated, the presence of a slowly growing tumour or even a fracture may send the patient for advice In the early stages of the disease the patient's general health is good, but later anæmia and cachexia rapidly set in Inquiry must always be made for chest complaints suggestive of secondary deposits, and it is important that an X-ray of the chest should be taken On examination of the limb a deep swelling will be found with little evidence of increased heat or redness in the skin There will probably be muscle wasting of some degree, but movements of the adjacent joints will be free In the late stages the soft parts will be involved and the growth will ulcerate through the skin X-ray examination will show an area of bone involvement with generalized absorption of the metaphysis, with perhaps little new bone formation So great may the bone absorption be in the *osteolytic* type of sarcoma that re-

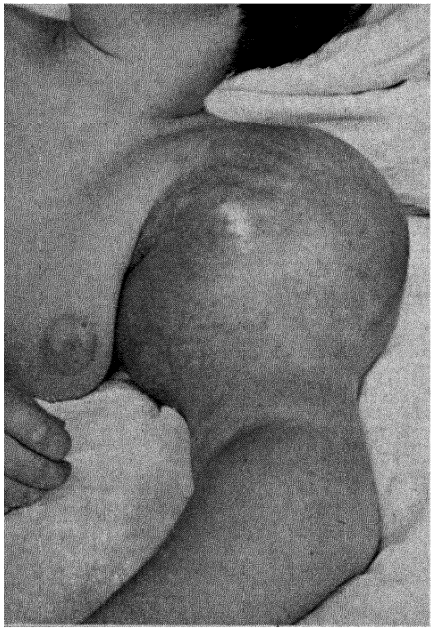


FIG 392.—LARGE OSTEOGENIC SARCOMA OF HUMERUS THE TUMOUR WAS SO VASCULAR THAT IT PULSATED (MR ROBERT MILNE'S CASE)

semblance to a cyst is at first sight great, but the irregularity of the extension serves as a differentiating point The prognosis in these cases is bad Where doubt exists as to the diagnosis biopsy may be justified following a preliminary course of deep X-ray therapy

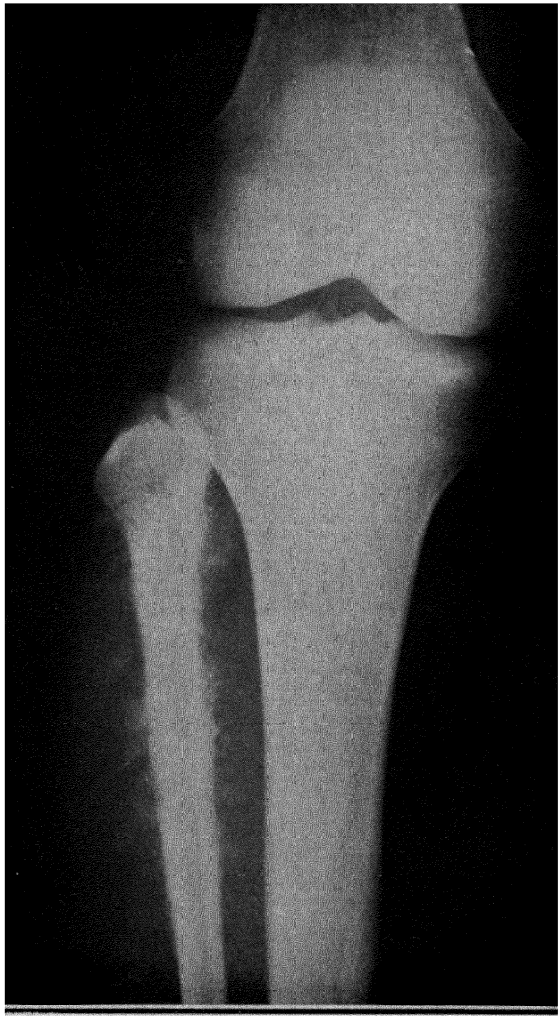


FIG 393 —SKIAGRAM OF AN OSTEOGENIC SARCOMA OF THE FIBULA

Treatment will consist of either deep X-ray therapy or amputation at a high level A combination of these two is probably best, and it is most desirable to give the patient a course of X-ray therapy and follow this by an amputation X-ray treatment alone often causes

a disappearance of the tumour, but recurrence is the rule, and these recurrences are resistant to further treatment

Ewing's Tumour or Sarcoma is a rare tumour affecting the shaft of the long bones, more especially the tibia and the humerus, and giving rise to metastatic secondary deposits in other bones It usually affects young adults and adolescents, who give a history of preceding trauma associated with some pain This is followed by the appearance of a swelling which seems to undergo periodic variations in size, which are paralleled by leucocytosis, fever, general malaise, and perhaps redness and heat over the site of the tumour These signs and symptoms may easily lead to the erroneous diagnosis of subacute osteo-myelitis As in osteogenic sarcoma, during the early months of the disease the patient is generally fit and well, but with the onset of secondary deposits in the ribs, sternum, vertebræ, and other bones, anæmia, cachexia, and intolerable pain rapidly drag the patient downhill The tumour consists of masses of round cells with very little intercellular matrix Giant cells are never present There is a general lysis of the bone affected, although the raised periosteum attempts to form lamellæ in the line of the original shaft To the naked eye the tumour has an appearance suggestive of that associated with a subacute pyogenic condition in bone, which further serves to account for mistaken diagnosis in the past The condition is probably less lethal than that of osteogenic sarcoma, but the treatment is identical

Secondary Sarcoma of bone is by no means uncommon It is almost always endosteal in character, and, except in the most unusual circumstances, will not demand treatment, owing to the general infection of the system Possibly where it has led to spontaneous fracture, and there is much pain owing to the difficulty of fixation, it would be justifiable to remove the limb

Carcinoma of bone is always secondary in nature, although it may be involved by direct extension in a primary growth Secondary growths are endosteal in character, and often extremely painful, they may occasionally lead to spontaneous fracture, but the bone may consolidate again satisfactorily After scirrhus mammæ, the bones of the chest wall, the upper end of the femur and vertebræ are those most often affected

Pulsating Tumours of Bone, or Osteo-Aneurism —Apart from pulsating sarcoma, two other conditions are met with in which distinct pulsation is also noticeable In the first of these the medullary cavity is occupied by a non-malignant vascular tissue, practically identical with what has been already described as an *aneurism by anastomosis* (p 369) These tumours are situated most frequently in the cranial bones, and may be multiple, the medullary tissue being in consequence atrophied, and the compact tissue thinned, so that 'eggshell crackling' may be obtained The second form is found most commonly in the upper end of the tibia, or some such cancellous mass It consists of a hollow cavity filled with blood Several distinct arterial twigs may open into it, and the overlying bone is thinned and absorbed It is probable that the majority of such cases are in reality due to the breaking down of a sarcoma of extreme tenuity, or possibly of a mye-

loma **Treatment.**—If it seems probable that the condition is not associated with malignant disease, the cavity should be incised, scraped, swabbed out with pure carbolic acid, and then packed with a muscle graft, or with gauze, so as to obtain healing by granulation If the bleeding persists, amputation is the only treatment

Hydatid Disease of Bone.—The cancellous tissue of bones occasionally becomes the site of hydatid development, any part either of the medullary cavity or of the ends being involved The bone becomes expanded, with all the symptoms of an endosteal growth Considerable deformity may occur, and when the compact layer has been sufficiently absorbed, spontaneous fracture may follow In this affection there is no limiting wall, the small daughter cysts being diffused through the affected area Radiography and laboratory tests (p 232) should suffice to ensure a diagnosis, but in countries where hydatid disease is rare, the condition is very liable not to be recognized until an exploratory incision has been made **Treatment.**—If all the cysts can be removed without interfering with the integrity of the shaft, a recovery, with good subsequent utility of the limb, should follow Where, however, the disease has encroached widely on the bony tissue, whether spontaneous fracture has occurred or not, amputation holds out the only prospect of cure, unless bone-grafting is feasible

Affections of the Ribs and Sternum.

Osteomyelitis of the ribs is very unusual Occasionally an acute pyococcal variety, running its usual course to necrosis, occurs in children, but the most common cause is typhoid fever (p 651) The affection is then generally of a subacute type, and a more or less extensive cario-necrosis results A special feature is the tendency of the bacilli to remain in a latent condition in the tissues, so that to ensure a perfect cure complete extirpation of the affected portion of bone is required

Syphilitic Disease is more common in the sternum than in the ribs The upper part of the *sternum* is usually involved, and the affection is characterized by a formation of gummata in and upon the bone, which erode it, usually in a pitted fashion, and may cause necrosis Treatment with iodide of potassium and mercury is required, and sequestra must be removed In connection with the *ribs*, syphilis appears as a tertiary periostitis or perichondritis A fusiform swelling develops with but little pain or tenderness, it may easily be mistaken for tuberculous disease or a new growth, but the history may help to a correct diagnosis, which can be confirmed by the Wassermann test

Tuberculous Disease affects the ribs much more frequently than the sternum In the *ribs*, it may arise primarily as an osteomyelitis implicating an extensive portion of the medulla, but it is not unfrequently secondary to tubercle of neighbouring parts, *e g* the spine or pleura, and then commences beneath the periosteum, several ribs may be involved at the same time. The disease is most commonly seen in young people, and affects either the middle of the rib or the

costo-chondral junction The usual manifestations of tubercle in bone are seen, giving rise to expansion of the bone, or to caries or necrosis, and suppuration is common The abscess cavity may be mainly external to the ribs, but is not unfrequently hour-glass-shaped, a narrow neck connecting the cavities which lie inside and outside the chest *Treatment* in these cases may have to be of a radical type, including complete removal of an extensive portion of the rib and of the abscess cavity attached to it

In the *sternum* tubercle runs its ordinary course, and may present an abscess which points either in front near the middle line, or may come forwards from behind through an intercostal space Treatment is of the usual sanatorium type, but if an abscess needs to be opened, the opportunity should be taken of curetting the bone

Tumours of the ribs and sternum are usually chondromata or chondro-sarcomata, perhaps the former are a little more common in the ribs, the latter in the sternum The patient complains of but little pain, and therefore the cases are usually late in coming under observation In time the growth becomes adherent to the pleura, and the lung itself may be invaded In the early stages it is sometimes possible to remove them, although the lung is liable to collapse unless special precautions are taken

Bone-grafting is an operation which has come much to the front of late, and is required for many ununited fractures, especially where there has been great loss of tissue, as also for reparative purposes where much bone has been removed with tumours or cysts It is also employed for purposes of fixation of joints or of the spine

Formerly fragments of dead bone, or rods of ivory, were employed, but, of course, they are merely passive actors in the process of regeneration, being absorbed or replaced Living bone, on the contrary, is capable of retaining its vitality, and uniting with the surrounding parts, even if totally separated from its former osseous connections The graft must be obtained from the patient himself (*autogenous*), those from another patient (*homogenous*) or from a freshly killed animal (*heterogenous*) being unsatisfactory as they do not survive the transplant

The persisting capacity of bone cells to reproduce osseous tissue away from their old surroundings is the basis on which the success of bone-grafting depends Unfortunately, this capacity is not always exercised in the direction the surgeon desires, thus new bone may form where it is not wanted, *e g* in cases of traumatic myositis ossificans, and it may fail to develop where most needed, as after fractures or bone-grafting Sometimes a graft is absorbed completely after an apparently successful operation, and non-union follows It is clear, therefore, that there are still some points in this procedure which are not fully understood

Many methods of grafting have been employed from time to time, varying with the different ideas as to the destiny and usefulness of grafts, and with the manipulative dexterity and mechanical appliances at the disposal of the particular surgeon

1 It is possible to utilize chipped-up fragments of living bone, either loosely powdered in the cavity to be filled, or firmly packed in These may easily be procured from the subperiosteal surface of the tibia It is probably best to pack the cavity firmly and close it entirely, the grafts survive on account of the blood-plasma permeating through the cavity until the time arrives when the whole mass is vascularized and organized An ununited fracture may be treated in this way by freeing the ends, and making a fresh section of them to expose healthy bone tissue, they are then fixed, *e g* by a plate, and the interval between the fragments packed firmly with bone chips This is not, however, a procedure to be recommended if other means are available

2 In some situations all that is required is a thin lamella of bony tissue, *e g* in cranioplasty, or in some ununited fractures of the lower jaw A suitable shaped flap is marked out on the front of the tibia or crest of the ilium, and the superficial layer of bone, together with the periosteum, is chiselled up and transplanted In some fractures of the jaw a thin graft such as that described may be rolled up like a cigarette and fixed between the bone ends

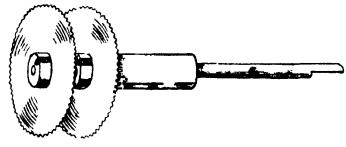


FIG 394 —DOUBLE CIRCULAR SAW FOR BONE-GRAFTING (ALBEE)

The distance between the two saws is easily regulated

3 In other places a more massive graft is desirable, and for this purpose complete sections of bones, *e g* of the fibula, or a metatarsal bone, were employed in the first place They are effective, but not very suitable in all cases Portions of ribs also have been used for reconstituting a lower jaw

The introduction by Albee of the double circular saw (Fig 394) driven by an electric motor has revolutionized this procedure, and placed in the hands of surgeons the means of cutting rapidly grafts which are well adapted for the part they have to play The front of the tibia is the favourite site from which to obtain such grafts for work on the long bones

Much discussion has arisen as to whether or not a bone-graft should include the periosteum, and as to its depth There is no question that the retention of vitality of the graft depends upon its gaining a fresh blood-supply as rapidly as possible, failing this, the graft dies, and is absorbed or cast out of the body To establish vascular continuity between the graft and the tissues in which it is placed must obviously be easier if it is covered with fibrous tissue which is vascular under normal conditions, or leaves an exposed surface of cancellous bone Hence, whenever practicable, it is desirable that the graft should be covered with periosteum externally, and should include a portion of the vascular medullary tissue on its deeper aspect Naturally the less the graft is handled the better, inasmuch as the superficial cells are thereby less likely to be killed

It is hardly necessary to point out that for success the following essentials must be secured (1) *Absolute asepsis.* This excludes early

operation on compound fractures, however desirable it may appear from the functional standpoint Healing must have been secured for some time before bone-grafting is considered (2) *Absolute hæmostasis* is necessary in order that the graft may unite rapidly with the surrounding tissues, and thus its vascular supply be ensured, the presence of a hæmatoma may jeopardize its vitality (3) *Effective fixation* is most desirable, but if this can be secured without the use of nails, screws, or wires, so much the better, these all have a tendency to hinder reparative activity in their immediate neighbourhood, wires are less harmful than nails or screws Autogenous bone nails or pegs are very useful, and may be cut by the shaper provided with the Albee saw outfit (4) Complete rest must be provided after the operation,

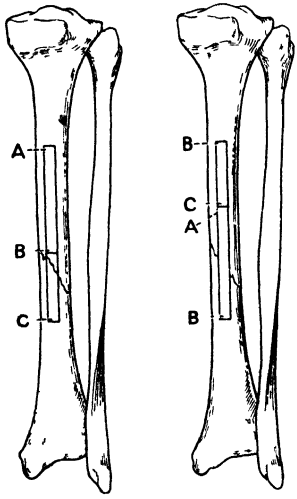


FIG 395 —SLIDING INLAY BONE GRAFT

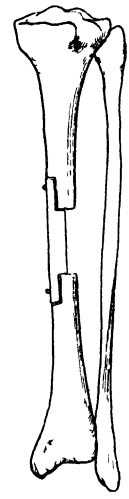


FIG 396 — BONE GRAFTING BY A 'STEPPED LATERAL GRAFT

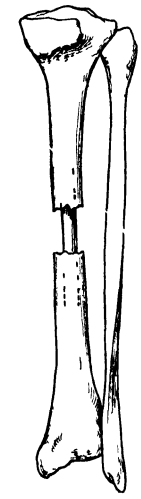


FIG 397 — BONE-GRAFTING BY AN INTRAMEDULLARY PLUG

so as to permit of effective healing between the bone and the graft, too early mobilization might break up this bond of union (5) On the other hand, as soon as union is effective, active use of the limb is desirable in order to stimulate its growth, the amount and direction of which reacts to the strain and stress placed upon the part, in other words, growth and structure depend on function

It is impossible here to enter into details as to the various operations which may be required It must suffice to point out three of the different methods of bone graft suitable for lesions of the long bones, others will be hinted at elsewhere

1 The **Sliding Inlay** (Fig 395) is a most useful method for dealing with fractures which are difficult to retain in position, or for certain ununited fractures It consists in cutting a long narrow graft extend-

ing over both fragments (AB and BC) in such a manner that the portion derived from one fragment is double the length of that from the other They are detached from their deep connections, and the longer (AB) is slid down so as to lie across the line of fracture, the shorter (BC) is transferred to fill up the gap left by the displacement of AB If the grafts go down to the medullary tissue they fit accurately, and no fixation wires or screws are necessary, the periosteum in such an operation is advisably stripped back, and replaced after the operation

2 The **Lateral Graft** (Fig 396) is employed more frequently where there is actual loss of substance The parts are laid open, the ends of the bone are freed, and suitably ' stepped ' so as to receive the graft cut from the tibia It is laid in position and fixed by wires or bone pegs or screws, and the soft tissues closed over it A similar plan may be adopted for ununited fractures with no great loss of substance

3 The **Intramedullary Plug** (Fig 397) gives fairly accurate fixation, but, as already pointed out (p 551), it is not an altogether desirable method of procedure There is also a considerable liability to fracture of the graft if exposed to strain too early

CHAPTER XXII

INJURIES OF JOINTS—DISLOCATIONS.

Sprains or strains result from sudden violence applied to a joint either directly or indirectly, and consist in tearing or stretching of ligaments or tendinous insertions of muscles close to the articular lines, in not a few instances the synovial membrane is also involved The accident itself is very painful, and is followed by heat and swelling of the joint, due to a hæmorrhagic effusion, which with care and rest disappears in a few days, and with suitable after-treatment the joint recovers perfectly, but in the absence of the latter, recurring attacks of pain and persistent weakness are likely to develop A neglected sprain may originate tuberculous disease or osteo-arthritis If the patient is in a bad state of health at the time of the injury, an attack of infective arthritis may be determined

Careful palpation to discover the most tender spot indicates the situation of the lesion, which may be at the insertion of the muscle or ligament, or at any part of its course **Treatment** consists in putting the part to rest and supporting it firmly by a bandage over cotton-wool so as to limit effusion and to bring the segments of the divided structure into close apposition, in the more severe cases a splint should be applied At the end of a week or ten days the splint may be dispensed with, and support secured by strapping or an elastic bandage Massage and the alternate application of hot and cold douches also assist in restoring the function of the part, but special care must be taken to prevent stretching or injury to the newly-formed bond of union

Thus in a **sprained ankle** the lesion commonly involves one of the fasciculi of the external lateral ligament To bring the damaged structures into apposition, the foot is everted, and bandages or strapping must be applied so as to maintain this position, and hence must pass across the sole of the foot from within outwards and upwards When the patient begins to get about once again, this position must still be kept up by the use of a boot, the heels and sole of which are thickened slightly on the outer side Similarly, if the internal lateral ligament is damaged, the foot must be kept in the varus position, and the sole and heel of the boot thickened by patches placed on the inner side

A sprain of the **internal lateral ligament of the knee** causes tenderness over its attachment to the tibia (Fig 415), and pain is specially elicited by eversion or abduction of the leg The synovial effusion is treated in the usual way by rest in bed on a back splint, and when this has disappeared the joint must be strapped or firmly bandaged, and the weight diverted to the outer side of the limb by thickening the inner

aspect of the sole and heel of the boot Massage will, of course, be helpful, but efficient support and protection from recurrence of the mischief are even more important

Penetrating Wounds of Joints are often accompanied by an escape of synovia, which is recognized as a glairy, oily fluid, floating perhaps on the surface of the blood, if, however, the aperture is small, this may not occur It is always followed by a certain amount of reaction, the character of which depends on whether or not the joint is infected If no infection has taken place, a simple synovitis ensues, but soon passes, if, however, infection has occurred, suppurative synovitis probably supervenes, leading perhaps to acute arthritis and disorganization to the joint A penetrating wound, even if untreated, does not necessarily become infected, thus, if the lesion is produced by a small, clean instrument, and especially if this is inserted in a slanting direction, so that the wound is valvular, or if the incision is a large one, allowing free vent to all discharges, recovery without infection is possible

Treatment.—If the wound is small, and there is reason to believe that infection has not occurred, the external skin should be thoroughly purified, and an aseptic dressing applied, together with a suitable splint to keep the limb at rest A careful watch is kept upon the temperature and pulse, and also on the condition of the joint, painful distension of which probably indicates infection The synovial cavity is then at once aspirated with a syringe and its contents withdrawn and carefully examined (1) If the fluid is quite clear and merely blood-stained, probably no serious mischief is present (2) If it is slightly turbid, infection is present, and the joint should be washed out with sterile saline solution, and perhaps injected with 2 drachms of a 2 per cent solution of formalin in glycerine, or with 2 to 4 drachms of a 1 in 1,000 solution of flavine The limb is placed on a splint with slight extension and kept at rest, for a knee-joint, a Thomas's splint should be employed Re-accumulation of the fluid necessitates a repetition of the same procedure every day or two (3) If the fluid is from the first frankly purulent, or becomes so, a similar proceeding may be undertaken so long as the general and local symptoms are satisfactory and do not indicate any grave arthritic complications, but if the swelling of the limb increases, as also the pain and fever, then the treatment for acute arthritis must be instituted (4) If the bacteriological examination reveals the presence of a hæmolyzing streptococcus, the chances of curing the trouble without ankylosis or amputation are much diminished

Where the external wound is large, and probably infected from the first, its treatment must correspond to that of a gunshot wound, *viz* it must be carefully excised down to the lesion in the synovial membrane The margins of the rent in the membrane are cut away, and the joint cavity washed out with sterilized saline solution, followed perhaps by ether or by the 2 per cent solution of formalin in glycerine The cavity is now closed, a proceeding facilitated sometimes by loosening the suprapatellar pouch from the front of the femur, and the external wound sutured or packed with gauze impregnated with

flavine or 'bipp,' with a view to delayed primary suture in a day or two

The after-treatment of these cases is as for those of suppurative lesions of joints generally (p 732)

Dislocations.

A **Congenital Dislocation** is one due to some irregularity of location of the bony constituents of a joint present at birth, resulting from some error of development The hip-joint is most frequently affected (p 500) A **recurring** dislocation is one which develops again and again on the slightest provocation or follows any injudicious movement It is generally due to some slight irregularity in the shape of the bone end, but also to capsular relaxation, largely induced by the frequently repeated attacks of synovitis following the displacement The shoulder and temporo-maxillary joints are most often affected

Pathological Dislocations are produced as the result of some intra-articular affection, *e g* tuberculous disease, osteo-arthritis, Charcot's disease, etc It is unnecessary to describe them here

Traumatic Dislocations—The **Causes** are divided into predisposing and exciting Under the former head may be included anatomical peculiarities, such as the shallow socket of the glenoid cavity, or some muscular or ligamentous weakness Dislocations are rare in children since any violence directed to a joint or its neighbourhood is more, likely to lead to an epiphyseal separation Moreover, in old people the bones become brittle, and thus fractures, rather than dislocations, are produced, hence the latter lesions are almost limited to adults, and, owing to their greater exposure to injury, occur in men rather than in women

The **Exciting Causes** are the application of external violence and muscular force, acting alone or in combination The former may be direct, but is more commonly indirect, the force being applied at a distance from the joint Muscular action by itself can only produce dislocation in certain joints, the head of the humerus, the patella and condyle of the jaw, are the bones most often affected in this way If, however, the ligaments of a joint have been stretched by previous disease or displacement, recurrent dislocations from muscular action are not unusual

The term *complete dislocation*, or *luxation*, is applied to that condition in which the articular surfaces of the bones are completely separated from one another An *incomplete dislocation*, or *subluxation*, is one in which the surfaces are only partially separated

An *open dislocation* is one in which the skin has been ruptured and communication established with the external air A *complicated dislocation* is one in which there has been some associated injury of vessels, nerves, or viscera The term *fracture-dislocation* is one applied to a condition in which a dislocation is complicated by fracture of one or both bones involved

The **Signs** of a dislocation are as follows (1) The evidences of a local trauma, *e.g.* pain, bruising, and swelling of the soft tissues, due

to their laceration and the effusion of blood into them, (2) deformity, due to the articular end of the displaced bone being in some abnormal position, where it can often be felt and sometimes seen, and (3) restricted mobility of the affected joint, and hence impairment of function The degree to which this latter phenomenon obtains is necessarily variable, but as a rule it is very marked, if, however, fracture is also present, passive movements may be possible, though associated with pain and crepitus

The **Effects** produced by a dislocation extend to all the structures entering into and surrounding the site of injury The ligaments are partially or completely torn, the bony surfaces are not unfrequently fractured, especially in closely-fitting hinge-joints, such as the elbow and ankle, the cartilages may be bruised, or portions of them detached, and neighbouring muscles and tendons lacerated and displaced, adjacent vessels and nerves are often contused or compressed Considerable effusion of blood is always present

The character of the injury explains the difficulties that are met with in its reduction (*a*) The anatomical arrangement of the joint and its ligaments results in the hitching of bony prominences against one another, whilst the head of the bone does not always lie opposite the hole in the capsule through which it originally passed In a few cases the end of the bone may be grasped by neighbouring ligaments and tendons in such a way as to hinder its replacement (*b*) Muscular contraction also constitutes an obstacle, which, though it can be counteracted by suitable traction, is more effectively overcome by the use of an anæsthetic Not only does the patient maintain the limb in a condition of rest by a voluntary tonic contraction, but it becomes fixed by the involuntary passive tension of the displaced muscles

When once reduced, there is usually but little tendency for a dislocation to occur Reparative changes quickly manifest themselves, blood-clot is absorbed, the rent in the capsule closes by cicatrization, and in many cases no permanent lesion remains, in some, however, the joint is left in a weak and relaxed state, and liable to a recurrence of the displacement, while intra-articular adhesions, or the cicatricial contraction of the injured ligaments and muscles, may cause some loss of mobility

If a dislocation is *allowed to remain unreduced*, the true articular cavity becomes shallow and partly filled up by a transformation of its cartilage into fibrous tissue, whilst the displaced head of the bone becomes adherent to the structures amongst which it lies, as the result of a plastic inflammation, either dense fibrous adhesions are formed, or a new false joint (*pseudarthrosis*) The articular cartilage is eroded, and the exposed bone eburnated and sclerosed, whilst, owing to chronic periostitis, the end of the shaft may be considerably deformed The portion of bone upon which the displaced head rests undergoes changes, partly atrophic (from pressure), partly hypertrophic (as a result of chronic periostitis), whereby a new socket is produced (Fig 398) Neighbouring muscles are secondarily shortened, and accommodate themselves to the abnormal position of the limb, and tendons which have been torn gain fresh attachments These

changes necessarily interfere more or less seriously with the power of the limb and the movements of the joint Serious pain is not unfrequently caused by pressure on neighbouring nerves

Treatment.—The displaced bone should be reduced with as little delay as possible, and to effect this two chief methods are employed, *viz* manipulation and extension

Manipulation should always be used when practicable, less injury being sustained by the surrounding tissues It consists in moving the

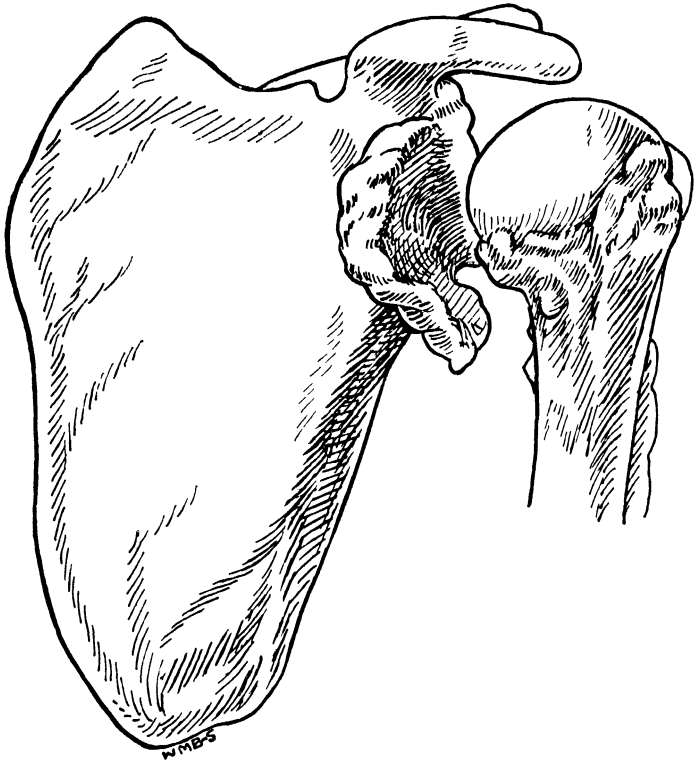


FIG. 398.—OLD-STANDING SUBCORACOID DISLOCATION OF THE SHOULDER, SHOWING ATROPHY OF TRUE GLENOID CAVITY, TOGETHER WITH FORMATION OF NEW JOINT AND ALTERATION IN SHAPE OF HEAD OF BONE (FROM COLLEGE OF SURGEONS MUSEUM)

limb in such directions as shall cause the displaced end to retrace the course that it has already taken, through the rent in the capsule to its normal position The shoulder and hip joints are more amenable to this method of treatment than hinge joints Anæsthesia will be required in difficult cases, and especially in dislocations of the shoulder and hip joints, but it is only right to draw attention to the fact that a large number of anæsthetic fatalities have been reported as occurring in the treatment of shoulder dislocations, this is due mainly to two

causes, *viz* the deep anæsthesia required, and the want of preparation of the patient

Extension is employed to overcome muscular and other forms of resistance, so as to allow the bone to slip back or be manipulated into its original position In order to make this effectual, the parts above the dislocation are steadied by some *counter-extending* force applied either by the hands of an assistant, or by a belt or towel, or by the knee or foot of the surgeon Extension may be made by the hands, or a firmer grip may be maintained, and greater force used, by applying a bandage or towel to the limb

Reduction, however produced, is usually accompanied by a sudden and distinct snap or suction sound, due to the contraction of muscles, unless the patient is deeply under an anæsthetic, and the muscles are absolutely relaxed The limb is subsequently kept at rest for some days, to allow the rent in the capsule to heal, but massage may be started in a day or two, and passive movements after a week

The treatment of an unreduced dislocation is often a matter of considerable difficulty Attempts at reduction *may* be undertaken up to two months, but the greatest caution must be employed for fear of rupturing adhesions and endangering the main vessels or nerves

The amount of mobility in an unreduced dislocation varies much in different cases, and the character of the treatment is mainly governed by this If movement is tolerably free, and not particularly painful, massage and manipulation may be undertaken and a very useful limb result Where, however, movement is both painful and limited, operative treatment is desirable (i) Reduction by *open operation* consists in cutting down on the head of the bone, and freeing it from adhesions to surrounding structures, the capsule of the joint being also opened and the cavity cleared, reduction may then be possible by means of manipulation or extension A few cases of successful treatment of old-standing dislocations of the shoulder by this means have been recorded, but as a rule the improvement is scarcely commensurate with the risks and difficulties of the operation, especially if a considerable interval has elapsed since the accident (ii) *Excision* of the displaced portion of the bone will often give a better result In the elbow-joint it may be the only practicable treatment, and in the shoulder and hip it is usually better than attempting open reduction

Open dislocations are always serious lesions, for not only are adjacent vessels and nerves liable to injury, but unless efficient treatment is adopted, suppurative arthritis ensues, leading to disorganization of the articulation, with subsequent ankylosis, or, in the case of larger joints, possibly to death from pyæmia or toxic poisoning The **Treatment** consists in applying the principles already enunciated for those of all serious lacerated wounds (p 239) The surrounding skin is first thoroughly purified, the edges of the external wound are excised, as also any gravely damaged soft tissues, the dislocation is reduced, the deeper parts are examined, and if need be washed with an antiseptic, or 'bipped,' and the whole wound closed with or without drainage, or temporarily packed with a view to performing delayed primary suture The bone, if much damaged, must be dealt with according to the

instructions given for the treatment of open fractures, but immediate excision is probably desirable if retention of the damaged part is likely to be followed by ankylosis

Special Dislocations.

Dislocation of the Lower Jaw forwards is not a very common accident, and usually results either from muscular action, or from a blow on the chin when the mouth is widely open, as in gaping, laughing, or attempting to take a large bite It has also been produced in dentistry during tooth-drawing, or from digging out roots with an elevator

The *mechanism* of the dislocation is as follows When the mouth is opened, the condyle of the jaw slips forwards on to the eminentia articularis, and it requires very little force to displace it still further into the zygomatic fossa (Fig 399) The interarticular cartilage follows the condyle, and the attachment of the external pterygoid muscle to that structure and to the bone explains the occurrence of dislocation from muscular action

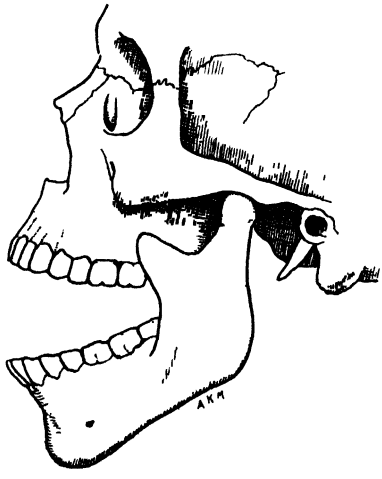


FIG 399—DISLOCATION OF JAW

The displacement may be unilateral or bilateral—more frequently the latter The mouth remains widely open, the teeth and the jaws being separated by an interval of about an inch The lower jaw projects and is fixed, saliva dribbling over the lip, speech and deglutition are impaired, the pronunciation of the labial consonants being especially difficult A hollow can be detected immediately in front of the tragus, where the condyle is normally lodged, and in front of this the condyle can be felt, being recognized by the slight amount of passive movement still possible A finger in the mouth may define the coronoid process in an abnormal position beneath the zygoma

Treatment.—Reduction is usually easy All that is needed is to depress the condyle below the level of the eminentia articularis, when the masseter, temporal, and internal pterygoid muscles speedily draw it back into the glenoid cavity The patient is seated in a chair, the surgeon standing in front protects his thumbs with thick napkins, and introduces them into the mouth, pressing upon the lower molar teeth Pressure is continued in a downward and backward direction until the condyle is free, and then the chin is raised by the fingers on either side The jaw is kept at rest for a week or ten days by means of a four-tailed bandage Anæsthesia is occasionally necessary

A few cases are on record of displacement of the condyle of the jaw *backwards*, associated with fracture of the tympanic plate and tearing or separation of the cartilage of the auricle, leading to bleeding from the ear Displacement *upwards* into the cranial cavity through the roof of the glenoid fossa has also been described

Subluxation of the Temporo-maxillary Joint is due to displacement of a relaxed interarticular cartilage, which becomes folded or nipped on opening the mouth, the result being a painful temporary fixation of the jaw, with a snap or crack on freeing it (*q v*)

Dislocation of the Sternal End of the Clavicle.—In spite of the apparent weakness of this joint and the great strains to which it is subjected, dislocation is uncommon, owing to the strength of the ligaments surrounding it, particularly of the rhomboid, the clavicle being more easily broken than displaced The **cause** of these dislocations is always violence directed to the outer end of the bone, and since that usually acts from in front, the inner end of the bone is generally thrown forwards Two other varieties are described, however, in which the displacement is backwards or upwards, but it is generally incomplete

In the **forward** dislocation the end of the bone lies on the anterior surface of the manubrium, where it can be easily detected, all the ligaments of the joint are torn, except, perhaps, the interclavicular The point of the shoulder is approximated to the middle line **Treatment**—Reduction is effected by placing the knee against the spine between the scapulæ, and drawing the shoulders backwards, the elbow on the affected side being kept in front of the mid-axillary line To prevent recurrence, a pad of adhesive plaster, six or eight layers thick, and with the sticky side out, is carefully moulded over the end of the bone and fixed by other strips of plaster The arm is then put up as for a fractured clavicle No bad result follows, even if the dislocation remains partly unreduced

The **backward** and **upward** dislocations are both extremely rare, and in each pressure symptoms on the trachea and great vessels of the neck may be produced Reduction is effected as in the forward displacement, or by levering the inner end of the clavicle outwards by manipulating the arm over the surgeon's knee placed as a fulcrum on the axilla

Dislocation of the Acromio-clavicular Joint consists in the acromion being forced either above or below the outer end of the clavicle, more commonly the latter The displacement is easily recognized by the abnormal prominence of one or other of the bones It usually results from violence directed to the scapula No difficulty is experienced in reduction, but the displacement is very liable to recur, especially in the more common form The elbow is then flexed to a right angle, and pads of several layers of adhesive plaster placed over the acromion and beneath the elbow, a bandage or strap, applied over the shoulder and under the elbow, suffices to maintain the bone in position The strap is kept from slipping by passing a bandage under it round the opposite side of the chest The arm is kept in a sling bent to a right angle Should the displacement persist, the bones may be wired

together after bringing the cartilaginous surfaces into contact, the wires being placed so as not to encroach on the joint surfaces Either they may be passed through the bones vertically, or as a mattress suture from before backwards

Dislocation of the Shoulder occurs almost as frequently as all the other dislocations of the body put together The shallowness of the glenoid cavity, the size of the head of the humerus, the laxity of the capsule, the extent and force of the movements possible, and the exposed position of the shoulder, explain the great frequency of the accident It usually results from falls upon the hand or elbow, the arm at the time of the accident being widely outstretched The weak lower and inner part of the capsule first yields, the head of the bone being primarily displaced downwards into the axilla (subglenoid variety), and then, according to the direction of the force, or the character of the subsequent manipulations, the head travels either

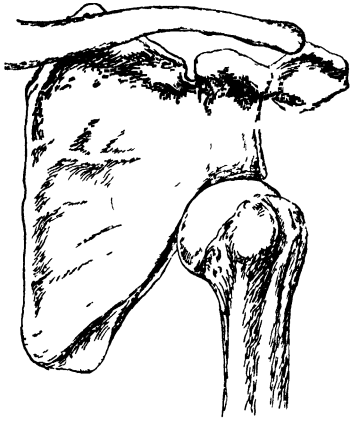


FIG 400 —SUBGLENOID DISLOCATION OF SHOULDER

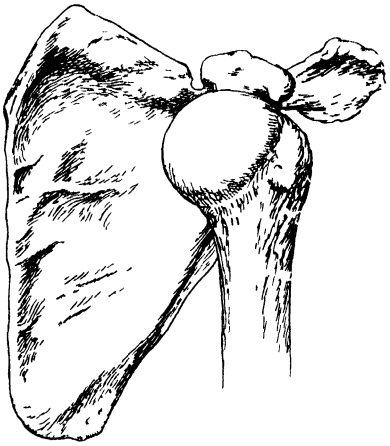


FIG 401 —SUBCORACOID DISLOCATION OF SHOULDER

forwards (subcoracoid or subclavicular dislocation) or backwards (subspinous) Falls on the elbow or shoulder may, however, cause a direct forward or backward displacement

The **Signs** of a dislocation of the shoulder are sufficiently obvious, and certain characteristic features are present in almost all varieties (1) The shoulder looks flattened, owing to displacement of the head inwards (Fig 402), and as a result of this the acromion process is unduly prominent, and a hollow is felt below it, occupied by the tense deltoid (2) The head of the bone lies in some abnormal position, and the glenoid cavity is empty (3) The elbow is displaced away from the side, and it is impossible to make it touch the chest wall at the same time that the hand is placed on the opposite shoulder (Dugas' test), this does not always obtain in the subcoracoid type (4) The vertical measurement round the axilla is increased in all the varieties (Callaway's test), whilst inspection reveals a lowering of

the anterior or posterior axillary fold (Bryant's test) (5) A ruler or straight-edge can be made to touch both the acromion process and the outer condyle of the elbow in most cases of dislocation (Hamilton's ruler test), this is impossible when the head of the bone is in its normal position, but can also occur in fractures of the anatomical neck At the same time, the usual signs of a dislocation, *viz* rigidity and local bruising, are also present Stereoscopic radiography is, of course, invaluable for diagnostic purposes

Subglenoid Dislocation (Fig 400) is always the primary condition when due to a fall upon the outstretched arm, but is not often seen, since further displacement usually occurs before the case comes under observation The head of the bone passes down into the axilla, resting against the outer border of the scapula below the glenoid cavity, between the subscapularis above and the teres minor below,

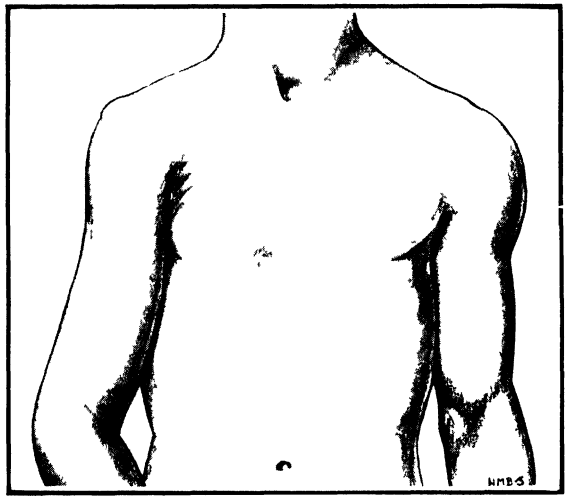


FIG 402 —SUBCORACOID DISLOCATION OF THE RIGHT SHOULDER

with the long head of the triceps behind The capsular ligament and muscles passing to the tuberosities are torn, whilst the axillary vessels and nerves may be seriously compressed, leading to numbness of the fingers The head of the bone is felt in the axilla, and the anterior axillary fold is much lowered, the elbow is directed away from the side and slightly backwards, the arm is lengthened, perhaps to the extent of 1 inch, whilst the forearm is usually flexed The lower edge of the glenoid cavity is sometimes broken off, and then reduction with crepitus is easily accomplished, but the displacement as readily recurs

In a few cases the arm has been abducted and displaced vertically upwards, although the head of the bone was in the usual position of a subglenoid dislocation, constituting the *luxatio erecta*

Subcoracoid Dislocation (Figs 401 and 402) is the most common variety The head of the bone lies under the coracoid process on

the anterior part of the neck of the scapula, immediately in front of the glenoid cavity, the anatomical neck impinging on its anterior border In this position it lies over the tendon of the subscapularis, which is either torn or stretched across the neck as a tense band, considerably impeding reduction The muscles attached to the great tuberosity may be stretched, resulting in marked external rotation of the limb (subcoracoid variety), or they are torn, or even the great tuberosity itself pulled off, the humerus being then rotated inwards (intracoracoid variety) The elbow is displaced backwards and outwards, and the head of the bone can be felt on rotation of the arm under the outer third of the clavicle Little alteration is produced in the length of the arm

The **Subclavicular** variety is uncommon, and merely an exaggeration of the subcoracoid The head of the humerus passes further inwards, and lies deeply under the pectoralis minor, on the second and third ribs The elbow is markedly separated from the side and directed a little backwards, whilst distinct shortening is present



FIG 403 —SUBSPINOUS DISLOCATION OF SHOULDER

The **Subspinous Dislocation** (Fig 403) is unusual The head lies in the infraspinous fossa, immediately behind the glenoid cavity, between the infraspinatus and teres minor muscles, the subscapularis being generally torn The elbow is displaced considerably forwards, but can be made to touch the chest wall, the arm is rotated inwards, so that the hand is thrown across the front of the body There is usually a marked hollow in front of the shoulder, whilst a prominence is caused behind by the head of the bone in its false position The length of the arm is often unaffected, but if any change is present, it is slightly lengthened

A few cases have been described of what is known as a **Supracoracoid Dislocation.** The head of the bone is displaced upwards, and either the coracoid or acromion process is broken, more commonly the former Replacement with crepitus is easily obtained, but the dislocation is liable to recur

The **Treatment of Dislocation of the Shoulder** consists in reduction by manipulation or extension

1 For *reduction by manipulation* an anæsthetic is always advisable, but must be given with caution Many methods have been suggested, of which the following are the more important Not unfrequently, however, when the muscles are relaxed, any slight rotary movement suffices to 'put the bone in'

Kocher's Method for Subcoracoid Dislocations —The surgeon, standing in front of the patient, who is seated or reclining, and supported by an assistant, grasps the flexed elbow with one hand, and by leaning on this produces slight extension With the other hand he grasps the wrist and rotates the arm firmly and steadily outwards as far as

it will go, the elbow being pressed to the side (Fig 404) Distinct resistance will be felt, due to the contraction of the subscapularis, which must be tried out by maintained pressure in the position described At length the tension of the muscle gives, and this allows the head of the humerus to slip slightly downwards towards the axilla and finally to roll out beneath the acromion, and may suffice to effect reduction If the limb is still displaced, the elbow should be drawn steadily forwards and upwards as far as it will go, with the humerus still fully everted (Fig 405), whilst finally the arm is rotated inwards so as to carry the hand towards the opposite shoulder, and the elbow drawn across the chest and lowered (Fig 406) All these movements should be carried out steadily and evenly, and without undue force or jerking for fear of fracturing the surgical neck of the bone

2 *Extension* may be employed in different ways, the object being to overcome the tension of surrounding ligaments and muscles It may be applied directly downwards by the surgeon grasping and



FIG 404 FIG 405 FIG 406

FIGS 404-406.—KOCHER'S METHOD OF REDUCTION OF A SUBCORACOID DISLOCATION OF THE SHOULDER

pulling on the arm, whilst his unbooted foot is used as a counter-extending force in the axilla, the patient lying flat on a mattress placed on the ground, and the surgeon sitting by the side Another plan consists in using the knee as a fulcrum instead of the heel, the patient sitting in a chair, one assistant makes traction on the limb abducted to a right angle, whilst another makes counter-extension and steadies the scapula

After-treatment.—The whole arm is bandaged to the side for a week or ten days, so as to allow the extravasated blood to be absorbed and the rent in the capsule to be closed The arm is then carried in a sling, and gentle movements (other than abduction) permitted, flexion, extension, and rotary movements must be gradually restored, and finally abduction In three to four weeks a full range of movements should be possible in the absence of complications

Associated fracture of the lower margin of the glenoid cavity requires more careful and prolonged fixation, so as to prevent recurrence of the trouble When the dislocation is complicated by fracture of the great tuberosity, the head of the bone must be reduced, and the

limb fixed in abduction so as to approximate the fractured surfaces Radiography will be essential in order to test the position of the head of the bone and of the fragment, if this is unsatisfactory, open operation to fix the tuberosity by screw or bone peg must be undertaken

Recurring or Habitual Dislocation of the shoulder is an uncomfortable condition in which the head of the bone slips out of place without sufficient cause It is due either to irregular shape of the head, or more often to a relaxed capsule, possibly due to too early and vigorous mobilization after a traumatic dislocation Prevention is possible if the patient can remember never to undertake certain movements, *e g* hyper-abduction of the arm, as in doing the hair, but more often relief by operative measures will be acceptable (1) It is possible to expose the capsule from the front and take in the slack, either by excising an elliptic portion, or by folding it into suitable creases, which are fixed by sutures, in many cases this will suffice (2) A more certain result may be anticipated to follow *Clairmont's operation* Two incisions are required back and front of the joint, exposing the anterior and posterior borders of the deltoid Through the anterior incision the muscle is split longitudinally, and opened up so as to enable the surgeon to define and enlarge the quadrilateral space Through the posterior incision a slip-like flap of the deltoid is detached from below, but left attached above, and its nerve-supply carefully guarded Its free end is passed through the quadrilateral space, and sutured to the split anterior portion of the deltoid This operation is most reliable, as the transposed flap acts not only as a sling to keep the head of the bone in place, but also tightens up when abduction is attempted



FIG 407 —BACKWARD DISLOCATION OF THE ELBOW

Dislocations of the Elbow-Joint are not very uncommon, occurring particularly in young people, and are due to either direct or indirect violence The diagnosis is often difficult from the amount of swelling that quickly follows A careful investigation of the relative position of the bony points, and of the degree of mobility of the different parts on each other, is essential in order to arrive at a definite conclusion as to the exact nature of the lesion In cases of doubt a radiograph should be taken

1 **Dislocation of Both Bones** may occur either *backwards*, *forwards*, or *laterally*

The **backward** variety (Fig 407) is that most often seen If the coronoid process remains unbroken, it sometimes becomes locked in the olecranon fossa, and renders the arm immobile, if, however, it is detached, considerable mobility of both bones occurs, with crepitus The forearm is semi-flexed, the hand held midway between pronation and supination, and the displaced bones form a considerable swelling at the back of the joint, above which is a marked hollow, crossed by the triceps The lower end of the humerus projects in front, and the artery and the soft parts are displaced forwards The measurement from the acromion process to the external condyle remains unaltered, but that from the condyle to the styloid process of the radius is distinctly shortened, and the distance between the condyles and the olecranon process is increased

Dislocation **forwards** of both bones rarely occurs without fracture of the olecranon, although a few cases are on record The displacement is readily detected, the forearm being lengthened perhaps to the extent of an inch The arm is in a condition of flexion, and, indeed, the accident can only take place from falling backwards on the point of the elbow when in this position The triceps muscle will be considerably torn

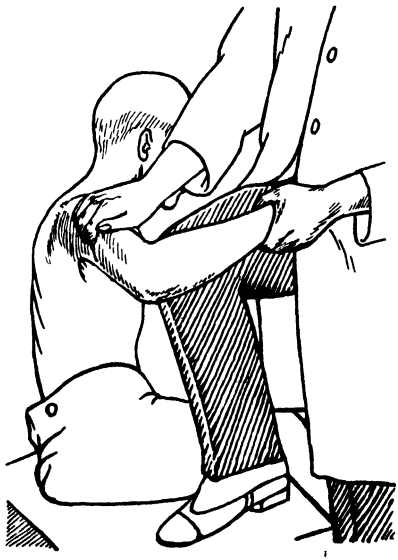


FIG 408.—REDUCTION OF BACKWARD DISLOCATION AT THE ELBOW

Lateral dislocations of the forearm are almost always incomplete, and are rare apart from fractures, the bones may be displaced either inwards or outwards, the latter being the more common They are recognized by a careful examination of the relative position of the bony prominences and by stereoscopic radiography

2 **Dislocation of the Ulna alone** occurs only in a *backward* direction It is very uncommon owing to the position and strength of the orbicular and oblique ligaments and of the interosseous membrane In a position of full pronation, however, forcible adduction of the forearm may determine this displacement without extensive ligamentous lacerations, which, indeed, have not been noted in any of the cases observed

In the **Treatment** of the above dislocations all that is necessary is to unhitch the interlocking bony prominences, so as to allow the bones to return to their normal positions by muscular contraction This is usually accomplished by the method described by Sir Astley

Cooper The patient being in a sitting position, the surgeon presses backwards, with his knee in the bend of the elbow, against the lower end of the humerus, at the same time he grasps the patient's wrist, and slowly and forcibly bends the forearm (Fig 408) The arm is bent to a right angle and kept at rest for two or three weeks at least, so as to permit repair to be accomplished perfectly, and to minimize the likelihood of a development of traumatic myositis ossificans in the substance of the brachialis anticus (p 466), a by no means unfrequent sequela

3 **Dislocation of the Radius alone** may occur either *forwards*, *backwards*, or *outwards*

The **forward** dislocation (Fig 409) is that usually seen, and results from falls on the hand when the forearm is in a state of extreme pronation, or from forcible traction upon the hand, or from direct injury applied to the back and outer side of the elbow The head of the radius rests against the lower end of the humerus in the hollow above the capitellum, and the most characteristic feature consists in the inability of the patient to flex his forearm, owing to the bone impinging against the lower end of the humerus It can be readily detected in this situation, rotating with the movements of the forearm, whilst a deep hollow is felt behind, immediately below the external condyle The forearm is somewhat flexed, and midway between pronation and supination, the former act can be satisfactorily accomplished, but supination cannot be carried further than halfway A marked fulness exists on the anterior aspect of the limb when the arm is extended Fracture of the upper third of the ulna sometimes accompanies this accident, especially when produced by direct violence If this luxation is not reduced, great impairment of the mobility of the limb results, flexion beyond an obtuse angle becoming impossible **Treatment.**—Reduction is accomplished by traction from the wrist, with the forearm flexed to a right angle, combined with pressure over the head of the bone Owing to the fact that the orbicular ligament is ruptured, the deformity is likely to recur, unless the limb is kept completely flexed in order to relax the biceps, full supination must also be maintained Active movements of the limb must be interdicted for three or four weeks In old-standing cases excision of the head of the bone is desirable

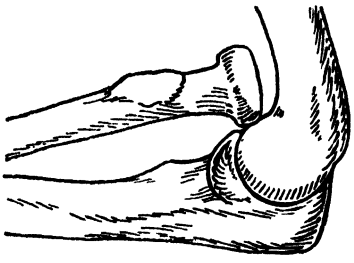


FIG 409.—DISLOCATION OF THE RADIUS FORWARDS

Dislocation **backwards** is less common The head lies behind the external condyle on the outer side of the olecranon, where it can be detected on rotating the limb The forearm is flexed, and the limb pronated Even if left unreduced, it leads to but little inconvenience

Dislocation outwards is also rare, the head of the bone being displaced to the outer side of the external condyle, where it can be felt,

causing considerable impairment of movement Reduction is accomplished without difficulty, or, if necessary, the head may be excised

Occasionally a rare form of dislocation is met with in which the ulna passes backwards and the radius forwards, resulting in great deformity

A very common accident in children under four years of age consists in a **subluxation of the head of the radius downwards** within the orbicular ligament, so that a fold of synovial membrane slips up and becomes nipped between the head and capitellum It results from forcible traction of the hand, as from pulling up a child roughly after it has fallen, and is a common nursery accident popularly known as **pulled elbow.** The limb becomes fixed in a position of slight flexion and with the hand pronated, and the child cries out with the pain, it is readily treated by completely flexing the limb, and subsequently extending and fully supinating it, and leaves no bad results

It must not be forgotten that here merely the pure dislocations have been described In actual practice **complications** of a serious nature are frequently present in the shape of fracture of one or both condyles, which add to the difficulty of diagnosis, apart from radiography, and even then the results of treatment may be unsatisfactory Abundant callus is formed, and considerable impairment of function is liable to ensue

Dislocation of the Wrist is a very uncommon accident, and may occur *forwards* or *backwards* The lower ends of the radius and ulna project under the skin, and the styloid processes retain their relative positions, it is thereby easily distinguished from a Colles's fracture Reduction is readily effected, and the hand should be kept at rest for some four to six weeks in a slightly dorsiflexed position

Occasionally the radius, carrying with it the hand, is dislocated from the lower end of the ulna, as a result of forcible pronation, which results in laceration of the inferior radio-ulnar ligaments, and probably of the lowest portion of the interosseous membrane The triangular fibro-cartilage is in some of these cases loosened, and its mobility may subsequently give rise to a painful weakness of the wrist The ulna projects backwards, and its reduction is easy, but some laxity of the inferior radio-ulnar joint may persist, unless the bones are kept firmly together by suitable bandaging

Dislocations of Various Carpal Bones have been described, and radiography has demonstrated that they are by no means uncommon The semilunar is probably more frequently displaced than the other carpal bones In reality this displacement is a posterior dislocation of the distal part of the carpus Usually the posterior ligaments of the semilunar are broken and it becomes rotated forwards through anything up to 180 degrees, so that its os magnum articular surface may come to look directly upwards (Fig 410) It is associated with much pain in the wrist and limitation of movement, and oftentimes there is an accompanying fracture of the scaphoid Reduction can usually be effected by strong and steady traction on the fingers and thumb, exerted by an assistant, counter-traction being maintained by passing the upper arm through a loop of webbing attached to some fixed point Many cases will slip into position during traction,

the tension on the flexor tendons moulding the bone into its right position, but in others some manipulation will be required In old-standing cases operation may be necessary and the bone excised A plaster cast is applied for three weeks following the reduction

Dislocations of the Metacarpal Bones and Phalanges are not unfrequent, but need no special mention, except in the case of **Dislocation Backwards of the First Phalanx of the Thumb** The chief interest here lies in the difficulty experienced in reduction, which was formerly attributed to the head slipping between the two portions of the flexor brevis pollicis and being grasped by them, as a button in a button-hole It has now been shown that there are two much more important factors, *viz* the tension of the long flexor tendon, which hitches round the neck (Fig 411), and the arrangement of the glenoid ligament This fibro-cartilaginous structure passes between the two heads of insertion of the short flexor muscles, and is thus incorporated between the two sesamoid bones, whilst firmly attached to the base of the phalanx, it is but loosely connected with the head of the metacarpal bone, so that it accompanies the phalanx in its dislocation, and will then be situated immediately behind the head of the metacarpal, so as to prevent reduction **Treatment**—Traction and manipulation are always attempted in the first instance The thumb is grasped by a suitable apparatus and hyper-extended to a right angle, thus making the head of the metacarpal project still further through the muscular interspace, and, as it were, enlarging the button-hole Still maintaining the traction, the thumb is rapidly flexed into the palm, the metacarpal bone being at the same time pressed inwards Should this fail, as it often will, a sterilized tenotome should be inserted in the middle line of the thumb behind, immediately above the base of the phalanx, and should be pushed on till it reaches and divides the glenoid fibro-cartilage between the sesamoid bones, this little manœuvre will at once render replacement simple



FIG 410.—DISLOCATION FORWARDS OF CARPAL SEMILUNAR

Dislocation of the Hip is fortunately not very common, as it is a condition of extreme gravity The depth of the socket in which the femur rests, and the strength of the muscles and ligaments surrounding the articulation, explain the comparative unfrequency of the accident It always results from violence applied to the feet or knees, or, if the legs be fixed, to the back It is rarely met with except

in young people or adults, since after the age of forty-five fractures of the neck of the bone are much more likely to occur

Four chief varieties of dislocation are described, in two of which the head of the bone is displaced posteriorly, and in two anteriorly The former are known as the *Dorsal* and the *Sciatic* varieties, in which the head of the bone occupies some situation on the dorsum ilii, determined by the integrity or not of the obturator internus tendon The anterior dislocations are known as the *Obturator* (or *Thyroid*) and the *Pubic*, in the former the head of the bone is located in the obturator notch, and in the latter upon the pubic ramus The relative frequency of these dislocations is as follows About 50 to 55 per cent of the cases are dorsal, 20 to 25 per cent sciatic, 10 to 15 per cent obturater, and 5 to 10 per cent pubic In addition to the above, many other slight modifications have been described, which it is unnecessary further to particularize

Mechanism.—In considering these dislocations, the relative strength or weakness of the different parts of the capsule and its surrounding structures must be remembered The weakest part of the capsule is placed below and behind, and it is through a rent in this position that the head of the bone most frequently escapes In front, the ilio-femoral or Y-shaped ligament of Bigelow is a structure of much strength, on the integrity of which depends the fact whether the displaced head of the bone shall occupy some definite position or be freely movable Bigelow, to whom we owe so much in the elucidation of the mechanism of these dislocations, has divided them into two classes—the *regular* and the *irregular*—according to whether this ligament is intact or completely lacerated Posteriorly, the plicated tendon of the obturator internus is the most important structure, and the position and level of the bone on the dorsum ilii depend in some measure on whether it remains intact or is ruptured It must also be remembered that the ligamentum teres is relaxed when the thigh is forcibly abducted, and is made tense by adduction

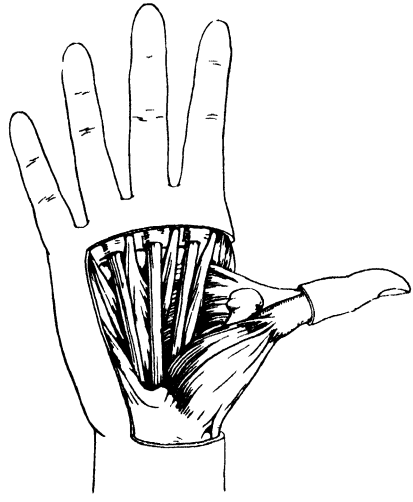


FIG 411 —DISLOCATION OF THUMB, SHOWING HEAD OF METACARPAL BONE PROTRUDING FORWARDS BETWEEN THE HEADS OF THE SHORT FLEXOR MUSCLE

The limb is usually in a position of *abduction* at the moment of dislocation, the head of the bone escaping through a rent in the lower and back part of the capsule The type of accident responsible for this is a fall with the legs widely separated or when the limbs are drawn forcibly apart, as, for instance, when one leg is placed on a boat just

moving away from a pier on which the other is fixed The direction of the violence, or the subsequent manipulations performed by willing but ignorant friends, or the voluntary movements of the individual, determine what form of dislocation will be subsequently produced If the limb is externally rotated and extended, or the trunk is hyper-extended and the limb remains fixed, the head travels forwards, and either the pubic or obturator variety results If, however, the leg is inverted and flexed the head of the bone passes backwards, and either the dorsal or sciatic form is produced Again, in the posterior dislocations, if the obturator internus tendon remains intact, it may hitch across the front of the neck, and prevent any further upward displacement of the bone, thus giving rise to the so-called sciatic variety, or as Sir Astley Cooper called it, the 'dorsal below the tendon', but if the tendon is ruptured, or if the head of the bone slips in front of it, there is no obstacle to its upward displacement on the dorsum ilii

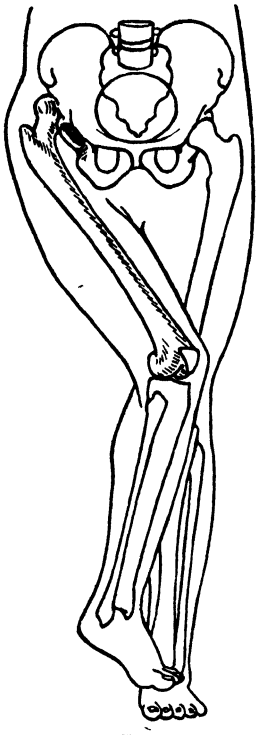


FIG 412 —DORSAL DISLOCATION OF THE HIP

Dislocation may also result when the limb is in a position of *adduction*, a direct dorsal dislocation being thus produced, the head of the bone escaping from the capsule above the tendon of the obturator internus, such an accident is sometimes associated with fracture of the posterior lip of the acetabulum The type of violence leading to this occurrence is when a heavy weight falls on the back of a person whilst kneeling, or when, the knee being flexed, the body is thrust forwards, so that the limb is forcibly inverted If, however, the thigh is in a position of extreme flexion, the head may be displaced below the tendon of the obturator internus, and the sciatic variety will then result

1. **Dorsal Dislocation** (Fig 412) —The head of the bone lies on the dorsum ilii, a variable distance above and behind the acetabulum, and always above the obturator internus tendon It may be detected on manipulation of the limb, although in muscular subjects this is difficult The ligamentum teres is necessarily ruptured, as also the capsule, the rent being situated either below or above the obturator tendon, according to whether the dislocation is due to forcible abduction or adduction The small external rotator muscles are often lacerated, and perhaps even the glutei and the pectineus The ilio-femoral ligament usually remains intact The great sciatic nerve is sometimes compressed or contused The trochanter is raised above Nélaton's line (p 604) and approximated to the anterior superior spine, the ilio-tibial band of fascia is therefore relaxed, and there is

considerable shortening of the limb, amounting sometimes to 2 or 3 inches The leg is in a position of flexion, adduction, and inversion, so that the axis of the femur crosses the lower third of the sound thigh The knee is semiflexed, and the ball of the great toe rests against the opposite instep, the heel is somewhat raised A marked hollow is felt in the upper part of Scarpa's triangle, the main vessels appearing to be unsupported

The **Diagnosis** should be easy, the only difficulty being experienced in distinguishing it from an impacted intertrochanteric fracture The character of the accident, the presence of adduction and inversion, the increased breadth of the trochanter in the case of fracture, and the abnormally placed head of the bone in dislocation, are the points to which attention must be directed

2 **Sciatic Dislocation,** or ' dorsal below the tendon,' is one in which the head of the bone is prevented from travelling upwards to the dorsum ilii by the integrity of the obturator internus tendon It may occur either from forced abduction of the limb, or from extreme flexion in the adducted position The lesions of muscles and ligaments are practically the same as for the dorsal variety The ilio-femoral ligament is uninjured

The **Signs** resemble those of a dorsal dislocation, but are less marked There is less shortening, often not more than ½ to 1 inch, the limb is flexed, adducted, and inverted, but the axis of the femur is directed across the opposite knee, and the great toe rests against the ball of the great toe of the opposite side The head of the bone is often much less distinct, owing to the greater thickness of the glutei muscles at the lower level

Treatment of the Two Backward Dislocations is effected in much the same way, whether the dorsal or sciatic variety is present The most usual method is that of *circumduction*, so accurately worked out by Bigelow The patient is anæsthetized, preferably on a mattress placed on the floor The leg is first flexed on the thigh, and the thigh on the abdomen, the position of adduction and internal rotation being still maintained, so that the knee extends beyond the middle line of the body This position is maintained for some moments, and then the limb is lifted up and freely circumducted outwards, and brought rapidly down into a position of extension parallel with the other By this manœuvre the tense structures in front of the joint are relaxed, and then the head of the bone is made to retrace its course towards the rent in the capsule, and finally directed upwards into the acetabular cavity These movements can be tersely summarized *' Lift up, bend out, roll out '*

If this plan does not succeed, the following method of *traction* may be employed The patient, lying on his back, is firmly fixed by a bandage or towel passed over the pelvis and secured to two or three hooks or staples driven into the floor The surgeon stands over the patient, whose thigh is flexed to a right angle on the abdomen, as also the knee upon the thigh The surgeon's arms are passed under the knee sufficiently far to enable him to grasp his own elbows, and the front of the leg is steadied against the operator's perineum, Direct

and forcible traction upwards as if to lift the patient from the floor can now be made, and this is often sufficient in itself to lift the head of the bone into the acetabulum If this is unsuccessful, the same process is repeated in a position of internal or external rotation The above plans, combined with the use of an anæsthetic, rarely fail in reducing a backward dislocation of the hip, and hence *extension by means of pulleys* is rarely required

3 **Obturator (or Thyroid) Dislocation** (Fig 413) —The head of the bone in this case passes downwards through a rent in the lower part of the capsule, and its position is subsequently but little altered, a slight forward and upward movement being alone superadded The ilio-femoral ligament is untorn, but the pectineus and adductors are very tense, or may even be lacerated, the ligamentum teres is, of course, ruptured The head lies on the obturator externus muscle, and can be detected in the perineum The trochanter is less prominent than usual, and, indeed, its normal position may be represented by a depression The limb is slightly abducted and everted, as well as lengthened, perhaps to the extent of 2 inches, though this is more apparent than real It is also flexed, owing to the tension of the ilio-psoas muscle, and advanced before the other, with the toes pointing outwards The adductor longus tendon stands out prominently, and much pain may be experienced from pressure on the obturator nerve If the patient stands the body is bent forwards, and if the dislocation remains unreduced the patient may be able to walk without much pain or inconvenience, though in a more or less stooping attitude

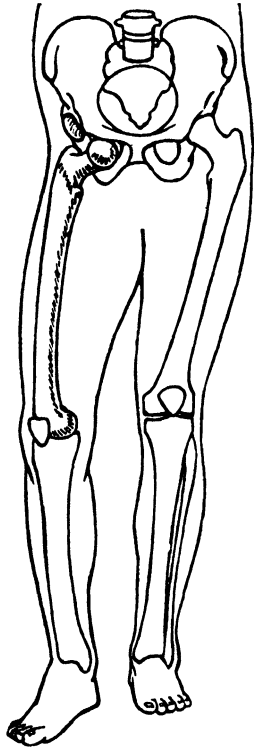


FIG 413 — DISLOCATION OF THE HIP FORWARDS OBTURATOR VARIETY

4 **Pubic Dislocation** (Fig 414) —In this variety the head of the bone either escapes from the joint below, or may be forced out in front and to the inner side of the ilio-femoral ligament as a result of hyperextension of the trunk The head lies on the horizontal ramus of the pubes, just internal to the anterior inferior spinous process of the ilium, where it can be felt rolling under the finger on any movement of the limb The vessels are pushed inwards, and considerable pain may be felt down the limb from pressure on the anterior crural nerve The ilio-femoral ligament is untorn, whilst the ligamentum teres and capsular ligament are ruptured, the small external rotator muscles, with the exception of the obturator internus, are usually torn There is marked flattening of the hip, the trochanter being

approximated to the middle line and raised The limb is shortened to the extent of 1 inch, and there is considerable abduction and eversion, so that the inner aspect of the limb looks forward The thigh is slightly flexed to relax the ilio-psoas muscle

Treatment of the obturator and pubic dislocations is undertaken along similar lines as for the posterior dislocations The patient is anæsthetized, the knee is flexed, as also the thigh upon the abdomen, but in a position of abduction, pressure backwards upon the head of the bone by the hands of an assistant will assist it in retracing its course towards the rent in the capsule Circumduction inwards follows, and on extension of the limb the head again enters the acetabulum The obturator variety may sometimes be reduced by upward and outward traction when the limb has been flexed to a right angle in the abducted position, the unbooted foot being placed against the pelvis to steady it

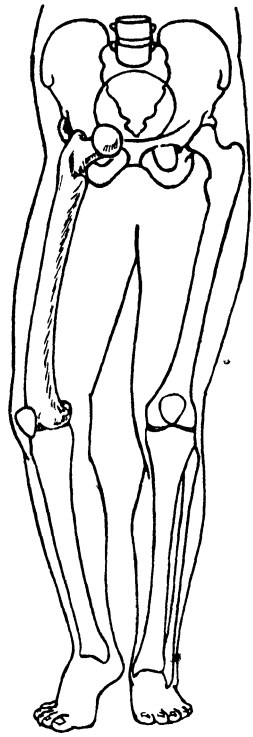


FIG 414 — DISLOCATION OF THE HIP FORWARDS PUBIC VARIETY

After reduction of any form of dislocation of the hip, the patient should be kept in bed with the legs tied together for about a week or ten days, and then movements, either passive or active, may be permitted, but only with great caution, and with the patient still in bed Unless protected by a plaster-of-Paris spica, he ought not to attempt to stand or walk for three weeks

Should the dislocation recur, it may be due to fracture of the posterior lip of the acetabulum, or to some involuntary movements of the patient, or perhaps to the fact that the displacement has not been fully reduced Under such circumstances further attempts at replacement should be undertaken, and the limb subsequently kept immobilized, and extended in an abduction frame for some weeks

Dislocation of the Patella may occur *outwards*, *inwards*, or *edgeways* A dislocation upwards resulting from rupture of the ligamentum patellæ is sometimes described, but it is scarcely to be included in the same category as the others The displacement may be complete or incomplete, in the former, the capsule is always lacerated, in the latter, not necessarily so

The **outward** is the only variety commonly seen, and then, on account of the obliquity of the limb, it may result from muscular action, especially in people suffering from genu valgum, it also arises from direct violence In either case it occurs most frequently when the limb is extended, since during flexion the bone is firmly lodged in the intercondyloid notch It lies upon the outer surface of the

condyle, with its inner margin projecting forwards, and is easily felt, whilst the knee appears flattened and broader than usual, the intercondyloid notch being plainly distinguishable in the position usually occupied by the patella *Reduction* may take place spontaneously, but is usually effected by manipulation The thigh is flexed on the abdomen, and the knee extended, so as to relax the quadriceps, and then a little pressure on its outer margin causes the bone to slip back into place Subsequent treatment consists in keeping the limb in a position of extension for some four weeks in a plaster cast

The **inward** dislocation is rare, being always due to direct violence In characters and treatment it is the exact converse of those met with when the bone is displaced outwards

A dislocation edgeways, or **Vertical Rotation** of the patella, is an interesting condition in which the bone is said to be twisted vertically upon its own axis, and even to have been turned completely round

Recurrent dislocation of the patella is always associated with genu valgum, or with laxity of the extensor muscles from paralysis In the former case it may be cured by correcting the deformity by means of osteotomy of the femur, but sometimes the synovial membrane of the knee-joint on the inner side will also require to be braced up by excision of a portion and suture of the margins of the defect In this, as also in the paralytic variety, when the extensor muscle is slack, the tubercle of the tibia should be chiselled off, together with the ligamentum patellæ, and re-attached lower down

Dislocations of the Knee may occur *laterally*, as also *forwards* or *backwards* When due to disease of the joint, the backward dislocation is commonest, but when arising from traumatic causes, the lateral is the most frequent

The **lateral** displacements are rarely complete, and are usually associated with a certain amount of rotation, the leg is partially flexed Reduction is effected without difficulty

Dislocation of the tibia **forwards** is more common than displacement backwards It is generally complete, the lower end of the femur projecting into the popliteal space, and compressing the vessels, so that gangrene not unfrequently follows The upper end of the tibia, carrying with it the patella, lies in front, forming a well-marked swelling with a hollow above it There is usually considerable shortening of the limb if the articular surfaces overlap

Dislocation of the tibia **backwards** is a much rarer accident, and is also as a rule complete The signs are exceedingly characteristic, the pressure effects upon the popliteal vessels and nerves often resulting in gangrene

Reduction of either of these conditions is easily accomplished by traction on the limb, whilst the thigh is flexed, combined with manipulation in order to guide the head of the tibia into its normal position The limb must subsequently be kept at rest in a plaster cast for a period of anything up to three months, according to the degree of initial injury If the joint is mobilized too early, the damaged muscles and ligaments will not return to normal and a flail joint will result

Internal Derangement of the Knee-Joint is so important a subject

and leads to so many mistakes both in [illegible] and treatment that it must be discussed somewhat fully The shape of the articular surfaces of the femur and tibia is certainly not such as to guarantee a stable joint, considering the severity of the strains to which it is exposed, and the freedom of movement present The most powerful ligaments are of course attached posteriorly so as to limit extension, and the crucial ligaments are needed to assist in this check, and to prevent rotation To serve as elastic buffers, the interarticular cartilages are interposed, fixed to the head of the tibia, and to occupy the spare space a fatty pad of considerable size is present It is obvious that many injuries can occur in these structures, and considerable discrimination is required if accurate diagnosis and treatment are to be effected

1 *Ligamentous Sprains and Strains* are common, and most frequently involve the internal lateral ligament, the reason for this is obviously the mechanical disadvantage to which this ligament is exposed by the displacement outwards of the upper end of the femur to engage the acetabulum This lesion has already been noticed (p 690), but one would draw attention to the frequent recurrence of slight injuries to this structure with repeated attacks of mild synovitis Tenderness is usually experienced over the extreme inner border of the tibia (Fig 415), and much can be done to protect the damaged ligament by deflection of the weight to the outer side of the limb, this is effected by thickening the inner side of the heel and sole of the boot

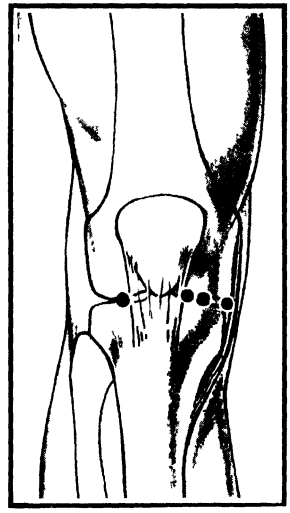


FIG 415 —POINTS OF MAXIMUM TENDERNESS IN VARIOUS CONDITIONS OF KNEE-JOINT

2 *Thickening of the Fatty Pads* behind the patella is another common source of functional disability and pain Hæmorrhagic infiltration into this structure causes it to project backwards into the joint cavity, and exposes the free edges to the likelihood of being nipped between the bones in full extension of the joint This in turn produces increased thickening of the pad, and the fimbriated edges become fibrous and hard, projecting into the joint cavity like the villi often seen in osteo-arthritis, and perhaps becoming adherent to the back of the joint

The patient complains of discomfort and pain in the knee, with recurring attacks of slight synovial effusion The chief pain is experienced in complete extension, and this is referred to either side of the patellar ligament (Fig 415), where the thickened pads of fat can be felt From time to time acute pain is experienced during walking owing to the nipping of the synovial tags, or the drag of adhesions, but there is no locking of the joint, and the synovial reaction is slight

With careful manipulation the fatty tabs and fringe can sometimes be felt rolling in the joint on movement

Treatment.—In the early stages when it appears likely that hæmorrhage has recently occurred, all that is required is rest and support by a firm flannel bandage, followed by a gradual restoration of the functions of the joint In old-standing cases where painful limitation of movement suggests the existence of adhesions, manipulative treatment under an anæsthetic through a full range of flexion and extension may suffice to snap the adhesions and restore the joint to usefulness

If this fail and the condition is of a chronic character, the mobility of the joint must be limited by the use of a knee cage or splint, which prevents full extension Counter-irritation may be of some use, and massage to tone up the quadriceps, which in chronic cases is almost always atrophied, it also helps to tighten up the attachment of the subcrureus to the synovial membrane, and thus pull the fatty pad aside Operation to remove these structures is rarely necessary, and not very satisfactory

3 *Rupture of the Crucial Ligaments* results from twisting injuries, which are more severe than those which occasion simple sprains, and may be accompanied or not by fracture of the tibial spine The pain and hæmorrhagic effusion produced are so great that a diagnosis is not often made at once, except when radiography reveals an injury to the spine of the tibia The limb is placed at rest on a back-splint, and it is only at a later date that the persistent weakness of the joint leads to a closer examination, and reveals the fact that abnormal to-and-fro movements are possible, as also perhaps internal rotation The anatomical arrangement of the crucial ligaments is such that, when intact, inversion of the extended leg is impossible If the anterior ligament (which is tense in extension of the leg) is torn, the tibia can be displaced forwards with the knee extended, if the posterior ligament (which becomes tense in flexion of the knee) is torn, the tibia can be displaced backwards with the knee flexed—movements which are impossible with unruptured crucials

Treatment —If the case is recognized fairly early, the limb is placed on a back-splint and kept at rest with a view to allowing the torn ligament to be repaired by scar tissue, the period of rest is maintained sufficiently long to permit the scar to contract and become firm To this end a leather knee splint or cage must be used, allowing either no movement or only a very limited range, one similar to that advised for a fractured patella is useful Operation is probably of little value, since the knee must be fully flexed in order to expose the parts, and careful approximation is in such a position almost an impossibility The good results claimed for these operations are probably due to the effective after-treatment.

In old-standing cases with much disability Hey Groves has suggested an operation for reconstituting the crucial ligaments, utilizing the semitendinosus tendon for the posterior and a strip of the ilio-tibial band for the anterior In either case holes are drilled through the femur and tibia in such a direction that the new ligaments when threaded through them shall lie in the situation of the old, the loose

end is fixed below by stitching This operation has now been performed in a number of cases, and up to date has given some excellent results

Where radiography demonstrates that the spine of the tibia is broken, an attempt must be made by manipulation and flexion of the joint to push it up into the intercondyloid notch and so prevent it from hampering movement, after-treatment is as for rupture of the crucials Failing this manœuvre, the joint must be opened and the portion of bone fixed by a bone-nail or removed

To open the knee-joint so as to expose the posterior parts, it is best to split or saw the patella vertically and to draw the divided halves and the split ligamentum patellæ and tendon of the quadriceps to either side, when the knee thus opened up is bent, all the posterior structures are easily accessible The divided bone is subsequently sutured accurately

4 *Displacement or Rupture of a Semilunar Cartilage* is a very common accident, resulting from sudden violence directed to the knee, usually in the nature of side-slips associated with torsion, slipping from the kerbstone, injuries in mines, or falls in the football field or on the tennis court are the most frequent sources of this lesion The close attachment of the outer margin of the cartilages to the lateral ligaments or capsule explains the causative influence of lateral strain upon these injuries, whilst in any rotary movement of the knee, only possible with the joint flexed, the pressure of the condyles always modifies the position of the cartilages, which, moreover, are relaxed and more freely movable on the upper surfaces of the tibia in flexion than in extension The inner cartilage is much more frequently affected than the outer, and the character and extent of the lesion varies much in different cases

The lateral ligament or capsule usually gives way first, and allows the joint to open up as a result of the leverage applied laterally upon the ankle The cartilage then slips out from the joint, sometimes tearing the anterior or posterior attachment, more commonly the former (Fig 416), most frequently, however, the cartilage is broken across (Fig 417) or split longitudinally (Figs 418, 419) The former lesion appears constantly after athletic injuries, *e g* football, and involves the anterior portion of the cartilage rather than the posterior In the latter the so-called ' bucket-handle ' injury (Fig 418) is produced in the first place, but either end of the loosened fragment may be subsequently torn, and here again usually in front, and then the handle flaps freely in the joint, and is obviously liable to cause locking If both ends are torn across, a loose body in the joint results When the violence ceases, the joint surfaces come together again, and may close on the torn or displaced cartilage, fixing it and locking the joint, or the cartilage may slip back into place and give no indication of its temporary displacement beyond pain

Repair in cartilage is always imperfect, owing to the fact that vessels penetrate only a very little way into it, and thus the free margin of a torn semilunar cartilage is a very unfavourable tissue for this process The surfaces, moreover, become covered with endothelium, and this is a still further hindrance

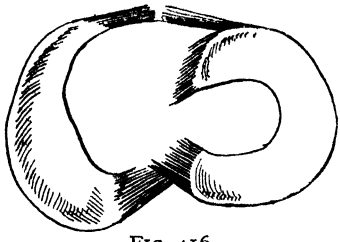


FIG 416

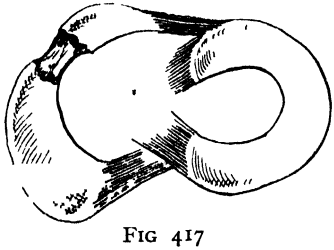


FIG 417

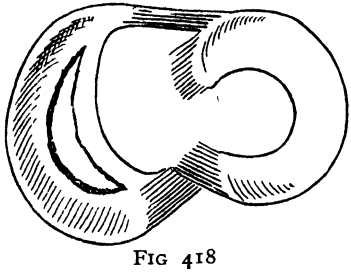


FIG 418

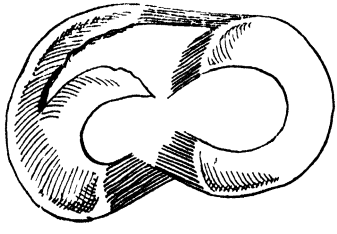


FIG 419

FIGS 416-419 —DIAGRAMS OF VARIOUS TYPES OF INJURY SUSTAINED BY THE INTERNAL SEMILUNAR CARTILAGE

In Fig 416 the anterior attachment has been stretched and torn, and the cartilage is consequently loose In Fig 417 the cartilage has been torn transversely across, and a weak cicatrix has formed In Fig 418 the cartilage has been split longitudinally (bucket-handle injury) In Fig 419 the anterior end of the bucket-handle has also given way, leaving a loose tag, which often causes trouble

The **Symptoms** produced by this accident are a sudden sickening pain of much severity, located in the knee, which may become locked in a position of flexion, with inability to extend it The patient may be able to 'wriggle' his joint free, or the limb may remain stiff for some hours, or even a day or two, when movement suddenly returns more or less spontaneously, a snap being at the same time felt within the joint An attack of subacute synovitis usually follows In other cases the cartilage remains out of place until reduced by the surgeon, with or without an anæsthetic The usual evidence of this is inability of the patient to extend the knee fully, any attempt to do so causing severe pain in the back of the joint, and possibly the projection of the posterior portion of the cartilage may be detected on careful palpation Even if full reduction has been effected, the displacement is liable to recur unless sufficient time is permitted to allow firm cicatrization, otherwise the bond of union between the cartilage and the tibia, or between the severed halves of the cartilage, will be loose and elongated, permitting recurrence of the displacement, the cartilage or a portion of it slipping out of place, either externally, where it can be felt, or into the intercondyloid notch, getting nipped and locking the joint temporarily, this is followed by a mild attack of synovitis As times goes on, this becomes more and more easy, owing to the ligaments of the joint being relaxed from the recurrent attacks of synovitis, and the limb may pass into such a state of chronic weakness as to interfere seriously with the patient's comfort There is usually a spot of localized pain in the front of the joint, correspond-

ing to the upper surface of the tibia (Fig 415), possibly there may be some amount of lateral mobility of the leg, and movement of the cartilage may be detected on flexing and extending the knee The quadriceps muscle is always atrophic, atonic, and relaxed

The **Diagnosis** is often a matter of considerable difficulty, as many conditions give rise to symptoms akin to those of a displaced cartilage Recurring *sprains of an internal lateral ligament*, due to want of prolonged fixation, are known by the absence of locking, or of the crepitus usually caused by a slipping cartilage, whilst the tender spot is over the extreme inner edge of the tibia *Chronic traumatic arthritis* with a development of synovial fringes (p 754) produces in certain cases symptoms almost identical with those of a displaced cartilage, except that usually there is no history of sudden onset The margins of the articular cartilages are usually thickened and characteristic, and the synovial villi and fringes can often be felt, the crepitus is different from that of a slipping cartilage, and the other knee may be similarly affected The edges of the *retropatellar fatty pad* may be thickened and villus-like, and then may project backwards and get nipped between the ends of the bones An enlarged subligamentous bursa may have a similar effect in pushing the pad backwards The history in these cases is usually distinct from that of a torn cartilage, and the tenderness is not at the same spot The diagnosis of a *loose foreign body* in a joint is referred to at p 763

Inflammation of a semilunar cartilage (*meniscitis*) also needs to be considered, it usually results from a heavy fall on the foot or heel, whereby the cartilage is bruised, painful limitation of movement results, and especially pain on standing, or straightening the knee, which is kept semiflexed, there are usually no sudden attacks of painful locking of the joint, but the cartilage is tender, and can perhaps be felt, though it is not movable

The **Treatment** in the early stages consists in complete reduction of the displacement by manipulation, if need be under an anæsthetic Unless the patient can extend the knee fully, some displacement persists, and subsequent trouble is sure to follow Reduction of an internal cartilage is effected by flexing fully both the knee and hip joints, the leg is then everted fully, and abducted so as to open up the joint interspace on the inner side A rapid movement of inversion and extension, combined with pressure on the back of the cartilage with the thumb, usually brings about satisfactory reduction, and complete extension is at once possible, and the full range of movements is restored

Subsequent treatment consists in applying a firm pressure bandage to the knee, combined with rest, and later massage and electrical treatment will be required to tone up the quadriceps

Should these methods of treatment fail, and the diagnosis of a torn or displaced cartilage be fairly well established, **operative treatment** is justifiable The most minute precautions as to asepsis must of course be taken (p 724). The patient's knee flexed to a right angle hangs over the end of the operating-table, and the surgeon may with advantage sit facing it and perhaps support the foot between his knees

A curved incision sloping backwards is made by the side of the patella, or a transverse one along the upper edge of the tibia, the extent of the superficial incision is of no importance so long as the incision in the capsule is correctly placed Alternatively, the incision illustrated in Figs 420 and 421 may be used where a more complete exposure of the joint is advisable This is made advisably with a fresh knife (to avoid possible contamination from organisms in the skin) between the inner edge of the patellar ligament and the internal lateral ligament, which must not be encroached on The cartilage is now exposed, and its shape and mobility readily tested by picking it up on a blunt hook slipped under its free edge Torn and partially detached fragments are easily seen and removed, and in cases of general mobility the whole cartilage can be excised by pulling on it from the front,

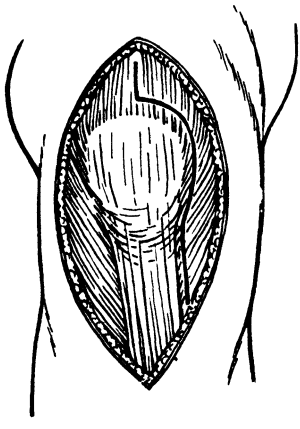


FIG 420 —ILLUSTRATING INCISION USED FOR COMPLETE EXPLORATION OF THE KNEE-JOINT

Curved incision through aponeurosis on the inner side of patella

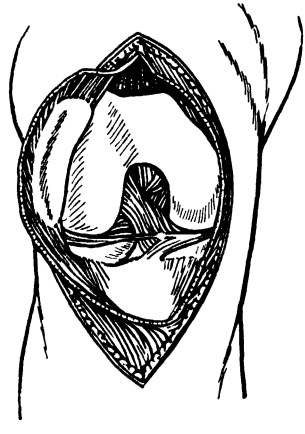


FIG 421 —PATELLA AND LIGAMENTUM PATELLÆ DISPLACED OUTWARDS TO EXPOSE INTERIOR KNFE-JOINT

care must be exercised not to leave tags projecting from the divided attachments, as they may cause trouble later on The fringes are then explored, and the other cartilage, hæmostasis is effected, and the joint carefully closed in layers without drainage It is kept quiet on a splint for two or three days, and then gentle movements are permitted, when the wound is healed, massage and movements against resistance are instituted, but the patient should not place his weight on the limb for ten to fourteen days at least Careful exercises to improve the muscles of the limb are subsequently required

Dislocations of the Ankle-Joint may occur in the following directions *outwards, inwards, backwards, forwards,* and *upwards,* this being the order of their frequency Owing to the fact that the astragalus is wedged like a block into the mortice formed by the lower ends of the

tibia and fibula, it is obvious that fractures of these bones are frequently met with as complications

The **lateral** dislocations are in reality fracture dislocations, and have been already described in the chapter on fractures (p 627)

Although the upper articular surface of the astragalus is broader in front than behind, dislocation of the foot **backwards** is a more common accident than displacement forwards It results from falls on the feet while running or jumping, or by sudden violence applied to the limb when the foot is fixed Usually both malleoli are fractured, and the articular surface of the astragalus is thrown behind the lower end of the tibia The heel projects unduly backwards, and the articular surface of the tibia usually rests upon the neck of the astragalus, the scaphoid, or even the cuneiform bones

Dislocation **forwards** is very uncommon, and may occur without any associated fracture of the bones of the leg The foot is apparently lengthened, and the tibia rests upon the posterior part of the upper surface of the os calcis, behind the astragalus, the prominence of the heel and of the tendo Achillis being lost

The **Treatment** of antero-posterior dislocations consists in reduction by traction, followed by immobilization, with the foot at right angles The leg is flexed upon the thigh, so as to relax the tendo Achillis, or, if necessary, this structure is divided

A dislocation **upwards** has been described in which the astragalus, together with the foot, is carried up between the tibia and fibula, owing to a rupture of the inferior tibio-fibular ligament and the lower end of the interosseous membrane, or a fracture of the tibia with displacement upwards of a wedge-shaped fragment The deformity is very marked

Dislocation of the Astragalus alone is by no means common It consists in a partial or complete detachment of the bone from all its normal connections, both to the bones of the leg and of the foot, and its displacement from under the tibio-fibular arch It may travel *backwards* or *forwards*, with or without lateral rotation, and be complete or incomplete It is frequently more or less compound

Dislocation **forwards** is much the more common variety, and is usually associated with partial rotation, the displacement occurring more frequently outwards than inwards When complete, the bone is entirely detached from its connections, and lies upon the upper surface of the external cuneiform and cuboid bones, the skin of the dorsum being tightly stretched over it, or even torn

In the incomplete variety, the head of the astragalus impinges either upon the scaphoid on the inner side, or the cuboid on the outer, whilst the lower end of the tibia rests on the posterior half of the articular surface of the astragalus

Dislocation **backwards** is almost always complete, and may or may not be associated with rotation of the bone, which can easily be felt between the tendo Achillis and the malleoli Fracture of one or both malleoli is almost certain to accompany this displacement

Treatment.—Reduction is possible only in the incomplete forms of dislocation The patient is anæsthetized, the knee flexed to relax

the muscles or the tendo Achillis divided, and traction upon the foot established, so as to enable the surgeon to apply pressure upon the displaced bone in a suitable direction In the complete variety reduction is impracticable, owing to the fact that the os calcis is drawn up into contact with the malleolar arch In such cases manipulation is useless, and excision of the bone is necessary Comparatively little impairment in the function of the foot results from this operation

Subastragaloid Dislocation.—By this term is meant a displacement of all the bones of the foot from below the astragalus, which retains its normal position between the malleoli It is due to some violent strain or wrench of the foot Displacement may occur either forwards or backwards, but in the great majority of cases it is either *backwards and inwards* or *backwards and outwards* The luxation is rarely complete as regards the calcaneo-astragaloid joint, but the articular surfaces of the head of the astragalus and scaphoid are completely separated, the former structure lying on the dorsal surface of the latter bone The foot is greatly deformed, the anterior portion being shortened, the heel projecting, and the toes pointing downwards The head of the astragalus forms a rounded globular swelling under the tense skin In a compound dislocation of this nature examined *post mortem*, the inner edge of the under surface of the astragalus had burst through the skin, the vessels and nerves were torn or stretched, and even when the wound in the skin had been enlarged reduction was impossible owing to the tendons which were caught around the neck of the astragalus In such a case removal of the astragalus would have been the only practicable treatment

In the **inward** displacements, the foot is somewhat inverted, so that the outer malleolus is unduly prominent, and the inner malleolus is lost in a deep depression caused by the lateral displacement of the os calcis, the foot is thus in a position somewhat simulating talipes equino-varus In the **outward** dislocations the foot is everted, the inner malleolus prominent, and the outer buried, a position of talipes equino-valgus being thus assumed In both forms the tendo Achillis is curved, with its concavity towards the displacement **Treatment** consists in reduction by manipulation, which is sometimes readily accomplished, but may be a matter of the greatest difficulty, probably from the tibial tendons becoming hitched around the neck of the astragalus Section of the tendo Achillis is occasionally needed In difficult cases excision of the astragalus may be required, and when there is much associated injury to the soft parts amputation

CHAPTER XXIII

DISEASES OF JOINTS.

General Considerations.—A careful study of the anatomy and physiology of joints is required in order to appreciate the many problems, mechanical and pathological, which confront the surgeon in the treatment of their diseases Limitations of space prevent us from discussing these, but we would remind students that the exposed ends of the bones entering into a joint are covered with articular cartilages, which in young people are separated from the shafts by the intervention of epiphyses, and these protect the joint in many cases from the spread of disease from the diaphyses, but in some cases are a source of danger in that the junction cartilages are intra-articular, *e g* in the hip-joint Holding the bones together is a complicated series of ligaments, of varying strength and density, usually inserted into the epiphyses in young people, and arranged so as to resist the various forms of strain to which the particular joint is exposed Lining the under side of the ligaments, and more or less closely attached to them, is the synovial membrane, a thick, smooth structure which secretes a glairy fluid for lubricating purposes, it extends as far as the margins of the articular cartilages Where it is not in close proximity to the ligaments, as in the knee-joint, the interspaces are padded with fat, which may occasionally prove a source of trouble On the inner aspect of the membrane are a number of small villi, which sometimes develop to a considerable size

Inflammatory affections of joints are of the most diverse character, and are brought about by injury, infection, or general constitutional conditions, such as gout The trouble may be limited mainly to the synovial membrane, constituting merely a **synovitis,** or may spread to and involve other articular structures, such as ligaments, cartilages, ends of the bones, etc , thereby constituting an **arthritis,** but there is no absolute line of demarcation between the two

Effusion into a joint occurs in most of the various manifestations, the exudate varying with the cause The phenomena, however, are similar in all the diverse conditions, and it would be well to note them here *Shoulder* The curvature of the shoulder is increased, and the deltoid expanded by a fluid swelling beneath it, which is especially noticeable at its anterior border along the bicipital groove, and sometimes posteriorly, in the axilla a painful intumescence may also be felt These symptoms may be somewhat simulated by inflammation of the multilocular subdeltoid bursa, but the latter condition is recognized by the absence of any axillary swelling, by its not encroaching on the anterior and posterior borders of the deltoid, and by the fact that, although when the patient voluntarily moves his arm

pain is produced, yet when the surgeon gently manipulates it, so as to press the head of the bone against the glenoid cavity, there may be none

Elbow The arm is maintained in a position of flexion and pronation, the hollows on either side of the olecranon and tendon of the triceps are replaced by soft fluid swellings, the outer of which also extends down to, and masks, the head of the radius, there is usually a little general puffiness in front of the joint It is readily distinguished from inflammation of the olecranon bursa by the fact that in the latter condition there is a central fluid prominence over the bone, whilst in the former the swellings are placed on either side of and above the bony projection

Wrist The hand is in a condition of slight flexion, and there is a general fulness around the joint, most marked on the anterior and posterior aspects, but also noticeable below the styloid processes The tendons in their sheaths are lifted up back and front, and deep fluctuation may be detected beneath them It is distinguished from a teno-synovitis by the facts that the swelling is limited more or less to the joint line, and does not extend up and down in the direction of the tendons, there is also no limitation of movement of the fingers, and the characteristic crepitus of teno-synovitis is absent

Hip-joint Effusion cannot be easily detected by digital examination There may be a little fulness and tenderness in the gluteal region, or in the upper and outer part of Scarpa's triangle The most characteristic feature, however, is the position of flexion, abduction, and eversion taken by the limb, whilst limitation of movement is equally marked

The *Knee*, when distended with fluid, presents a rounded outline, in which all the normal hollows, especially those on either side of the patella and ligamentum patellæ, have disappeared There is also a swelling corresponding to the subcrural pouch, more marked on the inner than the outer side, and extending for 3 or 4 inches above the patella Fluctuation can be readily detected when one hand is placed above the patella, and the fingers of the other hand compress the tissues on either side of the ligamentum patellæ below, or by alternate pressure on either side of the rectus tendon When the effusion is considerable the patella is felt to float, and on pressing it sharply backwards can be made to tap against the intercondyloid notch of the femur (*patellar tap*) A smaller effusion is recognized by pressing the fluid downwards from the subcrural pouch with the knee fully extended, when the patellar tap can usually be demonstrated Enlargement of the bursa patellæ is recognized by the swelling being central and in front of the patella, so that its outline is obscured

Ankle The foot is held in a position of slight equinus, and the hollows between the tendo Achillis and the malleoli are replaced by fluctuating swellings, whilst the dorsal tendons are displaced forwards, and a fluid swelling appears in front of each malleolus Enlargement of the bursa beneath the tendo Achillis is so obviously confined to the back of the joint that it should never be mistaken for true synovitis of the ankle.

The position to be adopted in the treatment of inflamed joints is a most important matter and must be carefully noted It may be termed for convenience the **Position of Rest,** and is such as not only gives comfort to the patient, but also ensures that if the joint should become fixed, the maximum of utility is secured for the limb Each joint must be separately studied

Shoulder The arm may simply be bandaged to the side if there is but little likelihood of subsequent stiffness, but whenever ankylosis is possible, it should be fixed at an angle of about 40 degrees away from the side This permits later of a much greater range of usefulness, inasmuch as it utilizes the scapular movements Fixation with greater abduction than this prevents the arm being placed to the side, as there is only a limited range of scapular movement

The *Elbow* (which of course includes the superior radio-ulnar joint) is placed on an internal angular splint and flexed to a little more than a right angle, so that the hand can be approximated to the mouth The palm of the hand must be turned slightly upwards, *i e* so that the patient can just see into it Before allowing the joint to become fixed in this position, however, it is well to ascertain from the patient what his work is, and what position of the arm will be most useful to him, as this varies much If both elbows are threatened with stiffness, one should be kept in a position of flexion to a little more than a right angle, the other to a little less In a person whose occupation is clerical, it may be best to allow fixity of the left forearm to occur in a position of pronation, so as to enable him to hold papers down to the table when writing

The *Wrist* must always be immobilized in a position of slight dorsiflexion, so as to improve the power of grasping When possible, the fixation should not include the fingers, if it is necessary to place them on a splint, movements must be maintained by giving them a full range each day It is wonderful how quickly adhesions form in the small joints of the fingers and in tendon sheaths when prolonged fixation of the fingers is associated with septic changes in the wrist or arm

The *Hip* is best immobilized in a position of moderate flexion (35 degrees) and slight abduction, so as to counteract the pull of the powerful adductors, which are always liable to adduct and invert the limb A careful watch must be kept on the patient's pelvis, to make sure that it has not been tilted by muscular action, so as to bring about once again a position of adduction, this warning is especially necessary in reference to children A Thomas's splint usually suffices to secure this position, but in children a double Bryant with extension to both legs is sometimes desirable

The *Knee* is usually kept in full extension, but there is no question that the most convenient position for permanent fixation is one of slight flexion, as this assists in mounting stairs and in sitting A shaped back-splint will suffice in milder cases, but in the more severe a Thomas's splint is required

The *Ankle* should be kept with the foot at right angles to the leg, and this can be obtained by placing the limb on a Macintyre splint.

Finally, it must be noted that although joints are now known to

possess a considerable power of resistance to infection by pyogenic organisms, yet any breach of strict aseptic precautions is only too likely to be followed by disastrous results, endangering both the utility of the limb and also the life of the patient, hence the most minute care must be taken in all **operations which involve the opening of joints.** Very thorough sterilization of the skin must be insisted on, and fingers should never be introduced into the wound A fresh knife should be employed to open the synovial membrane, for fear that in passing through the skin the knife may have been contaminated No antiseptics are allowed to enter the joint, as they are always somewhat irritating, and may cause a considerable synovial effusion which becomes a suitable nidus for the development of bacteria, if such happen to be present At the conclusion of the intra-articular manipulation, the joint should be gently irrigated with hot saline solutions so as to remove blood-clots, and carefully closed by buried sutures, which involve *seriatim* the synovial membrane, the ligaments, the overlying muscular or aponeurotic structures, and finally the superficial parts, exact co-aptation of each of these structures is necessary if good functional repair is to be obtained free from weakness Drainage is most undesirable, and the technique must always aim at avoiding the use of a tube, but if there has been much bleeding, it may be advisable to place a drainage-tube *down to, but not into,* the joint cavity for twenty-four hours The limb is usually kept at rest for a few days, perhaps on a splint, and then movements are cautiously permitted, at first passive, then active, and finally active against resistance, and all these advisably before the patient strains the joint (if a knee) by bearing upon it the weight of the body Massage to the surrounding muscles will of course be employed as soon as the wound is securely healed

Traumatic Synovitis is the condition which follows such injuries as strains or sprains, and is characterized by an effusion of blood and synovial fluid within the joint cavity, and by pain on any movement which stretches the injured part The characteristic signs of effusion into the particular joint are manifested, but inasmuch as the exudate is aseptic, it is quickly absorbed, granting that the joint is kept at rest Some of the blood which escapes into the joint clots, and the coagula may collect in the reflections or pouches of the cavity, or may become fixed to the raw tissues exposed by the tear in the synovial membrane These coagula are not always readily absorbed, but are organized into fibrous tissue, constituting adhesions which may limit the free movement of the limb

If the condition is not treated effectively by suitable rest in the early stages, the tear in the synovial membrane may be opened up again and again, leading to recurring attacks of synovial effusion (the so-called chronic synovitis, *q v*) with relaxation of ligaments and increasing disability On the other hand, too prolonged fixation may result in stiffness due to the formation of adhesions and atrophy and loss of tone of muscles **Treatment** must therefore be a judicious combination of rest and movement In the early stages rest must be employed for a few days in order to secure absorption of the exudate,

the position of rest already alluded to must be adopted It may not always be necessary to immobilize the joint on a splint, but at any rate it must be well supported by pressure exercised by a firm bandage over a pad of cotton-wool

As soon as the effusion has disappeared, the joint should be strapped and fixed in such a position as shall approximate and keep at rest the damaged tissues Union will be secured in seven to ten days to such a degree as to permit of gentle active movements and a greater range of passive movement, but these must never be pushed at this stage to the point of causing obvious pain Practitioners must remember that one full range of movement up to the limit of painlessness in the course of the day is all that is required to ensure against subsequent stiffness, repeated 'sawing' movements of a joint only irritate it, and may do harm rather than good by stretching unduly or tearing the new bond of union Patients should never be allowed to place any strain on a limb after an attack of synovitis without support, this may be given by elastic pressure, or by a crepe bandage over cotton-wool Massage is useful to maintain the tone of the muscles and to assist in the absorption of the exudate, but must be employed with discretion, and cannot take the place of active exercise Should the effusion persist, assistance may be gained by the alternate applications of hot and cold water, and by rubbing with stimulating embrocations

Pyococcal Infection of Joints.

It is now well recognized that most cases of acute synovitis of joints are associated with the presence of pyococci, which are derived from the blood It has also been abundantly shown that penetrating wounds associated with the presence of pyococci are not invariably destructive, and rightly handled there is much defensive power in the synovial membrane On the other hand, if the inflammatory trouble progresses beyond certain limits, it results in the gravest destructive manifestations and threatens both life and limb It is obvious that the pyococcal infection of a joint may result in many types of inflammatory trouble, but for descriptive purposes it is convenient to describe three varieties, which may be merely stages in one case, or to which the trouble may be limited

The **organisms** present vary necessarily with the cause Non-penetrating wounds are likely to be infected by some particular organism derived from elsewhere in the body, *e g* it may be secondary to pyorrhœa, impetigo, carbuncle, tonsillitis, scarlet fever, or be dependent on gonorrhœa In many cases it is impossible to find the causative lesion, although one looks for it carefully In penetrating wounds (nails, knives, gunshot wounds, etc) the infection is often of a mixed type, and in military work anaerobes are often present Of particularly grave prognosis is a hæmolyzing streptococcus

I Acute (Non-Suppurative) Synovitis.

In this affection the inflammation is limited almost entirely to the synovial membrane, the ligaments and other structures of the joint being but little affected. It is sometimes attributed to cold or injury,

the organisms reaching the joint from the blood, as is also the case in the milder pyæmic and gonococcal affections, and some so-called cases of rheumatism

Pathological Anatomy.—Acute synovitis is characterized by hyperæmia of the synovial membrane, and exudation of plasma and leucocytes firstly into the substance of the membrane, causing it to be thickened and spongy, and subsequently into the joint, the endothelium also proliferates, and is shed In the early stages the effusion consists of synovia, diluted with blood-plasma, and often discoloured with blood in traumatic cases, and hence on removal is sometimes spontaneously coagulable, after a time the plasma may coagulate, depositing lymph upon the articular surface, whilst serum remains This lymph may either be removed by a natural process of absorption when the inflammation comes to an end, or it may become organized, so as to form adhesions, which consist of loose fibro-cicatricial tissue containing a few delicate blood-vessels and covered with endothelium from adjacent serous surfaces In some varieties, especially if repair is not quickly established, a certain amount of perisynovial inflammation follows, resulting in congestion, infiltration, and perhaps relaxation of the ligaments

The **Clinical Signs** of acute synovitis consist in the joint becoming painful and distended, and in the case of superficial joints hot to the touch and even red The limb is maintained by muscular spasm in that position which gives the most ease, *viz* that in which its capacity is the greatest, and this is usually one of slight flexion If the condition is neglected, the flexion may increase considerably, and the limb become more or less fixed in an undesirable position, whilst the muscles governing the movements of the joint undergo rapid atrophy The phenomena resulting from effusion into various joints have been already noted (p 721)

When the acute stage has passed, the joint is usually left in a weak and relaxed condition, with a little passive effusion, or perhaps some adhesions The adhesions which follow acute synovitis are usually slight in character if the case has been properly treated, and extend between opposing surfaces of synovial membrane or bone The characteristic signs of such a condition are definite limitation of movement in some particular direction, and possibly a little soft crepitus, no pain is experienced until tension is put on the adhesion.

The **Treatment** of acute synovitis consists in immobilizing the limb in the position of rest (p 723), and necessarily, in all severe cases, the patient must be confined to bed In the early stages cold should be applied to the joint by means of evaporating lotion, an icebag or Leiter's tubes, but this is not advisable in old people, in the later stages fomentations give greater relief When the distension is considerable, removal of some of the fluid by a carefully purified aspirator or syringe will diminish pain and hasten recovery Such fluid should always be examined bacteriologically, and if organisms are found the joint should be washed out with normal saline solution and treated as described below (p 728) In not a few cases of acute synovitis

the induction of passive hyperæmia by the application of an elastic bandage will give relief and hasten repair

In the subacute stage, when the joint is weak and relaxed, massage or friction with stimulating liniments should be employed, whilst in the later stages elastic pressure is often of the greatest value. If the case has been neglected and the limb has assumed a vicious position, the patient should be anæsthetized and the deformity corrected, or gradual extension is made by means of a weight and pulley until a correct position is attained

If the movements of the joint are limited by the presence of **adhesions,** these must be broken down under full anæsthesia It is not always easy to select the cases which require this treatment, and in which it will be beneficial In this connection the following points should be remembered (1) Limitation of movement due to a general arthritis, however mild, is characterized by pain in every direction, with adhesions suitable for breaking down there is a certain degree of painless movement, and pain only commences when this is exceeded, and the adhesions are stretched (2) Massive adhesions, such as those which form after serious inflammatory trouble, hold out little prospect of improvement by wrenching (except for the correction of deformity), as the divided surfaces have to heal, and in so doing fresh adhesions form (3) The time for breaking down adhesions is as soon as possible after the inflammatory trouble has ceased, as evidenced by cessation of pain and reduction of swelling Delay only means increased strength of the adhesions, and increased atrophy and want of tone of muscles (4) The actual breaking down of the adhesions should be accomplished by steady force, and not by intermittent jerks In the less serious cases, a full range of movements should be aimed at from the first, and the freedom of all movements of the joint should be tested In the graver cases it may be desirable not to do too much at a time, as a good deal of reaction often follows, the manipulation may be repeated more than once (5) When it is likely that a good deal of force will need to be employed, it is wise as a precautionary measure to place splints on the limb above and below the joints, since it is not difficult to break one of the bones (6) The joint is kept at rest for a day or two after the manipulation, but once at least each day the limb should be put through a full range of the movements secured (7) As already pointed out, no attempt should be undertaken to break down adhesions in a joint in the neighbourhood of septic sinuses, intra-articular hæmorrhage followed by suppuration is only too likely to follow

II Acute Suppurative Synovitis (or Empyema of Joint).

This condition is in reality merely a further stage of that just described, the effusion becomes at first turbid by the admixture of pus cells with the synovial exudate, but finally it becomes frankly purulent For a time it is quite possible for the suppurative process to be limited to the synovial membrane with a certain amount of perisynovial infiltration, but no true spread beyond the capsule or

destruction of the articular cartilage This stage proves most amenable to judicious treatment, but it is not uncommon to see cases of this type run over into an acute destructive arthritis, sometimes as a result of mismanagement, at others in consequence of the virulence of the causative organisms

Causation—(i) Every septic penetrating *wound* of a joint passes through a stage of suppurative synovitis, and if hæmolyzing streptococci are absent, if the patient's resistance is fairly good, and if he is correctly treated, the condition may not progress beyond this This statement is equally true of post-operative infection (ii) It may arise in a manner exactly analogous to that in which acute infective osteomyelitis is produced, *viz* by *auto-infection* A slight injury, *e g* a sprain or strain occurring in a weakly child, convalescent from measles or scarlet fever, may result in this affection, which is then commonly due to the pneumococcus Traumatism in a patient riddled with sepsis, *e g* the breaking down of adhesions in a joint, particularly if in the neighbourhood of septic sinuses and diseased bone, is almost certain to be followed by suppuration in the joint, which becomes distended with blood and pus (iii) It may be produced by the lodgment of a pyæmic *embolus*, and in a similar way it not unfrequently follows as a sequela of fevers, such as enteric or pneumonia, by direct transmission of some infective material (iv) It is sometimes met with as a result of *gonorrhœa* (p 725) (v) It may be lighted up as a result of the *extension* of inflammation from the end of a neighbouring bone, or from the bursting of a subcutaneous or bursal abscess into the joint Acute arthritis of the hip-joint is sometimes due to the former of these conditions, being consecutive to an acute infective osteomyelitis of the upper end of the femur

The **clinical signs** are merely those of a hyperacute synovitis The joint is swollen and distended with fluid, it is hot to the touch and tender, movements, even the slightest, are often extremely painful; and sleep becomes difficult, as the relaxation of muscles associated therewith means a change of position of the limb, which involves pain and wakes the patient There is almost always a certain degree of pyrexia, though usually not excessive

The **Treatment** of these cases is based on the recognition of the protective and defensive power inherent in the synovial membrane if correctly handled, in other words, the synovial membrane conforms in its reactive power to that of other serous membranes, such as the peritoneum and pleura To be effective, treatment must be early, and the essential elements are to remove the exudate, to irrigate the cavity, perhaps to introduce some antiseptic, and to close the joint once again, trusting to the membrane to do its own defensive work The limb is of course suitably immobilized, and slight extension applied

The removal of the exudate may be effected by a syringe or by trocar and cannula, but it is probably wiser in most cases to cut down on and expose the synovial membrane, which is then picked up by tissue forceps and opened sufficiently to give exit to the discharge, and to enable a small tube or catheter to be introduced for irrigation purposes The knee is approached from either side, but preferably

from the outer, the shoulder-joint from the front along the bicipital groove, the hip from the front between the tensor fasciæ femoris and rectus muscles, the ankle from either in front of or behind the malleoli, avoiding carefully the tendon sheaths, the elbow by the outer side of the triceps tendon

Irrigation of the joint cavity must be effective, normal saline solution is all that is necessary, but some surgeons prefer an antiseptic, such as flavine (1 in 1,000) or Dakin's solution If any fluid is to be left in the joint, either a 2 per cent solution of formalin in glycerine or a 1 in 1,000 solution of flavine should be employed, about one ounce of each will be required for a knee-joint If the effusion recurs, this process may be repeated more than once

Under no circumstances must a drainage-tube be introduced into a joint in this condition, it is certain to determine ankylosis, and the surgeon's aim and object is to secure a movable joint

The limb is placed in the position of rest, but some slight extension is applied so as slightly to separate the articular surfaces and thereby limit pain as well as check muscular spasm The extension must be only slight, as the ligaments are always liable to be softened to some degree and may become relaxed In dealing with a knee, for example, an adhesive plaster extension is applied to the limb under an anæsthetic, the joint is opened, irrigated, and, if thought desirable, injected A Thomas's splint with side-bars hinged opposite the knee is put on, suitable extension is arranged, and the splint is suspended from a Balkan frame

The great majority of cases treated in this way will quiet down, the temperature falls, the pain diminishes, and the swelling disappears The surgeon must now turn his attention to *mobilization* of the limb If this is undertaken rashly and too rapidly, the joint 'flares,' indicating that the bacteria in the joint are not destroyed, but merely that their activity is suspended, any injudicious stimulation gives them a fresh opportunity for evil

When the inflammatory trouble has apparently ceased, the knee is cautiously and gently bent to an angle of about 10 degrees, and the extension replaced, if there is no reaction, a larger range is given on the following day, and still more day by day After about a week the hinges of the splint are daily relaxed for a time, and the patient permitted and encouraged to move his knee actively within limits which can rapidly be increased, often in three to four weeks a full range of movement is possible Massage of the muscles of the limb will assist in this restoration of function

Not unfrequently, however, a joint 'flares,' even after a slight degree of movement cautiously regulated It is then kept at rest for a day or two, and the inflammatory reaction will probably subside, possibly the patient's general condition will be improved by this attack, which is in reality an auto-vaccination The next time movement is allowed the reaction will probably be less, and then the ordinary course outlined above may be followed out

Should the patient come under observation late, or should irrigation fail to check the inflammatory trouble, or should the 'flare-up' after

a preliminary or late movement be severe, more active measures must be taken if an acute destructive arthritis is to be prevented Free incisions must be made into the joint so as to give satisfactory drainage, *e g* for the knee an incision on both sides of the patella upwards to lay open the suprapatellar pouch, for the elbow, on either side of the olecranon tendon, for the shoulder, along the bicipital groove Here, too, the rule must be adopted *No drainage-tube in the joint* The incisions are left widely open, and the joint cavity irrigated occasionally, the essential element is to urge, and if need be coerce, the patient into moving the joint actively, however painful it may be No means of drainage is more effective than active movement, which squeezes out the pus from the synovial cavity After a short time the movements become comparatively painless, the joint heals up, and movement is retained There is no doubt as to the value of this method in cases of suppurative synovitis

Of course, when the inflammatory trouble has ceased and the wounds have healed, the patient is not allowed to put weight or strain on the joint without suitable support or until the muscles have been restored to tone by massage and re-educational exercises

III **Acute Suppurative Arthritis.**

In this condition the inflammatory process involves all the elements of the joint, synovial membrane, ligaments, cartilages, and bones, and may spread widely along muscle planes, or along the medullary cavity It is associated with great suffering and constitutional disturbance, and endangers both life and limb

For **Causation,** see p 728

Pathological Anatomy.—The *synovial membrane,* at first merely infiltrated and hyperæmic, soon becomes converted into granulation tissue, exuding an abundance of pus The organisms spread through the perisynovial cellular tissue to the *ligaments,* which become sodden and relaxed by the presence of a sero-plastic exudate between the fibres, rendering them soft and œdematous, so that the tonic contraction of the muscles easily stretches them and brings about displacement The *articular cartilages* are disintegrated and destroyed in various ways according to the acuteness of the inflammation and the amount of pressure to which they are exposed In acute cases they early lose their normal bluish-white appearance, and become opaque and slightly yellow The central parts, which are exposed to pressure between the ends of the bones, soon disappear, possibly by the activity of the tryptic ferment in the exudate, whilst the peripheral portions are eroded by the overgrown granulation tissue developing from the synovial membrane When once the cartilage has been perforated at any one spot, the suppurative inflammation spreads along its under surface, stripping it from the bone, and thus inducing necrosis, as a result of which isolated portions of dead cartilage may be found lying in the joint The *interarticular cartilages* are affected in a very similar manner, and quickly disappear The *ends of the bone* pass into a condition of acute osteitis resulting in the transformation of the

medulla into granulation tissue, absorption of the bony cancelli, with or without suppuration, and sometimes necrosis of small portions of the cancellous tissue (*caries necrotica*) The veins within the cancelli become thrombosed, and hence pyæmia may result The *periosteum* covering the ends of the bones is also inflamed and hyperæmic, in consequence of which spiculated or stalactitiform osteophytes are produced (Fig 422) The *muscles* in the neighbourhood of the joint undergo rapid atrophy and fatty degeneration

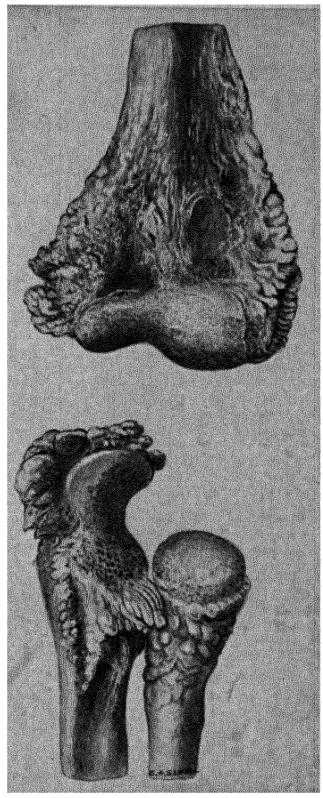


FIG 422.—ENDS OF THE BONES AFTER ACUTE ARTHRITIS OF ELBOW, SHOWING THE CARIOUS SURFACES DEVOID OF CARTILAGE, AND THE DEVELOPMENT OF STALACTITIFORM OSTEOPHYTES

Course of the Case—In the early stages acute arthritis manifests itself as a hyperacute synovitis, combined with severe pain and fever The pain is often so intense that the patient cannot bear the part to be touched or the bed shaken, and, indeed, the slightest jar of the limb is so exquisitely painful that the patient may scream with agony The joint itself is distended with a turbid effusion, which rapidly becomes purulent, and the tissues around are hyperæmic and œdematous The patient naturally places himself in that position in which the limb obtains the greatest ease, and therefore usually semiflexes the joint and fixes it by muscular contraction

As the disease progresses the tension within the capsule increases, until in time it yields, and the pus either travels directly to the surface, or burrows deeply into the substance of the limb, and spreads along the muscular planes, thus, in the knee an enormous abscess may collect beneath the vasti muscles, stripping them from the bone for a considerable distance The pain increases whilst the abscesses are forming, and becomes especially distressing at night, the patient being often waked by a painful start just as he has fallen asleep This condition usually indicates that the articular cartilages are becoming affected, and is explained by the fact that just as the patient loses consciousness the muscles which fix the joint are relaxed, and allow the inflamed surfaces to shift their position slightly, exciting severe pain and a sudden spasmodic contraction of the muscles Gradually the deformity becomes more and more obvious, whilst the infiltration

and relaxation of the ligaments sometimes allow of abnormal movements, *e g* of lateral mobility in the knee-joint, the ends of the bones become carious, and absolute displacement or dislocation may follow Sinuses may open in all directions, and the patient suffer from recurrent rigors, caused by toxæmia or the onset of pyæmia The constitutional effects are always severe, consisting of high fever, and rapid exhaustion from the pain, sleeplessness, and absorption of toxins

The *terminations* of this affection are as follows (*a*) Recovery, rarely with a movable joint, and then only after early and active interference, in most cases ankylosis in a good or bad position, according to the treatment, is the best result that can be expected (*b*) During the acute stage the patient may die of pyæmia, or acute toxæmia and exhaustion (*c*) If he survive the acute stage, chronic suppuration may ensue, and symptoms of hectic fever and amyloid degeneration of the viscera may supervene In such cases sinuses leading down to carious bone exist, and, unless efficient measures are taken to drain the parts or to remove the diseased structures, perhaps by amputation, the patient is likely to die from exhaustion or chronic toxæmia

The **Treatment** already described as suitable for a suppurative synovitis is initiated in the first place The limb is immobilized in the position of rest (p 723), extension is applied to keep the inflamed bone ends apart, but with as little force as possible, so that the infiltrated and softened ligaments shall not be unduly stretched, suspension of the limb is also most necessary If irrigation fails to check the inflammatory process, and increasing œdema of the peri-articular region and limb indicates that the trouble is extending, the joint must be laid open and free drainage secured

Small incisions with a view to introduce drainage-tubes are of little value, long incisions opening up the whole joint cavity must be employed When all hope of gaining a movable joint has disappeared, drainage-tubes or strips of rubber glove may be employed, or continuous irrigation utilized, the Carrel-Dakin treatment is sometimes valuable in this connection A keen watch must be kept on all aspects of the limb, so that the development of fresh abscesses may be detected and treated at once A vaccine may possibly be prepared from the pus and administered The fixation of the limb is carefully maintained and the general condition attended to Irrigation continues until all signs of inflammation, heat, pain, and all startings of the limb, have passed away The wounds are then allowed to granulate and the limb to consolidate Chronic sinuses may persist for a time, leading to undrained pockets of pus or to diseased bone, which must be dealt with in an appropriate manner

Excision is occasionally required early in the case in order to secure effective drainage, as in the shoulder, or more generally, at a later date, to prevent or remedy faulty ankylosis, or to place the limb in a good position, it is also sometimes used in cases of chronic suppuration with caries of the ends of the bones and displacement, but as a rule this is deferred until the wound has healed and all active trouble ceased.

Amputations may be needed for severe toxæmia or pyæmic symptoms threatening life, or for exhaustion from chronic sepsis, or for hopeless deformity

Acute Arthritis of Special Joints

In the **Shoulder,** infection sometimes occurs through the axilla, where the capsule is weak and easily invaded by organisms, as after an axillary cellulitis, more frequently it follows a penetrating injury Severe pain is caused by any movement of the arm affecting the joint, and if abscesses form, they will come to the surface in front of or behind the deltoid, or in the axilla It may suffice to open the articulation anteriorly, and irrigate it, but, if necessary, a counter-opening should be made behind by cutting down on a pair of dressing-forceps pushed backwards through the capsule In many instances the patient's condition will not improve until the head of the bone has been excised, and then the subsequent results as regards movement and power of the arm are, on the whole, satisfactory



FIG 423 —SECTION OF WRIST-JOINT TO SHOW THE DIFFERENT CARPAL JOINTS IN RELATION TO IT

In the **Elbow** there are no points requiring special mention as to clinical history or results, although it must be remembered that the superior radio-ulnar articulation is necessarily involved, and hence the power of pronation and supination of the hand is threatened As to treatment, incisions should be made on either side of the olecranon, the ulnar nerve being avoided The limb is then placed on a rectangular splint, *e g* Sir R Jones's flexed arm splint, which permits of extension, the hand is placed midway between pronation and supination In an adult excision may be undertaken as soon as the acute stage has passed, in order to obtain a movable elbow, but in children, where the growth is incomplete, it is better to allow ankylosis to occur, and excise, if need be, at a later date

The **Wrist** may be infected secondarily to septic conditions following operations on ganglia in the neighbourhood or through direct injury, the various carpal joints soon becoming infected owing to their anatomical arrangement (Fig 423) The essential treatment consists in free incisions parallel with the tendons, and avoiding the sheaths Ankylosis usually results, and excision is not resorted to except when the disease has become very chronic, with extensive caries of the carpus (Fig 424)

Acute arthritis of the **Hip-joint** is usually a sequela of acute infective osteomyelitis attacking the upper end of the shaft of the femur, and involving the joint, owing to the epiphyseal cartilage being intra-

capsular, it also results from pyæmia, and from penetrating injuries which in civilian life are rare The symptoms are similar to those of the first stage of ordinary tuberculous disease (p 771), but much more acute There is high fever, together with intense pain, marked flexion and eversion of the limb, early suppuration, and rapid disorganization if not properly treated, indeed, where nothing is done, and the patient lives long enough, the head of the bone may be entirely absorbed, or is detached, and remains as a sequestrum in the disorganized articular cavity As soon as the capsule gives way, the pus may come to the surface in any of the usual localities for hip-joint abscesses, and the limb then becomes inverted and adducted, spontaneous dislocation follows, and the head of the bone, or what



FIG 424 —TUBERCULOUS DISEASE OF THE WRIST-JOINT
Note the marked atrophy of the carpus with general blurring of the bones and narrowing of the joint spaces

remains of it, travels upwards and backwards on the dorsum ilii In treating these cases, the joint should be freely laid open in the situation which appears most favourable The anterior incision is more suitable for the early, and the posterior for the later, stages, when the head of the bone is either dislocated, or remains *in situ* and separated from the shaft A double opening may sometimes be utilized with advantage

The **Knee-joint** is more frequently involved by this disease than any other, and is usually infected from without The symptoms are exceedingly typical the pain is very acute, and the joint hot and distended to its utmost capacity, the limb lying semiflexed and on its outer side Left to itself, the capsule gives way, and suppuration rapidly extends upwards beneath the vasti, giving rise to large ab-

scesses, which ultimately find their way to the surface The deformity gradually increases, until in the worst forms the tibia slips behind the condyles of the femur, the leg is flexed to a right angle and rotated outwards, and if the limb has long rested on its outer side, considerable lateral displacement may also occur Early and efficient treatment (p 726) will usually prevent such a disaster If this fail, the joint should be freely incised on each side of the patella, so as to open up the subcrural pouch, and the whole articular cavity well washed out In severe cases counter-openings must be made behind so as to drain the posterior pockets of the synovial cavity A sinus forceps is introduced from the front, and passed backwards on either side so as to project posteriorly, and the point then cut down on Possibly a drainage-tube may be employed with advantage, reaching as far as, but not projecting into, the synovial cavity The nerves and tendons of the popliteal space must of course be carefully guarded In these severe cases it may be wiser, however, to lay the joint freely open from the front by a wide U-shaped incision, dividing the ligamentum patellæ and turning up that bone By flexing the leg completely, the femoral condyles can be exposed sufficiently to enable their posterior rounded ends to be removed by a vertical saw-cut Plenty of room is thereby secured for the insertion of drainage-tubes from either side or for irrigation purposes The anterior flap can be replaced and sutured in position

When the **Ankle-joint** is involved, amputation has often to be resorted to, in consequence of the difficulty of securing good drainage, although excision of the astragalus will sometimes cut short the disease and lead to a good result

Special Forms of Synovitis and Arthritis.

Pyæmic Synovitis is due to embolic infection from some suppurating focus The joint becomes rapidly distended with pus, and often without pain If the joint is promptly tapped or opened and irrigated, it usually does well, at any rate if the patient's vitality is fairly good, but if treatment is delayed, disorganization may follow (*vide* Pyæmia, p 77)

Typhoid Disease of Joints occurs either as a synovitis or arthritis, and is due to a blood infection with the *B typhosus*, either alone or in conjunction with pyogenic organisms If purely typhoid in type, suppuration does not occur, there may be a mild synovitis in several joints, or a marked effusion in one followed by relaxation of ligaments, so that spontaneous dislocation may occur, this is most marked in the hip-joint The prognosis is favourable in these purely typhoid lesions if deformity is prevented, effusion in excess is treated by aspiration or tapping, and washing out, a recurrence may require drainage If pyococci are present, either alone or together with the typhoid bacilli, suppuration develops and masks the typhoid element. The routine treatment of a suppurating joint is required

Pneumococcal Arthritis.—In the course of an acute pneumonia the pneumococcus is occasionally disseminated through the body, and is then very likely to attack a joint which has been already damaged,

giving rise to a suppurative arthritis with an effusion of thick creamy pus, or sometimes to a milder form of synovitis Males are more often affected than females, and the upper rather than the lower extremity Occasionally more than one joint is involved, and, with the exception of the hip, the larger joints are attacked rather than the smaller There are no special peculiarities in the disease, but since it is merely part of a general infection, the prognosis is not good When suppuration has occurred, the joint should be tapped or opened and irrigated

It may also occur primarily and apart from any other obvious pneumococcal lesion The symptoms are then those of a subacute arthritis with effusion, which apart from active treatment may lead to subsequent limitation of movement

Gonorrhœal Disease of Joints is always due to infection with the gonococcus, transmitted by the blood from the primary focus of mischief It is sometimes associated with pyogenic organisms, and then the prognosis is decidedly worse In the later stages the pus or serum from the joint is sometimes found to be sterile, the gonococci having died after causing the inflammation Such an occurrence is always suggestive, as sterile pus is rarely found in an acute abscess due to ordinary pyococci Whilst usually seen in connection with gonorrhœal urethritis in males, it has been known to follow ophthalmia neonatorum, and has been lighted up by passing a full-sized bougie on a patient with gleet It generally commences after the third week of the gonorrhœal attack, when the discharge is becoming subacute, but may sometimes appear at a much later period It may involve one or many joints, the knee, ankle, and wrist being most frequently affected, and perhaps on both sides of the body

Many distinct types of trouble manifest themselves, and they are not unfrequently combined In one, the synovial membrane is mainly affected, and the effusion is chiefly intra-articular, so that the condition closely resembles an ordinary attack of acute traumatic synovitis, except that it is more severe, more painful, and more persistent Occasionally a synovial effusion occurs with but little reaction, and then the gonorrhœal origin is likely to be overlooked A more frequent form is that in which the peri-articular structures bear the brunt of the mischief, and there is at first but little effusion *in* the joint, but much around it, the parts even becoming œdematous and reddened, the ligaments are infiltrated and softened, so that displacement readily occurs, surrounding muscles atrophy rapidly, the patient suffers from severe pain and fever, so that he becomes thin and worn In the worst cases the intra-articular effusion increases, and is sero-purulent, yellowish-green in colour, and contains flakes of lymph, sometimes it becomes frankly purulent All the forms are very chronic and resistant to treatment, and hence ankylosis, with or without disorganization, is very liable to follow

The **Treatment** of this condition has been considerably modified of late, and the prognosis improved, by a twofold discovery (*a*) that the virulence of gonococci is attenuated by a temperature which can not only be tolerated by the tissues, but which improves their activities (p. 139), and (*b*) that in diathermy we possess a means of thus in-

creasing the temperature of the part to which it is applied The results of the diathermic treatment of this condition have been most satisfactory Of course, additional measures must be taken to arrest the urethral discharge as soon as possible Sulphanilamide treatment should be given

If diathermy is not available, the joint should be kept at rest, and moderate pressure and counter-irritation secured by Scott's dressing Bier's treatment by means of an elastic bandage is also useful, and gonococcal vaccines are sometimes most beneficial Non-specific antitoxin treatment, *e g* the administration of anti-streptococcic or anti-diphtheritic serum, either by mouth or rectum, has also proved of value in some cases, probably acting by increasing the general resistance of the body

Very severe cases must be treated in the same way as a synovitis of pyococcal origin, *viz* by incision or tapping and washing out, followed by the introduction of some agent such as glycerine and formalin (2 per cent), the joint may, if thought desirable, be left open for drainage, but a tube must never be inserted

Rheumatic Synovitis is met with in the course of acute rheumatism, or as a chronic affection from the commencement In the former one joint after another is involved, complete resolution usually follows, but there may be some thickening of ligaments and consequent impairment of mobility If the disease is limited to one joint, absolute disorganization, though without suppuration, may ensue (acute rheumatic arthritis) There can now be little question that this disease is of bacterial origin and due to a diplococcus (Poynton, Paine), or to some form of pyococcal infection of low virulence, as from a chronic pyorrhœa

The chronic variety is characterized by swelling of the joints, due partly to effusion, partly to thickening of the synovial membrane, and of the capsular and other ligaments If neglected, it may produce fixity of the joint, due mainly to ligamentous changes, but also resulting from the development of intra-articular adhesions, but there is never any lipping of the cartilages or new formation of bone, as in osteo-arthritis Not unfrequently other evidences of rheumatism may be present, such as chorea, erythema, etc , whilst rheumatic nodules, *i e* new growths of fibrous tissue beneath the skin, perhaps attaining the size of a walnut, but more often much smaller, may also develop

The **Treatment** of the acute form is in the first place medical rather than surgical, and general rather than local The affected joints must be kept at rest in good position, and wrapped in warm cotton-wool, or, perhaps better, soda fomentations may be applied. In the presence of a marked effusion, however, there must be no delay in tapping or opening and washing out the joint, which will be found to be occupied by a greenish, semi-puriform effusion

In the more chronic forms drugs have but little power, and attention must be directed in the main to the general condition of the patient The diet must be simple, and butcher's meat, sweets, and rich dishes generally must be avoided Fish, eggs, and poultry should constitute the chief elements of the protein food Abundance of

plain water must be drunk, either hot or cold as best suits the patient, but *not at meals*, the fluid should always in these cases be imbibed about an hour before meals In the early morning before breakfast, it is often wise to add a small dose of Epsom or Glauber's salt to the water, and thus procure a slight purgative effect, thereby cleansing the intestine Thus it is possible even at home to secure many of the advantages derived from a visit to a suitable spa, which in persistent cases is very desirable In addition, acid fruits and vegetables should be avoided, such as rhubarb, tomatoes, and the 'berries' generally Locally, inunction of an ointment containing some suitable form of iodine, possibly combined with oil of wintergreen (methyl salicylate) is often helpful, but possibly the result is as much due to the massage as to the ointment Hot-air baths are also good, as also ionic medication with sodium salicylate (p 303), or diathermy (p 297) Of course, care must be taken to prevent deformity if practicable, or to correct it, but this is often not an easy matter

The practitioner must not forget to overhaul the patient thoroughly to ascertain whether or not there is any source of pyococcal infection in the body Particular attention must be devoted to the teeth and gums, removal of septic roots and decayed teeth has often a marvellous effect in curing so-called rheumatism Diseased tonsils, chronic suppuration of the nasal passages, chronic urethritis, or leucorrhœa, may also be causative factors, and must be dealt with in an appropriate fashion

Gouty Arthritis is characterized by certain well-marked features It often attacks the metatarso-phalangeal articulation of the great toe (podagra), or the metacarpo-phalangeal joint of the thumb (cheiragra) Its onset is usually sudden, and it frequently commences in the middle of the night The tissues around the joint become swollen, red, shiny, and œdematous, whilst the superficial veins are prominent The attack is exceedingly painful, and the skin exquisitely tender These symptoms pass off in the course of a few days, leaving the articulation swollen and sensitive

Even a single attack results in a slight deposit of bi-urate of soda in acicular crystals in the matrix of the articular cartilage close to the surface, but when the joint has been several times inflamed, the whole thickness of the cartilage may be invaded by this chalky deposit, whilst the ligaments and ends of the bones are also infiltrated In the smaller joints it may increase to such an extent as to form well-marked swellings, or 'tophi,' similar in character to those so commonly seen in the external ear, the skin sometimes gives way over them, and a chalky discharge results In some cases the cartilages are eroded, and eburnation of the exposed bone may follow, as in osteo-arthritis The **treatment** of acute gout consists in fomenting the parts or applying glycerine of belladonna, whilst colchicum, citrate of lithia, and alkaline purgatives are administered In the more chronic forms iodides may be given, and the diet and drink are carefully regulated Probably some form of hydro-therapeutic treatment will be required, and if the patient cannot go to a suitable spa much may be done at home by getting him to drink a large glassful of hot water an hour before each meal

Chronic Synovitis

This affection follows an acute attack, or may be lighted up by some injury or condition insufficient to determine a more violent form of inflammation The synovial membrane becomes thick and infiltrated, whilst the effusion is sometimes relatively less than in the acute form, sometimes excessive

Three varieties have been described (*a*) **Chronic Serous Synovitis** (Fig 425) is a condition in which effusion is the most prominent factor It results from many causes, which throw strain upon the joint, or is sometimes inexplicable It is not unfrequently associated with some condition such as a loose cartilage, osteo-arthritis, etc , and in its most aggravated form constitutes a condition of *hydrarthrosis* or *hydrops* (p 740) It is not unfrequently seen affecting the knees after rising from a prolonged stay in bed The fluid is often clear and limpid and the changes in the structure of the membrane are but slight The pain is usually not severe, being replaced by a sense of uselessness and weakness It is interesting to note that, in cases where the effusion is well marked, the bursæ communicating with the joint frequently become distended, they are prevented from participating in the acute forms of inflammation by the fact that the apertures of communication with the interior of the joint are narrow and slit-like, and thus readily become occluded by the swelling of the membrane

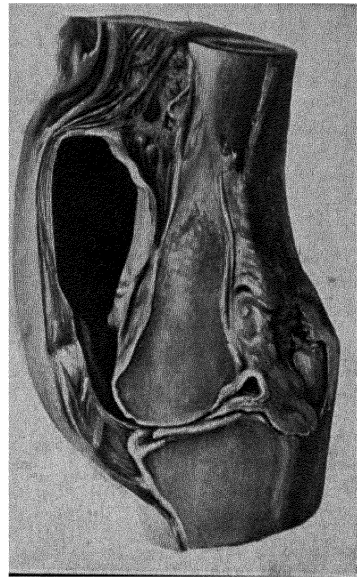


Fig 425 —Chronic Serous Synovitis of Knee, with Distension of the Subcrural Pouch (From College of Surgeons Museum)

(*b*) **Chronic Synovitis with thickening of the Synovial Membrane** is always a suspicious condition, as it may be a precursor of tuberculous disease, if it lasts, or an outcome of a syphilitic infection There is but little effusion, and the membrane may be even palpable Crepitus is sometimes met with in this condition, possibly from a roughening of the articular surfaces on which lymph has been deposited, or between which fibrous adhesions have formed

(*c*) **Chronic Papillary Synovitis** —Occasionally the synovial fringes and the villi of the synovial membrane become hypertrophied, giving rise to a condition somewhat similar to that described under osteo-arthritis (p 753) The overgrown villi usually spring from the reflections of the synovial membrane close to the bone, and may be loaded

with fat, constituting a condition known as 'Lipoma arborescens' In the knee-joint the fringes may be felt rolling under the fingers, and painful symptoms may be caused by the loose ends being caught and nipped between the bones

Treatment varies somewhat in the different types, but in all the joint must be kept at rest in a suitable position, and counter-irritation and pressure applied, Scott's dressing and blisters are especially useful in this affection At a somewhat later stage Bier's hyperæmia may be helpful, or elastic pressure by a Martin's bandage, together with friction with stimulating liniments, or hot-air baths When effusion is marked and resists these methods of treatment, removal of the fluid by aspiration and subsequent compression may do good, but if the effusion reappears, the best procedure consists in opening the joint and washing it out with sterile saline solution

In the chronic fibroid form iodide of potassium may be useful in addition to the above-mentioned methods, but as a rule one has to rely on prolonged massage, radiant-heat baths, ionic medication, or spa treatment

Should enlarged villi be present and give rise to trouble, the joint should be opened, and if they are limited in their distribution they may be clipped away, or the synovial membrane from which they grow dissected out

Hydrarthrosis (**Hydrops Articuli**) is the term applied to any condition of a chronic nature in which the joint is much distended with fluid It may arise from at least five different affections (*a*) Chronic serous synovitis, (*b*) in osteo-arthritis, a very common cause, (*c*) in Charcot's disease, (*d*) in secondary syphilitic synovitis, and (*e*) occasionally in tuberculous disease It must be remembered that it is but a symptom, and not a disease *sui generis*, and treatment necessarily varies with the cause

Baker's Cysts.—This condition, first described by the late Mr Morrant Baker, consists in a hernial protrusion of the synovial membrane of a joint through an aperture in its fibrous capsule It is usually due to some chronic affection of the articulation, especially osteo-arthritis or tuberculous disease, whereby the intra-articular pressure is increased, and not uncommonly several such sacs are connected with the same joint They vary much in size, contain synovial fluid, and, though at first communicating with the joint cavity, have a tendency to travel away from it, burrowing along muscular and fascial planes, and coming, perhaps, to the surface at a distance from their origin, the aperture of communication with the joint having in some instances been shut off If causing no troublesome symptoms, there is no necessity to interfere, but if they become inconvenient or painful, it is best to dissect them out, closing where possible by ligature or suture the narrow neck which leads into the joint Of course, the strictest asepsis must be maintained in all such proceedings, and the causative affection must not be forgotten

Tuberculous Disease of Joints

Tuberculous Arthritis may commence either in the synovial membrane or in the articular end of the adjacent bone (tuberculous epiphysitis, p 655), or it may spread to the synovial membrane from the periosteum, as a result of a tuberculous periostitis, or from a neighbouring bursa In children the disease commences most frequently in the epiphyses, whilst in adults it may start either in membrane or bone with about equal frequency, but considerable variation occurs according to the particular joint affected

The **Causes** may be summed up as follows The individual is predisposed to the development of tuberculous disease, often as the result of an inherited tendency, the general health of the patient may also be at fault Some slight injury, of which but little notice is taken, may lead to the actual deposit of the *B tuberculosis*, which has been probably lying latent in the bronchial or mesenteric glands, or is present in an active state in the lungs Severe articular lesions, such as dislocations, are less likely to induce tuberculous disease, partly because their gravity demands efficient treatment, partly because the activity of the reparative process is capable of dealing with the organisms, even if they are brought to the spot

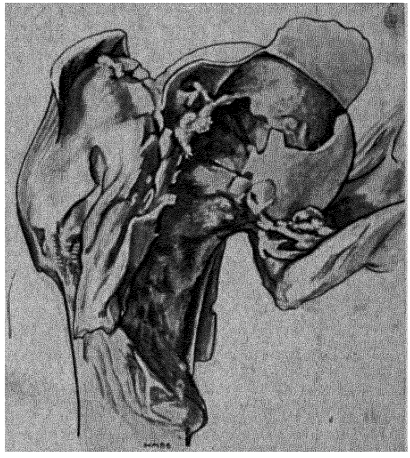


FIG 426 —TUBERCULOUS DISEASE OF HEAD AND NECK OF THE FEMUR

The disease evidently started on the under side of the neck which has been eroded, and spread into the head, the articular cartilage is loose and necrotic fragments of it have been stripped up off the bone

Pathological History — The *synovial membrane* becomes thickened, pulpy, and œdematous, and in the early stages is found to be studded with small gelatinous nodules about the size of a pin's head, situated immediately beneath the serous lining, later on, these may amalgamate into caseous masses, which burst and discharge into the joint, leaving ulcerated surfaces Occasionally these masses are of considerable size, more often they are only small Finally, the synovial membrane is changed into a so-called pyogenic membrane, consisting of granulation tissue similar to that lining the cavity of a chronic abscess, and more or less closely attached to the surrounding structures, which are transformed into œdematous fibro-cicatricial tissue, whilst the superficial parts undergo fatty or necrotic changes Fringes of the synovial membrane, swollen and succulent, spread over the

margins of the *articular cartilage*, and as they increase in size become adherent to it, just as, according to Billroth's classical description, ivy creeps along a wall On lifting the edges of these fringes, the underlying cartilage is found hollowed out and eroded As soon as the whole thickness is destroyed at any one spot, the cancellous tissue at the *end of the bone* becomes invaded by the tuberculous disease, giving rise to caries which is more or less extensive (Fig 427), and may be associated with necrosis The granulations spread along under the cartilage, cutting it off from its nutritive supply, and thus large flakes of necrosed cartilage may be shelled off (Fig 426) New formation of subperiosteal bone is unusual in tuberculous disease, but if pyococcal infection supervene, it may occur Occasionally, the periosteum itself is involved in the tuberculous process, and the disease may then extend some distance from the joint

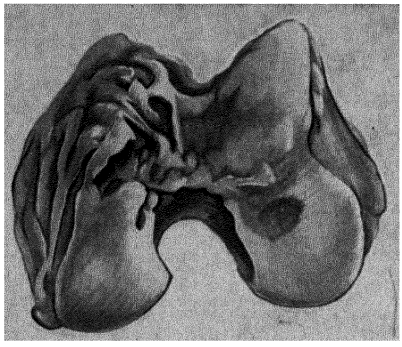


FIG 427.—TUBERCULOUS DISEASE OF THE LOWER END OF THE FEMUR

The cartilage is partly destroyed, and the exposed bone is carious and eroded

The joint itself usually contains but little fluid, being fully occupied by the swollen synovial membrane, but occasionally in the early stages there is much effusion, constituting a condition known as *tuberculous hydrops*, and in it there may be a considerable amount of fibrin, which is moulded by the movements of the joint into the so-called melon-seed bodies The chief cytological element in the effusion is the lymphocyte

The perisynovial tissues are frequently affected in these cases, especially where there is much loose fatty tissue, as around the knee The parts are infiltrated and gelatinous, and muscles and tendons are incorporated in the swelling and modified similarly in texture This change constitutes a large element in what is known as the *white swelling* of a joint

When the disease originates in the bone in adults, the tissue directly contiguous to the articular cartilage is often that primarily attacked, but in children it more frequently starts in connection with the epiphyseal cartilage The joint is usually infected by extension of the disease through the articular cartilage, but when the synovial membrane extends along the bone beyond the cartilage, as in the hip-joint, it may become involved without any cartilaginous lesion In the early stages a simple synovial effusion may occur, and should the osseous trouble quiet down and be cured, this may be absorbed, and merely a few adhesions be left Most commonly the infection is due to the gradual erosion of the cartilage towards its periphery, and the onset of the articular symptoms is then of a chronic type Sometimes, however, a tuberculous abscess of the bone or surrounding

parts bursts into a joint, acute symptoms supervene, but gradually quiet down, and the usual chronic phenomena subsequently develop

Clinical History.—The disease usually commences in a most insidious manner It may be dated back to some injury, but as often as not no such occurrence has been noted Slight impairment of movement, together with some pain, especially when the limb is jarred or twisted, is perhaps the first sign, causing the patient to limp if one of the lower extremities is involved This limitation of movement is usually manifested in *all* directions, and this will often assist in diagnosing it from the fixity due to the presence of adhesions in a simple chronic synovitis The amount of rigidity varies much, in a purely synovial lesion the movements may at first be painless and but little impaired, although the whole region of the joint may be puffy and swollen, when, however, the bone is affected, either primarily or secondarily, the limitation of movement is considerably increased The position of the limb is that which will give the greatest amount of comfort, and varies in different joints (*q v*) and at different stages of the disease On inspection a superficial joint, like the knee, looks white, smooth, and rounded (constituting the 'white swelling,' or tumor albus of the older textbooks), the swelling being more apparent on account of the wasting of adjacent muscles On palpation, the part is found to be slightly hotter than that on the opposite side of the body, whilst fluctuation is not readily detected, there being but little fluid in the joint, though the affected tissues are elastic and puffy In a few cases, where the synovial membrane is widely involved, the affection commences with considerable serous exudation, giving rise to the condition known as *tuberculous hydrops*, after persisting for a while, the usual manifestations of the disease show themselves If fibrinous melon-seeds are present, a soft crepitus may be felt on moving the joint

From time to time exacerbations of pain and increase of swelling occur, which subside after resting for a few days, but leave the joint more and more crippled Starting pains at night develop when the cartilages are becoming eroded, together with slight fever and malaise. Sooner or later an abscess forms, with increased local and general disturbance, when it bursts or is opened, temporary relief is experienced, but fresh abscesses are liable to form If pyogenic infection supervenes, the patient develops a hectic temperature, amyloid degeneration of the viscera may follow, the limb becomes more and more deformed, and finally the patient, exhausted partly by the discharge, partly by the pain, and partly by want of sleep, becomes emaciated, and may even die unless prompt measures are taken for his relief

Results —Where efficient treatment is instituted before there is any X-ray evidence of bony involvement, a good result with very little impairment of mobility is the usual outcome But where the articular cartilage is eroded, much limitation of movement with the formation of adhesions must be expected Sometimes tuberculous foci are encapsuled in this fibrous tissue, and may cause further pain and trouble from time to time, so that many authorities consider that these cases are often better treated by endeavouring to establish bony ankylosis by operative interference If the condition progresses

to suppuration and pyococci are admitted, the disease is aggravated, and unless effective drainage is provided, the bone ends become carious, sinuses form, discharging a varying quantity of pus, and the patient may be exhausted by toxæmia or amyloid disease Where such dangers are escaped and yet the disease progresses uncured, the limb becomes more and more crippled, and the patient lives more or less an invalid life, with sinuses which dry up or discharge at times, and are a constant source of danger and annoyance Finally, acute miliary tuberculosis may supervene as a complication at any time, or a tuberculous affection of the lungs, brain, kidney, or other viscera, and may prove fatal

The **Diagnosis** is by no means easy in all cases, although sometimes it is tolerably obvious One can never insist too often on the importance of comparing the diseased joint with the healthy whenever possible, observing the differences in contour, colour, temperature, and mobility The history of the case must be carefully noted, the amount and character of the effusion, and whether or not lymphocytes predominate in a cytological examination, the amount of movement must be ascertained, and whether the limitations are general or particular Radiography may help, and especially in distinguishing purely osseous conditions, *e g* sarcoma of the end of the bone Aspiration of the fluid from a joint and injection of this into guinea-pigs, or even the removal of a portion of the synovial membrane by an open operation followed by microscopical examination of this tissue, may be required to aid the diagnosis

The **Prognosis** is mainly dependent on the stage when the condition is recognized, and on the possibility of securing suitable treatment School clinics have done much to ensure the early recognition of this condition in children of school age, and the provision of sanatoria, etc , by public authorities is good, as far as it goes But there is abundant call for more beds for these cases, and also for some provision to ensure the medical oversight of children under school age The results of modern treatment are usually good, and, indeed, the complaints of hospital surgeons that they can obtain no material of this type to teach from is most satisfactory Of course, slum children and those of poor physique generally or with a grave tuberculous inheritance are liable not to benefit as do others The extremes of life also are unfavourable, babies resist tuberculous invasion badly, whilst patients over fifty years of age have sometimes comparatively little recuperative power

The **Treatment** of tuberculous joints is conducted along lines similar to those employed for other tuberculous foci

1 *General* treatment of the sanatorium type (p 175), or its equivalent, must be instituted as early as possible after a diagnosis is reached, and should be maintained at least until the active stage of the disease has terminated, but for preference until the condition is presumably cured

2 During this period *local* treatment must be maintained with the twofold end in view, not only of curing the disease, but also of leaving the limb subsequently in as good a functional condition as regards

position and movement as possible In the early stages absolute rest is essential, and must be secured by splints, plaster of Paris, etc , if there is much pain, and particularly if of the starting type, extension must be applied—just enough to keep the tender ends of the bones from pressing one against the other Extension is also applied in these cases, especially as regards the hip-joint, where owing to a trivial or even no bony involvement an endeavour is going to be made to establish a fully mobile joint and not an ankylosed one Undue weight may cause stretching of the ligaments and subsequent laxity of the joint Rest must include not only freedom from mobility, but also the absence of pressure, and therefore for all joints of the lower extremity the patient must be put to bed It is obvious that bed is also indicated for affections of the upper limb in the more active stages As the condition improves, the patient is allowed to get up, but the same restrictions as regards rest must be maintained to the end of the chapter

Inasmuch as there is always a likelihood of the development of ankylosis, the position in which the limb is placed is of great importance (see on p 721) If the position of the limb is already bad when first seen, endeavours to correct it must be instituted at once, and for this purpose weight extension must be relied on At first it is made in the direction of the displaced limb, and with only just sufficient energy to keep the articular surfaces at rest, gradually the tonic muscular contraction will disappear, and the malposition with it. At other times a little assistance is required in the direction of pressure applied locally to help a displaced bone into position Tenotomy may occasionally be needed, but any form of apparatus which depends on a screw mechanism is undesirable, as it increases intra-articular tension The sudden application of force under an anæsthetic is totally inadmissible, as thereby tuberculous material may be disseminated through the system Scott's dressing is sometimes useful locally for the more superficial joints, and Bier's hyperæmia may occasionally be employed

3 *Abscesses* should be dealt with sufficiently early and in such a manner as to obviate the need for drainage To this end they ought never to be left until the skin and subcutaneous tissues are involved, but as soon as a collection can be detected, it should be aspirated, or, if need be, irrigated

Of course, when the skin is thin and reddened, and the pus subcutaneous, the abscess must be incised and drained in the usual manner, any thin and undermined skin being snipped away

4 Effective sanatorium treatment and prolonged immobilization in a correct attitude have greatly destroyed the *operative treatment* of tuberculous joints, and therefore the following section may appear a little out of date, its retention is justified by the fact that the ' ideal ' is not always attainable, and surgeons have sometimes to practise the ' best possible '

A simple *arthrotomy* is sometimes useful The joint is incised and washed out thoroughly Disintegrated and loosened cartilages are removed, tuberculous débris is cleared away, the joint cavity is dried

out with alcohol and ether, and the exposed surfaces are then 'bipped' The cavity is closed, and the limb placed in a suitable position and immobilized Ankylosis will probably result

Arthrectomy, or erasion, consists in dissecting away all the diseased tissues that can be reached through a free incision The synovial membrane is cut away, diseased foci of bone are gouged out, and the resulting cavities disinfected by alcohol and 'bipped' Ankylosis is the usual result It is obvious that this proceeding is not equally applicable to all joints Thus, in the hip the opening is usually made from the front, and unless there is great laxity of the capsule and some increase in size of the acetabulum, the back and upper part of the joint cannot be reached The knee, ankle, and elbow are the most favourable situations for this operation The chief advantages are that it interferes neither with the immediate length nor with the subsequent growth, whilst there are no extensive sections of healthy bone exposed to infection

Excision is a more radical measure, but has the disadvantage of removing healthy as well as diseased tissues, whilst the fact that it encroaches on the epiphyseal structures renders it undesirable in children The chief conditions for which it is now employed in tuberculous disease are (*a*) For complete disorganization of the joint (*b*) to prevent ankylosis in certain joints, such as the elbow and temporo-maxillary, (*c*) to determine a rapid and radical cure with synostosis in such a joint as the knee, as soon as it is evident that the natural result of the disease must be an ankylosed limb Surgical art often produces a more efficient cure than Nature under these circumstances, since all foci can be removed A natural cure often leaves encapsuled many tuberculous foci, and these may subsequently cause pain and lead to recurrent attacks of inflammation (*d*) Deformity with or without ankylosis may justify excision

Amputation is required in cases which, in spite of every care, are steadily going from bad to worse, and where the patient's health and strength are being sapped by the disease It is needed not unfrequently in old people, and is indicated in patients where excision has been undertaken and failed, either from the limb becoming subsequently flail-like or useless, or from recurrence owing to incomplete eradication, or from the advent of pyogenic infection Lastly, if the disease is present in two joints at one time, or in a joint and some other organ, neither of which is improving, total removal of one focus of mischief will often induce a rapidly favourable change in the other

The choice of operation in any particular case is dependent on a variety of factors which must be taken into consideration (1) The *age* of the patient Typical excisions encroach on the growing ends of bones and render them undesirable in children, for even if growth is not stopped thereby, it may be rendered irregular and cause subsequent deformity As regards advanced age, the shoulder and knee may be excised satisfactorily later than the elbow, wrist, and ankle Probably forty to forty-five years would be looked on as the age limit for the latter, but excellent results have been obtained from excising the knee and shoulder at a much later period of life

(ii) The *general health and vitality* of the individual must be fairly good if either erasion or excision is to be undertaken In weakly individuals, if conservatism has failed, amputation is usually the better practice (iii) The *extent* of the bone mischief If this is slight, erasion may be undertaken, if more extensive, excision, but if the bone trouble is considerable, so that the removal of the diseased tissue would leave a flail-like, useless limb, then amputation is required (iv) Extensive invasion of the soft tissues may also render impracticable all treatment except amputation (v) No conservative operations are justifiable in any case where acute or subacute pyococcal suppuration exists, or where pus is retained under pressure, as indicated by discharging sinuses and constitutional reaction Free incisions to relieve all tension are first required, and subsequently more radical operative treatment may be considered Recently, with regard to tuberculous disease of the hip-joint, some form of arthrodesis following prolonged conservative treatment is being performed more frequently, as the incidence of recurrent disease is thereby greatly reduced

Tuberculous Disease of Special Joints

The **Shoulder-joint** is but rarely affected in children, and not very commonly in adults The disease usually starts in the head of the humerus, affecting subsequently the synovial membrane, and perhaps also the glenoid cavity Not unfrequently it results in ankylosis without suppuration (caries sicca) Effusion with the formation of melon-seed bodies is sometimes observed If abscesses develop, they are likely to point either in front of or behind the deltoid, in the former case extending along the synovial membrane lining the bicipital groove The ultimate result is usually ankylosis, with perhaps considerable shortening of the arm, or some forward displacement of the upper end of the bone simulating a subcoracoid dislocation The case is often slow in progress, though persistent, and may be very painful **Treatment** consists in fixing the arm in the position of rest (p 723), *i e* abducted to an angle of 70 degrees, and with the hand and forearm directed forwards When there is much effusion, the joint may be tapped and washed

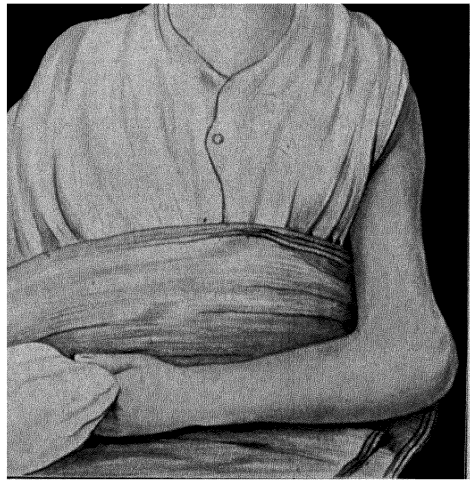


FIG 428 —TUBERCULOUS DISEASE OF THE LEFT ELBOW-JOINT

out by introducing a trocar just external to the coracoid process or below the acromion For extensive bone trouble (shown radiographically), or if the disease does not improve, excision must be undertaken, and the result is often satisfactory

In the **Elbow** (Fig 428) the disease is most common in young adults, commencing usually in the synovial membrane, especially that of the superior radio-ulnar articulation The swollen synovial membrane bulges on either side of the olecranon and tendon of the biceps, and can often be felt over the head of the radius, and the joint presents the typical appearance of a 'white swelling' Abscesses form by the side of the olecranon, or may burrow upwards along the ulnar nerve and open the inner aspect of the arm **Treatment** — Prolonged immobilization in the position of rest (p 723) with suitable hygienic measures should be adopted in the first instance A poroplastic or internal angular splint reaching from the axilla to the wrist may be sufficient, but plaster of Paris is better If, in spite of such treatment, the case progresses, the joint should be opened in children, diseased tissues cut or scraped away, and the surfaces 'bipped' Ankylosis will almost certainly follow, but no attempt to relieve it by excision should be made, or the growth of the limb will be impaired In young adults arthrectomy or excision may be undertaken with advantage in suitable cases The former is, perhaps, best effected by means of an H-shaped incision over the olecranon, which is divided at its base and turned up, so as to expose thoroughly the interior of the joint After removing all diseased tissue, the olecranon is sutured back in place Excision is often the better practice, especially in adults, as the more extensive removal of bony tissue improves the prospects of gaining a useful movable arm

In the **Wrist** diffuse disease of the synovial membrane and bones is met with, starting most frequently from the former structure If primarily osseous, it usually commences in the lower end of the radius It may also extend from a tuberculous affection of the adjacent tendon sheaths A characteristic doughy swelling forms over the dorsum, displacing the extensor tendons, whilst the palmar aspect of the wrist is also puffy, and the hand itself is slightly flexed, and the movements of the fingers are impaired by adhesions Sinuses develop most frequently on the dorsal aspect or by the side of the flexor carpi radialis tendon Conservative treatment, with the wrist dorsiflexed, may bring about a cure, and every effort should be made to avoid radical operative treatment Arthrotomy is sometimes useful The joint is laid open on the ulnar side by an incision which extends between the extensor and flexor carpi ulnaris tendons Diseased carpal bones and other evidences of the disease are removed After effecting hæmostasis, the cavity is disinfected with ether, 'bipped,' and packed with gauze, which is removed in a week or ten days, healing by granulation usually proceeds satisfactorily Sinuses in other positions are merely scraped or excised, and left to heal Excellent results follow this line of treatment if the hand is kept dorsiflexed, and the fingers and thumb are moved from the first In elderly people amputation is often the only resource

of the **Hip-joint** and of the **Sacro-iliac Articulation** are separately considered (pp 769 and 781)

The **Knee-joint** is, perhaps, more often affected with tuberculous disease than any other articulation It appears to start in the synovial membrane or bone with almost equal frequency, if the bones are first attacked, the primary focus is usually situated on the inner aspect of either the femur or the tibia Sequestra are found in nearly one-half of the cases in which the bone is involved, becoming more frequent as the age advances The disease runs a typical course, and needs no special comment When the joint has become disorganized, the tibia is liable to be displaced horizontally backwards, flexed, and externally rotated, and ankylosis in this position is difficult to remedy, even by operation (Fig 429)

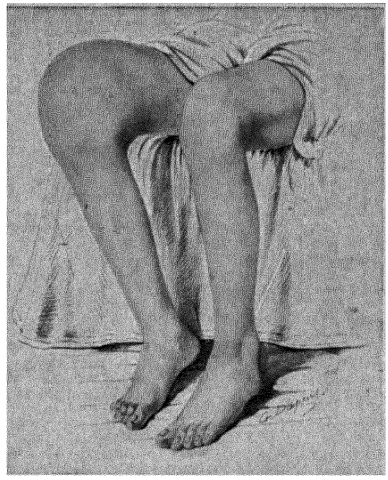


Fig 429 —Tuberculous Disease of the Knee in an Advanced State

The knee is flexed and backward displacement of the tibia is commencing the smooth swollen condition of the joint is very characteristic

Treatment —In the more active stages, where the joint is painful and perhaps deformity present, the patient must be kept in bed, and extension applied by means of a suspended Thomas's splint, bent at first to correspond to the degree of flexion As muscular spasm disappears, the limb and splint can be straightened If the head of the tibia is displaced backwards, it is advisable to incorporate two special bands of flannel attached to the side-bars of the splint, one passes in front of the limb just above the knee, and the other behind just below Suitable tightening of these bands tends to lift the head of the tibia into place, of course, effective extension is maintained at the same time In the later and more chronic stages, immobilization in plaster of Paris which includes the pelvis and the foot is carried out for a period of about a year This is then removed and the patient allowed to get up when he has been fitted with a caliper For the first six months it is best not to allow any weight bearing but to fit a patten on the boot of the sound leg and allow the patient to get about with crutches The walking-caliper is utilized for about two years Abscesses are, of course, dealt with in the usual way

If in spite of such measures symptoms persist and the case is progressive, a modified arthrectomy may be undertaken in children through an incision made across the front of the joint from condyle to condyle, dividing either the ligamentum patellæ or perhaps the patella, which is subsequently sutured together The synovial membrane is dissected away, special attention being directed to the sub-

crural pouch and the back of the joint A thin slice should be removed from the surfaces of both tibia and femur, and if the epiphyseal cartilages are not encroached upon the growth of the limb is not impaired to any great extent, although it may become irregular and lead to some deformity, *e g* well-marked flexion, or genu recurvatum

In adults, where the bones are not too extensively involved, so that on section broad healthy surfaces can be apposed, excision is a most satisfactory operation, provided, of course, that the synovial disease is also removed As soon as it becomes evident that the only possible natural cure is by ankylosis—and this evidence would be given by fixation of the patella to the femur, or by severe starting pains at night—excision is both justifiable and advisable It cuts short the disease, minimizes the risk of general dissemination, and provides a quicker and more radical cure than Nature can possibly effect Incomplete removal of the disease, either in the synovial membrane or bone, may determine recurrence, if this cannot be dealt with effectively, amputation may be required, and then a long posterior flap is the only healthy tissue available for covering the bone Under other circumstances the ordinary supracondyloid amputation can be adopted

The Ankle-joint —Tuberculous disease of this joint usually commences in the synovial membrane rather than in the bone The whole region becomes occupied by a pulpy swelling, which first pushes forwards the extensor tendons and bulges in front of the malleoli and subsequently appears on either side of the tendo Achillis Pain is often slight, and the movements of the ankle may be but little impaired, the calf muscles are usually wasted In the later stages, when the bones are involved, the pain increases, and the foot is maintained in a position of slight plantar flexion, so as to bring the narrower portion of the upper surface of the astragalus into the tibio-fibular mortice Flexion and extension of the foot are usually limited or lost, but with care the lateral movements (inversion and eversion) which occur at the mid-tarsal and sub-astragaloid joints can be undertaken without pain If the disease is primarily osseous, localized painful areas occur over the lower ends of the tibia or fibula, or over the astragalus, and the osseous lesions can be demonstrated by radiography In either type of case abscess formation is very liable to follow, and may become extensive owing to the implication of tendon sheaths **Treatment** —In the early stages prolonged rest and immobilization in plaster of Paris followed by the use of a short walking-iron are required Operative treatment is never very satisfactory Arthrectomy can be undertaken, but removal of the astragalus and of all available synovial membrane is probably a better course to adopt When, however, the astragalus is involved, it is often difficult to eradicate the disease, which has probably spread to the articulations and bones beneath it, and amputation may then be required Where the disease also involves the tibia and fibula, a supramalleolar amputation of the foot will probably be necessary

For diseases of the **Bones and Joints of the Foot,** see p 656

Syphilitic Diseases of Joints.

Although syphilitic disease of joints is rare in proportion to the prevalence of syphilis, yet several varieties have been differentiated and recognized (1) In the later stage of the secondary period a *chronic* form of *synovitis* occurs, evidenced by passive effusion into the joint, with or without pain, and usually persisting for some time Any joint may be attacked in this way, perhaps the knee most commonly, and the affection is often symmetrical in its distribution The effusion may be only slight, but is frequently very considerable (hydrarthrosis), and a marked feature in the condition consists in the rapid variations in the amount of swelling, even from day to day In some few cases this affection resists all treatment, and leads to ultimate disorganization (2) *Gummatous* inflammation of the *peri-synovial* fibrous tissue, which may or may not extend to the adjacent bone, is met with in the tertiary period It either appears as a localized hard nodule, resembling in measure a fibrous tumour, and then causing but little trouble beyond a sense of painful weakness in the articulation, or it is more diffuse in its distribution, leading to a moderate effusion, and later on to much thickening and infiltration of the capsular and other ligaments, and resulting in considerable impairment of its movements from cicatricial contraction Some of these gummatous nodules may break down and ulcerate (3) A diffuse *gummatous infiltration of the synovial membrane* itself is also seen, usually in children It closely simulates a tuberculous synovitis, from which it is often impossible to distinguish it locally, except by the rapid onset, the absence of pain, the greater amount of effusion, and the symmetry which is sometimes present It may occur apart from other evidences of congenital syphilis, but the Wassermann reaction will be helpful (4) A *chondro-arthritis*, described originally by Virchow, is the syphilitic analogue of osteo-arthritis It commences by fibrillation of the matrix of the cartilage, and proliferation of the cells The cartilage softens, and becomes eroded by friction of the articular surfaces The bone thus exposed is worn away, and curiously 'pitted' or excavated It is distinguished from osteo-arthritis by the facts that there is usually but little or no pain, that the eburnation of the exposed bone is less extensive, and therefore crepitus is but little marked, whilst the typical osteophytic outgrowths and 'lipping' of the joint margins are absent The eroded areas, moreover, do not correspond with the sites of intra-articular pressure, and are more rounded and punched out, and not arranged in linear grooves, as in the latter disease It is not uncommonly associated with a gummatous thickening of the synovial membrane, and, indeed, the hollows or pits above mentioned may be filled with caseous material derived from degeneration of this tissue

The **Treatment** in the early manifestation consists in the administration of mercury or salvarsan, and the judicious application of pressure with or without immobilization, according to the requirements of the case and the joint affected In the tertiary forms iodide of potassium in gradually increasing doses has a rapidly beneficial

action, which confirms the diagnosis, it may be occasionally combined with a small amount of mercury, either given internally or applied locally if any ulcerative lesion exists In the most pronounced cases, where the pain is severe and disorganization of the joint has occurred, excision may be necessary, and the results are often very satisfactory

Rheumatoid Arthritis and Osteo-Arthritis

Rheumatoid Arthritis is polyarticular in nature and is most commonly found in young adult females in contradistinction to Osteo-Arthritis, which often affects only one joint and is most common in elderly men

Rheumatoid Arthritis—The ætiology of this condition is obscure, although several factors are associated with the disease The patients affected are usually of a nervous disposition, and by some this has been regarded as the chief ætiological cause, in that disturbances in the normality of the joint may be occasioned by vascular spasticity dependent on the abnormal mental state An attempt has been made by others to identify some focus of infection such as an infected air sinus, a chronic appendix or gall-bladder, an apical tooth abscess or the like, and to attribute the arthritis to toxins circulating from these foci By some intestinal stasis or abnormal flora in the bowel are believed to be productive of the disease in a similar way

There is evidence to support these infective theories because organisms, sometimes a diplococcus, sometimes a streptococcus or staphylococcus, have been isolated from the regional lymphatic glands in cases of the disease, and on some occasions from the affected joints themselves

Pathology.—There is an infiltration of the synovial membrane with round cells, with the subsequent formation of delicate granulation tissue which grows over and underneath the articular cartilage as a delicate pannus Associated with this is a rarefaction of the bone just below the cartilage, which later becomes pulled off in small flakes The joint space is reduced and ankylosis either by fibrous or bony tissue is the end result, usually associated with considerable deformities There is often some slight effusion into the joint The joints most commonly affected are the smaller ones, but any one may be affected by the disease

The onset of the disease is generally gradual, but may be acute, the patient, who is usually pale and anæmic with evidences of neuro-vascular disturbances exemplified by clammy and cold hands, first noticing pain, stiffness, and limitation of movement confined at the start to one, but usually spreading to other joints Increasing flexion deformity occurs, muscular wasting ensues, and finally ankylosis cripples the patient On examination the affected joints are seen to be swollen, a swelling that is emphasized by the muscular wasting present The skin is shiny, bluish, and atrophic, and where the hands are affected the nails become brittle and furrowed (Fig 430)

Treatment of these cases is difficult and disappointing, and the disease may sometimes progress in spite of it Firstly the patient must be treated with a good environment, with a well-balanced diet A

search must be made for any source of sepsis, which, if found, must be removed An endeavour must be made to splint the affected joint in such a way that, should ankylosis occur, it will do so in the most beneficial position Sometimes where contracture is present when the case is seen this may be overcome with extension along a line which is gradually approximated to that of the optimum position Once each day the splint is removed so that the joints can be passively mobilized through the range of movement, because prolonged immobilization rapidly diminishes this Treatment with radiant heat, diathermy, and contrast baths should also be employed Internal medication seems of little value, although intestinal antiseptics such as salol, gr v t d s , or cyllin, ℥ij t d s , sometimes produce improvement Intravenous injections of ortho-iodoxy benzoic acid are worth a trial Intramuscular injections with gold salts hold out the best hope of improvement Injections are given at weekly intervals, starting with 0 02 gram and increasing gradually up to 0 2 gram

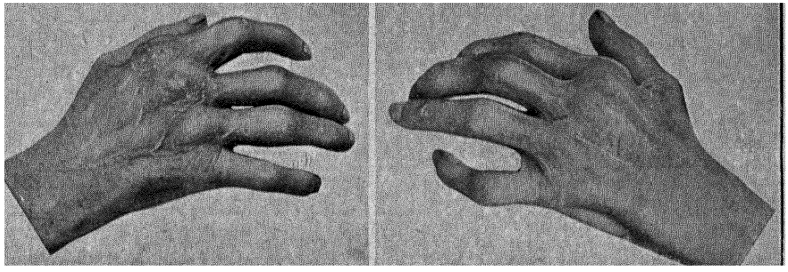


FIG 430 —HANDS OF PATIENT WITH CHRONIC RHEUMATOID ARTHRITIS SHOWING NODULAR CONDITION OF THE JOINTS AND MARKED FLEXION AND ULNAR ADDUCTION

the total amount injected during a course being 2 grams The employment of this drug is not without danger, and such complications as toxic rashes, albuminuria, jaundice, and purpura occur

Vaccine treatment has been tried, but without good results

As regards the operative treatment of this disease some advocate sympathectomy with remarkable successes Excision of the joints with subsequent ankylosis in a good position must in some cases be contemplated, and occasionally, where bony involvement is minimal, synovectomy is valuable In cases where ankylosis has occurred in a bad position osteotomy must be employed

Still's Disease is a form of rheumatoid arthritis affecting children Girls are more often attacked than boys, many joints are implicated, and neighbouring lymphatic glands are enlarged The cartilage is but little altered, and bony outgrowths are absent The spleen is also enlarged, and there may be pericardial and pleural adhesions

Osteo-Arthritis is a disease primarily affecting articular cartilage The changes in the cartilage consist in a breaking up of the matrix

into fibres, the so-called 'fibrillation,' so that the surface becomes rough like the pile on carpet or velvet (Fig 431) Meanwhile the cartilage cells are arranged in longitudinal rows between the fibrillæ and proliferate within their capsules, which become distended and burst into the joint The cartilage thus softened is readily worn away by the movements of the articulation, and the surface of the bone is exposed Concurrently with this destruction, hyperplasia is taking place at the margins of the articular cartilage, resulting in the production of irregular overgrowths (*ecchondroses*), which have been likened to the gutterings of a candle In them ossification occurs secondarily, and when such overgrowths have been produced more or less evenly around the joint margin, a characteristic lipping of the edge of the

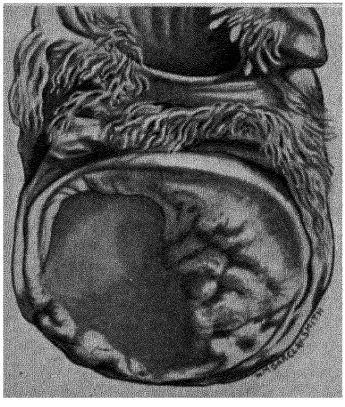


FIG 431 — PATELLA FROM EARLY CASE OF OSTEO-ARTHRITIS SHOWING FIBRILLATION OF CARTILAGE

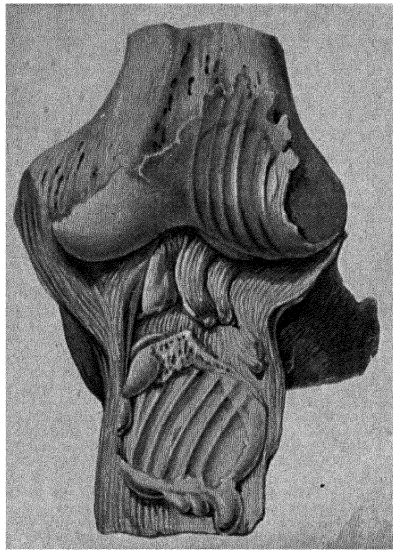


FIG 432 —LATE STAGE OF OSTEO-ARTHRITIS OF KNEE, SHOWING DESTRUCTION AND LIPPING OF THE ARTICULAR CARTILAGE, AND EBURNATION OF THE EXPOSED BONE IN LONGITUDINAL GROOVES (FROM COLLEGE OF SURGEONS MUSEUM)

articular surface results (Figs 431 and 432) Sometimes these osteophytes attain considerable dimensions, and by interlocking may lead to ankylosis of the joint

The bone exposed by the destruction of the articular cartilage is altered as the result of the movements of the joint The chronic irritation causes it to become hard, sclerosed, and polished like ivory (*eburnation*) This usually occurs in certain definite directions, in hinge-joints the surfaces become grooved longitudinally, whereas in ball and-socket joints like the hip the head is eburnated in a circular manner This condensed tissue does not extend very deeply, and immediately beneath it the bone is of a more open texture than usual and

filled with fatty medulla In spite of the sclerosis the articular end of the bone is being constantly worn away, and this may progress to such an extent as to lead to actual shortening of the limb

Associated with these changes is a thickening of the capsule of the joint and a proliferation of the synovial membrane with the formation of villi which project into the joint and may become cartilaginous or even undergo ossification These proliferations may break off and give rise to one form of foreign body

The disease most commonly affects the large joints, but may also affect the smaller ones, notably those of the fingers The age incidence is considerably higher than in rheumatoid arthritis There seems no doubt that in this disease as well the presence of a septic focus may aggravate or even give rise to the condition But a further important ætiological factor is that of trauma to the joint This may take the form of some previous fracture which has involved the joint, or the unnatural trauma excited on the joint surfaces where a fracture has been inadequately reduced This is commonly seen, for example, in a badly reduced Pott's fracture so commonly followed by pain due to osteo-arthritis of the ankle-joint Injury to the articular surfaces by disease such as occurs in the hip-joint in Perthes' disease, slipped epiphysis, or congenital dislocation are all followed by arthritis

The normal wear and tear that joints undergo, especially in those who have led hard lives, predispose to the condition, and it is for this reason that it is more commonly seen in male subjects

The patient first notices increasing pain in the affected joint This is associated with stiffness and limitation of movement At first these symptoms are most marked following a period of rest, and are relieved by movement of the joint, but later the pain tends to become constant Some will notice that one particular movement will initiate pain which tends to pass off fairly rapidly, and it is in these cases that most relief is obtained by manipulation Deformities gradually make themselves evident—the hip-joint, for example, becomes flexed and adducted—and these rapidly confine the patient's activities The hands develop the typical gnarled appearance when they are affected, and flexion of the interphalangeal and metacarpo-phalangeal joints with ulnar deviation of the wrist-joint occurs

The **Treatment** of this condition must firstly be the elimination of any septic foci of which the teeth are so often the prime offenders General treatment such as radiant heat can be employed, but gives only passing relief Deep X-ray therapy seems to offer considerable benefit after a preliminary intensification of the symptoms

Injections of colloidal preparations of sulphur intravenously or intramuscularly may be of value, and in certain joints such as the shoulder-joint the injection into the joint of an iodine-containing substance, Immetal, which acts as an artificial lubricant and is retained in the joint for many months, can be tried

Various operative procedures have been employed in an endeavour to relieve the pain and deformities of this condition, and have most widely been employed in the hip-joint, where the disease is most common and most marked

Osteo-Arthritis of the Hip-Joint—The onset in this joint is accompanied by pain and limitation of movement with increasing flexion and adduction deformity At first this is corrected by compensatory lordosis and tilting of the pelvis If both sides are affected, or in severe cases of the complaint, the deformity may be such as to prevent walking and to confine the patient to his bed

In addition to the pain in the hip there develops associated pain in the sacro-iliac joints as a result of the abnormal stresses to which these are subjected on account of the tilting of the pelvis X-ray examination shows the formation of osteophytic outgrowths not only about the femoral head but also around the acetabulum, which appears deepened At a later stage the head becomes *mushroomed*, and there



FIG 433 – OSTEO-ARTHRITIS OF THE HIP

A normal femur in section has been placed alongside of the affected one for comparison, the absorption of the neck and the relative elevation of the trochanter are obvious as also the distortion of the head of the bone

is absorption of the femoral neck followed by sclerosis, so that it becomes broadened and shortened (Fig 433) with a true shortening of the leg

Treatment—The points indicated above must be attended to, but relief is seldom very marked In those cases where one particular movement is associated with pain relief is often obtained by manipulating the hip under deep anæsthesia, putting the joint through a complete range of its movements, with especial reference to that which is limited and causes pain The relief may often last a year or so, at the end of which time further manipulation can be employed With the advance of the disease, however, the benefit of successive manipulation becomes increasingly less

In persons unfit for operation relief is afforded by supporting them with a walking-caliper, this serving to relieve the joint of weight-bearing In others immobilization by means of a plaster spica for two or three months is of value.

As regards true operative procedures a number have been employed by different authorities The simplest consists of opening the joint and removing the osteophytic outgrowths—a procedure known as *cheilotomy* Benefit, however, is short-lived, as further outgrowths develop and the diseased bone ends are still in contact with each

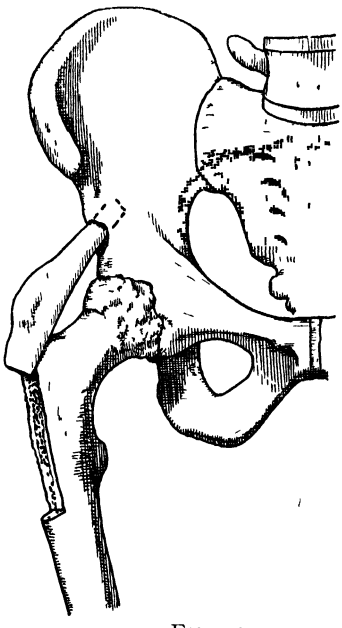


FIG 434

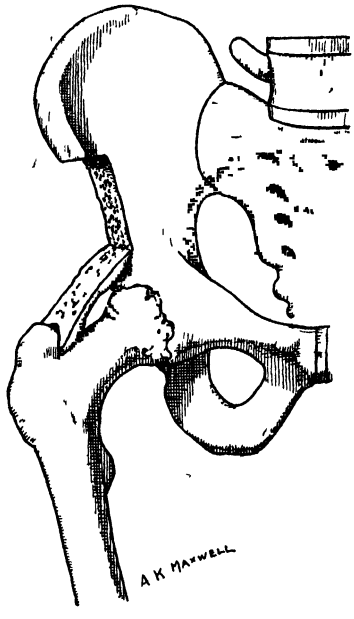


FIG 435

FIGS 434 AND 435 —TWO METHODS OF PERFORMING EXTRA-ARTICULAR ARTHRODESIS FOR PAINFUL HIPS

In one (Fig 434) a graft is taken from the upper end of the femur, and in the other (Fig 435) the graft is fashioned from the ileum

other and will give rise to pain Probably the best results are obtained by some form of arthrodesis, a procedure carried out in which an endeavour is made to obtain bony union between the articular surfaces in an optimum position with a resulting fixed and painless joint This may be achieved in various ways The joint is exposed by a Smith-Petersen incision, which incises the skin along the anterior aspect of the iliac crest and is carried down along the antero-lateral aspect of the thigh The tensor fascia femoris and the gluteal muscles are stripped from their insertions and the sartorius retracted medially The heads of the rectus femoralis are then separated from their origins

and the capsule of the joint incised An endeavour is then made to remove enough of the cartilage from the antero-superior aspect of the head of the femur and the corresponding segment of the articular surface of the acetabulum so that when the limb is placed in abduction to about 30 degrees slight flexion and the mid-position between internal and external rotation the bared bony surfaces are in contact The limb is fixed in this position by plaster, incorporating the whole of the chest from just below the axilla and the whole of the affected

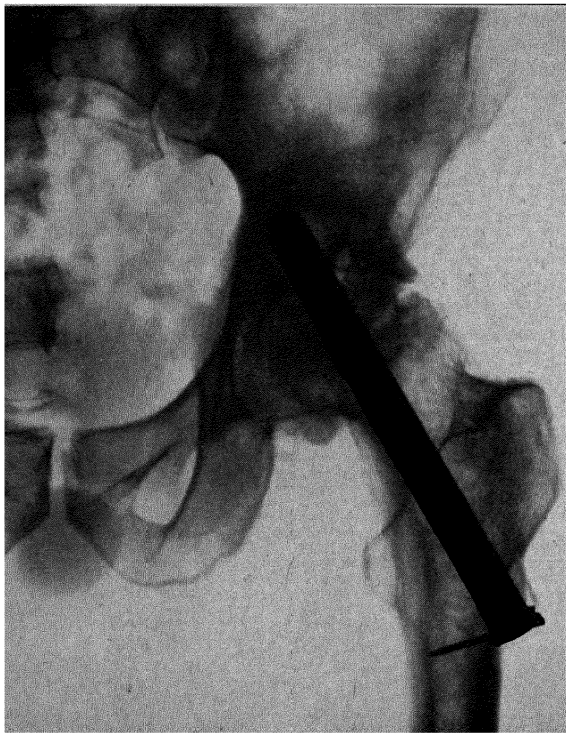


FIG 436—EXTRA-ARTICULAR ARTHRODESIS OF THE HIP-JOINT BY A HEAVY GAUGE THREE-FLANGED NAIL AND CROSS PIN (Watson Jones)

leg, a window being cut out of the abdominal portion of this cast, which is maintained for some three months

Bony ankylosis in the hip-joint is notoriously difficult to secure, and the chances of it occurring may be improved by adding an extra to this intra-articular arthrodesis A bone graft is fixed between the supra-acetabular region and the great trochanter (Figs 434 and 435) This bone graft may be removed from the tibia, the upper end of the femur, or may consist of a flap of bone turned down from above the acetabulum and fixed by a peg under the great trochanter

Recently a Smith-Petersen pin has been employed to produce arthrodesis, the pin being driven in through the neck and head of the femur into the upper bony buttress above the acetabulum (Fig 436). Various forms of arthroplasty have been employed, and where both hip-joints are affected, even if one is fixed operatively, a mobile joint must be secured in the other in order to enable the patient to get about The simplest of these procedures is to expose the hip-joint, dislocate the head, refashion it with a file, and enclose it with a thick pad of fascia lata The acetabulum is similarly treated Extension is then employed in abduction for two or three weeks and the patient encouraged to get about The operation is accompanied by considerable shock on account of the dislocation of the femur, and is not attended by good results Excision of the head and refashioning the neck is probably a better operation, and may be further modified with benefit by the removal of the great trochanter with its muscular attachments and the fixing of this to the shaft of the femur lower down

A valuable operation in those patients who are unfit to stand more than a minimal operation is subtrochanteric osteotomy The bone is divided below the lesser trochanter and the lower end displaced inwards so that it impinges just below the acetabular margin The limb is placed in plaster for three months, and during this time bony union will occur between the divided fragments and a buttress of bone form below the acetabulum which will serve to transmit a considerable proportion of the body weight, thus short-circuiting the hip-joint

When the *temporo-maxillary joint* is affected, the condyle of the jaw becomes larger than usual and somewhat flattened, the eminentia articularis is partially absorbed and the glenoid cavity increased in size, so that the condyle is liable to slip forwards, owing to the action of the external pterygoid muscles If only one joint is affected the bone is carried towards the sound side, but when both are involved the chin becomes prominent owing to a forward displacement of the whole bone Pain and crepitus are experienced on opening the mouth, rendering mastication difficult, and even impracticable If ordinary treatment fails to give relief, the affected condyle of the jaw should be excised

Neuropathic Arthritis (*Syn* **Charcot's Disease**).

This disease, bearing the name of the late Professor Charcot, is a peculiar affection of joints met with in the course of locomotor ataxy It is slightly more common in women than men, and is almost always an early manifestation, occurring usually between the lightning-like pains and the onset of the ataxic symptoms The most typical form is lighted up by some slight injury, *e g* a strain or sprain, and is characterized by a rapid painless distension of the joint with a light-coloured serum, which may also extend into the communicating bursæ, there is some amount of effusion into the surrounding cellular tissue, although without œdema This distension may be so rapid that abnormal mobility or even dislocation may occur at the end of a few hours The joints most frequently affected are the knee, hip, and

shoulder, occasionally more than one articulation is involved The course of the case varies, in some few instances the fluid is gradually absorbed, and the joint returns to its normal size and shape, although somewhat weakened Sometimes the attacks of distension recur, and after each the joint becomes more and more crippled Two chief types of the affection are described (1) In the *atrophic* variety, the more common, the bones become eroded to a considerable extent, the ligaments stretched, and a weak, flail-like articulation remains (Fig 439), in which the ends of the bones are atrophied and displaced

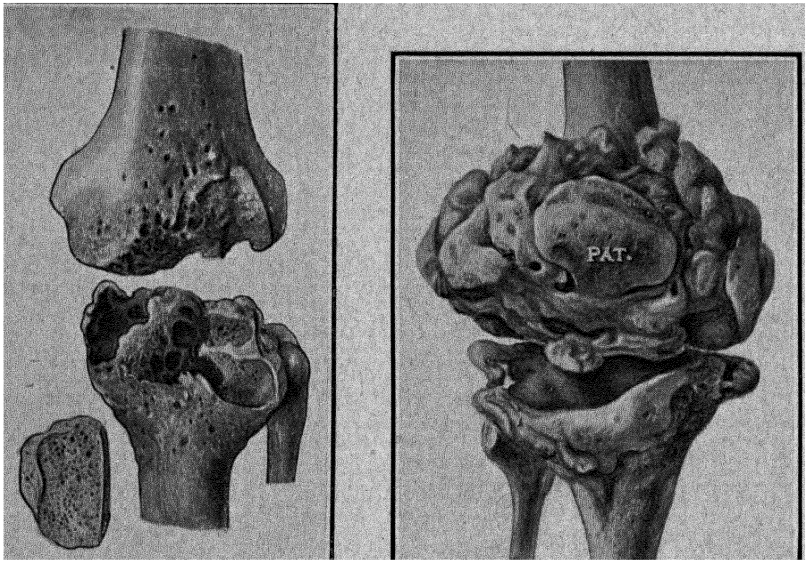


FIG 437 —ATROPHIC VARIETY OF CHARCOT'S DISEASE OF KNEE-JOINT (FROM COLLEGE OF SURGEONS MUSEUM)

The bones are cleanly eroded and no new formation is present The patella is reduced to a mere shell one-eighth of an inch thick

FIG 438 —HYPERTROPHIC VARIETY OF CHARCOT'S DISEASE OF KNEE-JOINT (FROM COLLEGE OF SURGEONS MUSEUM)

The patella (PAT) can be seen poised on the top of a mass of new bone formed by the welding together of a number of smaller portions formed in the perisynovial tissues

(Fig 437) (2) In the *hypertrophic* form new osseous formations occur here and there under the synovial membrane, especially in cases where there is much distension, so that on compression of the swelling between the hands a sensation is produced similar to that imparted by grasping a bag of bones After a time these osseous masses become welded together, giving rise to large overgrowths, which lead subsequently to fixation of the joint (Figs 438 and 440) The disease sometimes runs a more chronic course, and then closely resembles osteo-arthritis, since there is but little effusion, whilst the ends of the bones become eroded, and osteophytes, perhaps

of great size, form around the edges of the cartilages, leading to defective mobility and crepitus It should be noted that by some the hypertrophic stage is believed to follow the atrophic and that both are steps in an identical process

The **Diagnosis** of Charcot's disease from *osteo-arthritis* is, as a rule, readily made if one remembers the following points Charcot's disease is usually characterized by a rapid onset, limitation to one joint, considerable effusion, absence of articular pain, atrophy of the ends of the bones, and a tendency to the production of a weak, flail-like joint, whilst the early general signs of tabes are also observed, especially the lightning pains and the Argyll-Robertson pupil Osteo-arthritis, on the other hand, comes on slowly, often affects many joints, has but little effusion,

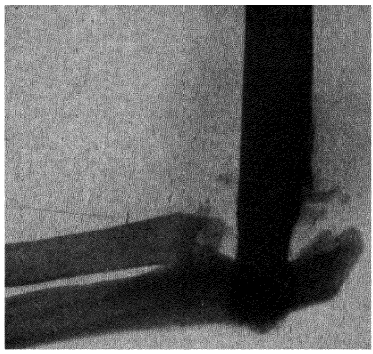


FIG 439 —SKIAGRAM OF CHARCOT'S DISEASE OF THE ELBOW-JOINT (ATROPHIC VARIETY)

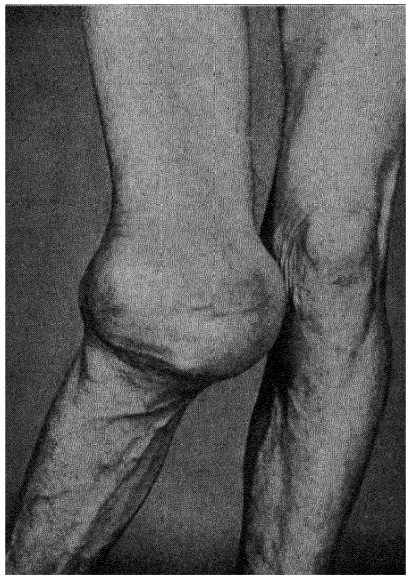


FIG 440 —CHARCOT S DISEASE OF RIGHT KNEE

The joint is distended with fluid and displacement of the tibia is commencing

is very painful, and is attended with marginal overgrowth or lipping of the cartilages (Fig 441) In the more chronic cases the distinguishing features are much less evident

The **Treatment** of Charcot's disease consists in keeping the limb at rest on a splint and applying elastic pressure The effusion, when considerable, may be removed by an aspirator, but is very likely to re-collect Ionic medication with salts of iodine may be of use In the later stages, where the joint is entirely disorganized, some form of fixed apparatus, such as a carefully moulded splint, may be applied to render the limb more useful, and it is remarkable how well a patient can get on in this way with a badly-affected joint In bad cases an attempt may be made to carry out some form of arthrodesis, and in

spite of an old idea that ankylosis will not occur many successful results are reported Sometimes, especially in the ankle-joint, it may be preferable to perform a below-knee amputation

The same type of articular lesion occurs in *Syringomyelia*, a disease which consists in a gliomatous development in the spinal cord, and usually in the cervico-dorsal region It is characterized by loss of the senses of pain, and of heat or cold, but tactile and muscular sensibility persists Atrophy of various muscles of the hand or fore-arm also occurs, whilst trophic lesions, *e g* whitlow, perforating ulcer, etc , are common Joint troubles are observed in at least one-third

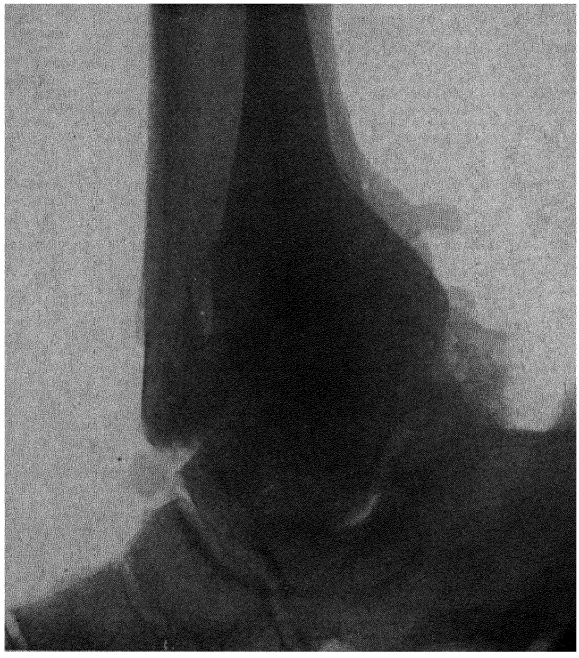


FIG 441 —CHARCOT S DISEASE OF ANKLE-JOINT

of the cases, mainly in the upper extremity, tabes generally affecting the lower (Fig 442) Either atrophic or hypertrophic phenomena are developed, and the course is identical with that of Charcot's disease, except that suppuration is a little more likely to follow, owing to the frequent presence of infected sores

Somewhat similar in nature to Charcot's disease is the chronic arthritis met with in many conditions where the nervous supply to a limb is impaired as a result of central or peripheral disease of the nervous system Thus, it may follow spina bifida, hemi- or para-plegia of cerebral or spinal origin, or may be secondary to a peripheral

neuritis, due to either injury, syphilis, gout, diabetes, leprosy, etc The terminal articulations of fingers or toes are those most often affected (acro-arthritis), although larger joints may be involved They become swollen and painful, and after a time ankylosis ensues

Hæmophilic Disease of Joints

In hæmophilia (p 269) any injury to a joint may lead to a copious effusion of blood into the articular cavity, which becomes suddenly swollen and distended The blood remains fluid for a time, but at length coagulates, and the joint then becomes tense and firm, and is often hot and tender Total recovery may ensue, but if the condition recurs, as is so frequently the case, the effects on the articular surfaces are curious the cartilages usually retain their normal colour, but become thin, worn, and rough, especially at the points of greatest pressure, fibrillar degeneration of the matrix may occur, and in some cases the cartilage has been found totally absent, being replaced by fibrous tissue Ecchondroses subsequently developing into bone are formed at the margins of the joint surfaces, the changes thus produced being somewhat akin to those of osteo-arthritis The ligaments and synovial membranes are slightly thickened, and usually of a russet-brown colour Adhesions are often present, causing considerable impairment of mobility The **Treatment** consists in keeping the part at rest, and applying ice in the early stages, whilst, later on, friction, massage, and pressure may be employed The surgeon must never attempt to aspirate the joint, even with a fine needle

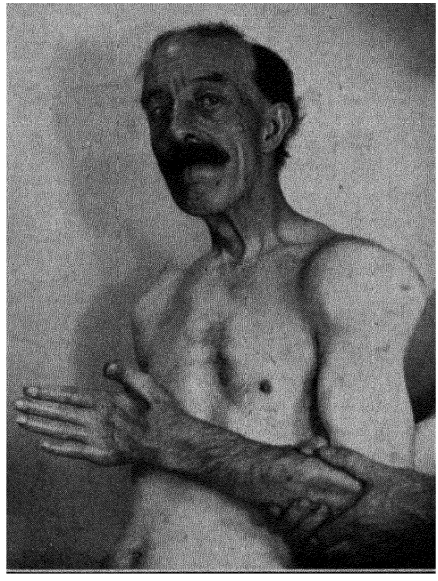


FIG 442.—CAST OF SYRINGOMYELIA IN WHICH THE LEFT SHOULDER-JOINT IS AFFECTED WITH A NEUROPATHIC ARTHRITIS

Loose Bodies in Joints

Several varieties of loose body are met with in joints, which may be described as follows (1) The so-called 'melon-seed bodies' consist of fibrin derived from altered blood-clot, or more frequently from a fibrinous exudation in cases of very chronic tuberculous disease At

first irregular in shape and laminated in texture, they are generally transformed into round or flattened pellets or elongated masses by the movements of the articulation Bursæ and tendon sheaths are much more frequently affected than joints The number present is usually considerable, whilst there is also some glairy effusion, causing distension and a certain amount of creaking In one case the knee-joint was occupied by a number of rounded, yellowish-white, translucent foreign bodies, several of which were nearly as large as walnuts, they were probably of hæmorrhagic origin (2) Portions of intra-articular cartilage may be separated from certain joint surfaces such as the medial condyle of the femur, the capitellum of the ulna, the superior articular surface of the astragalus, or the superior aspect of the head of the femur, probably as a result of trauma, the condition being known as osteochondritis dissecans Usually, in addition to the actual cartilage a flake of bone is separated as well The separation may be complete or the fragment may remain suspended from the main articular surface Occasionally the fragment appears to have been displaced and then become re-attached to its old bed If it has lain free in the joint for any length of time, the cartilaginous surface will grow around the bone so that the latter serves to form a central nucleus Radiography may demonstrate the foreign body and the cavity in the lower end of the femur from which it has been derived (3) They sometimes develop from cartilaginous nodules in the synovial fringes or villi, which either become pedunculated, then occasionally wearing a bed for themselves in the articular surface, or may be totally detached Such structures are usually lobulated and irregular in shape, and consist of calcified cartilage or bone, whilst a certain amount of normal cartilage is also present (Fig 443) This condition may result from osteo-arthritis, but sometimes the cartilaginous cells from which they are derived have persisted as a 'fœtal residue' (4) Ecchondroses may be broken off in cases of osteo-arthritis, or even portions of the articular cartilage showing villous changes A non-articulating epiphysis such as the internal epicondyle of the humerus may become broken off and displaced into the joint, and if not replaced will form a loose body

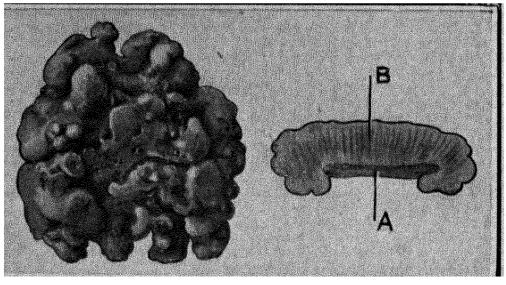


FIG 443.—LOOSE CARTILAGE IN JOINT, PROBABLY DEVELOPED IN A FRINGE OF SYNOVIAL MEMBRANE (FROM COLLEGE OF SURGEONS MUSEUM)
A, Cartilage, B, bone

Although cut off from all vascular supply, the growth of some of these loose bodies is said to continue, owing to the highly nutritious fluid which bathes their surfaces

The **Symptoms** caused by this condition are produced by the loose body being occasionally caught between the articular surfaces, leading to a temporary locking of the joint, and severe pain, owing to the stretching of the ligaments The fixation is but momentary, since the foreign body is readily displaced, but an attack of subacute synovitis follows When this has happened several times, the ligaments are likely to become relaxed, and the joint somewhat loose and distended It may then be possible to feel the foreign body, and to shift its position, but frequently the surgeon is unable to detect the intruder, as it slips away into the interior of the joint owing to its ready mobility From this point of view, the term 'Gelenkmaus' (joint mouse), as applied to this affection, is most happy The knee- and elbow-joints are those most frequently affected

The **Diagnosis** between a loose body and a torn and *movable semilunar cartilage* in the knee-joint is not always easy, since in both conditions painful locking of the joint occurs The fixation, however, is but momentary in the case of a loose body, but may persist until reduced in the latter, whilst a localized spot of tenderness may be detected corresponding to the site of the injury to the interarticular cartilage Moreover, the history of the case is very different, since the dislocation of a semilunar cartilage is always primarily referred to some twist or sprain of the joint, whereas with a loose body no such traumatic influence need be present It is always possible to detect a loose body by radiography, if there is any osseous tissue in it, and therefore all cases of chronic synovitis where the cause is at all in doubt should be radiographed

The **Treatment** consists in the removal of the foreign body by an open operation (p 724) In the knee-joint a vertical incision is made about 2 inches in length, extending a little above and below the line of the articulation It should be placed about 1 inch from the patella, on whichever side the loose cartilage presents most frequently, but preferably on the outer If possible, the foreign body should be fixed by the finger in one of the lateral pouches of the joint before making the incision The capsule and synovial membrane are opened, the loose body removed, and the cavity carefully closed

Neuromimetic and Neuralgic Joints.

In nervous individuals of either sex it is not uncommon to observe a persistence of joint disability with or without pain long after the causative trouble has passed away In a few cases this is definitely due to malingering, but more frequently it results from want of will-power and effort on the part of the patient, possibly because he has been warned in too forcible terms of the dangers of movement A patient of this type needs help and encouragement, he has walked perhaps for some time with the foot everted, and is unwilling to put his weight fairly on hip or knee Re-education in the correct method of walking is necessary, and his muscles must be carefully trained, much can be done by suggestion and will-power

Where numbers of wounded men have been brought together,

a persistent disability is often purely **neuromimetic** in origin one or two of the number limp as a result of their wounds, others follow their example because it seems to be the proper thing for a wounded man to do Injudicious, though kindly sympathy may maintain this condition A most careful examination must be made before such a diagnosis is reached The muscles governing the joint must be tested, and their electrical reactions noted If the patient's attention can be diverted, movement may sometimes be obtained without pain In some cases examination under an anæsthetic is most desirable, possibly a little peripheral stimulus during the administration, in the stage when the patient has lost consciousness, but retains his muscular activity, may be helpful

In a few cases a true **neuralgic** condition of a joint occurs, in which disease is simulated, and yet no actual lesion is present On careful examination the pain is found to be superficial, not increased by jarring the articular surfaces together, and often not strictly confined to the joint The movements are apparently limited, but if the attention of the individual is diverted or anæsthesia induced, they are found to be perfectly free There are no signs of effusion into the cavity, and no starting pains at night Occasionally a similar condition is met with in men, where there is no suspicion of hysteria

The *treatment* is constitutional and local The former is directed towards improving the general health, and correcting any error in the uterine functions The latter is best accomplished by the use of cold douches and electricity, although counter-irritation in the shape of blisters, or even the actual cautery, applied over the joint, has an excellent moral effect

Ankylosis.

By ankylosis is meant a condition of immobility, partial or complete, of a joint, resulting from some preceding inflammation of the particular structures

The term **false** ankylosis is sometimes applied to a condition resulting from extra-articular lesions It may be either fibrous or osseous, and is due to cicatricial contraction of the skin, shortening or fibrosis of muscles, or even to the development of bony tissue within them (*myositis ossificans*) A common and troublesome form of false ankylosis after fractures or gunshot wounds is due to the fixation of muscles to the underlying bone . Thus, in many cases the quadriceps is fixed to the front of the femur by such dense fibrous adhesions that movement of the knee is quite impossible, although the patella may be freely mobile from side to side Similarly the triceps may be fixed to the back of the humerus and prevent movement of the elbow

True ankylosis always involves the articular structures, and is either fibrous or bony

Fibrous or incomplete ankylosis results (*a*) from thickening and contraction of the ligaments, such as often occurs after gonorrhœal or rheumatic affections, (*b*) from the formation of cord- or band-like adhesions within the joint, after acute synovitis or fractures involving the articular surface, (*c*) from erosion of the cartilage and exposure

of the bone, as in acute or tuberculous arthritis, granulations sprout up on each side, and by their union lead to dense fibroid adhesions between the articular surfaces Some amount of movement is possible in most of these cases

Complete or osseous ankylosis (synostosis) arises from the union of either the whole or part of the opposing surfaces left by the destruction of the cartilage, the bond of union, at first fibro-cicatricial, being subsequently ossified (Fig 444), it may also be due to the interlocking and fusion of osteophytes, formed at the margin of the bone in osteo-arthritis or Charcot's disease

The position in which ankylosis occurs and the *effects* thus produced differ according to the joint affected (See also pp 289 and 723)

In the *shoulder* there is usually but little displacement, and the existence of immobility is of less importance than elsewhere, owing to the free movements of the scapula and clavicle The deltoid muscle is generally much atrophied The *elbow-joint* is very commonly ankylosed on account of its exposed position and the frequency of fracture-dislocations in its neighbourhood The formation of callus filling up the olecranon and coronoid fossæ, and the adhesions likely to form within the joint in these cases, readily explain its frequency The most favourable position for ankylosis is when the arm is flexed to a little more than a right angle with the hand slightly supinated so that the patient can see into the palm By this means access to the mouth is possible, and he can use his hand for feeding purposes Occasionally, however, the patient's work is such as can best be undertaken by a straight arm The *wrist* is most commonly fixed as a result of gonorrhœal or rheumatic synovitis In the *hip-joint* (Fig 444) much depends upon the treatment as to whether the ankylosis takes place in a good or bad position Slight flexion of the thigh (about 35 degrees) is probably the best position to ensure comfort both in sitting and standing, combined with moderate abduction In neglected cases the thigh may be in a position of adduction and internal rotation, crossing in front of the other leg Occasionally a *scissor-like deformity* has resulted from inflammation of both hip-joints, one leg lying in front of the other, progression is accomplished with difficulty, the body twisting at each step, and crutches are often needed In ankylosis of the *knee-joint* an absolutely straight position

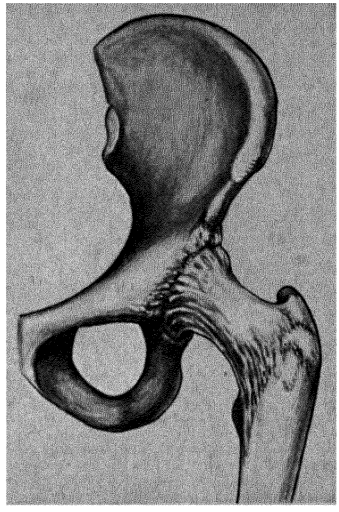


FIG 444 — ANKYLOSIS OF HIP JOINT IN GOOD POSITION (KING'S COLLEGE HOSPITAL MUSEUM)

is not quite so serviceable as when some slight degree of flexion (15 or 20 degrees) is present Unless care is taken in treating the causative affection, ankylosis is only too likely to be associated with deformity The knee becomes much bent, and the tibia is displaced backwards on the femur, whilst external rotation and even lateral displacement of the tibia externally are likely to supervene if the patient is allowed to lie with his leg on its outer aspect In the *ankle-joint* considerable trouble may arise from immobility, unless the foot is at right angles to the leg

The **Treatment** of ankylosis must vary considerably according to its cause In the simple forms of *fibrous* ankylosis, due to the presence of adhesions of no density, much may be done by manipulation, massage, and exercises Some adhesions may be dealt with by forcible movements under an anæsthetic, the surgeon ever keeping in mind that the bones involved may be atrophic and easily broken (p 727) Others are better treated more gradually, efforts being directed to lengthen and loosen the adhesions rather than to break them Remedial exercises may be useful in this direction

An exception to all vigorous treatment of this type, as also to some of the operative methods suggested below, is made in the case of ankylosis following tuberculous disease The surgeon can never be certain that infective foci are not encapsuled in the fibrous tissue, and active treatment might once again light up active disease

It is useless to attempt the rupture or division by open operation of dense adhesions, as they are certain to re-form These cases, as also certain non-tuberculous forms of osseous ankylosis, perhaps due to pyæmia or trauma, are best treated by the operation of **arthroplasty,** elaborated by J B Murphy The procedure is based on the recognized fact that one of the most frequent causes of the non-union of fractures is the interposition of fibrous, fatty or muscular tissues between the fragments If, then, the articular ends of an ankylosed joint can be separated, and a suitable flap of tissue interposed, the free movement of the joint should be restored, granting that the muscles which control the joint are operative For this purpose free or pedunculated fascial flaps stitched over the bone ends are now chiefly employed, and give the best results It is impossible here to enter into lengthy details of the procedure, it must suffice to state that the joint affected must be freely exposed, the articular ends are set free, and a gap made between them, which must be maintained until healing has occurred, shaping or rounding the bone ends may be desirable, but is not essential, the fascial graft is placed so as to cover completely the articular end of one or both bones involved, and stitched *in situ*, and then the wound is carefully closed It is immobilized for a week or ten days, and then movements are commenced The result in many cases is most gratifying, but, of course, all infective trouble must have ceased before the operation is undertaken, and absolute asepsis is essential if the flap is to live

Excision of joints for ankylosis is still occasionally required, especially in the *elbow*, but takes on the form of an arthroplasty in the majority of cases. It should never be considered when a labouring man has

a strong useful arm, even if stiff In the *knee* osseous ankylosis with deformity will frequently require the removal of a wedge-shaped fragment (cuneiform osteotomy) in order to overcome the deformity, where, however, the ankylosis is fibrous, arthroplasty will usually be practicable

At the *hip-joint* ankylosis in a bad position is most commonly due to tuberculous disease, and, as already stated, arthroplasty is then not desirable Most frequently the thigh is flexed on the pelvis and possibly adducted, the result being a most ungainly method of progression In the majority of such cases it is unwise to attempt division of the cervix femoris (Adam's operation), it is too near the diseased area Subtrochanteric osteotomy of the femur is the operation of choice a small incision is made just below the trochanter, and through this an osteotome is introduced and the bone divided To put the limb in a good position, tenotomy of the adductors is usually required, and this is easily effected subcutaneously close to the pubes The after-treatment must be sufficiently long to ensure sound and solid union of the bone, as the adductors are powerful, and can readily lead to displacement when the callus is soft In non-tuberculous ankylosis of the hip the joint is best exposed by a large U-shaped incision with its base upwards, and the trochanter well within the U This flap is raised, including the deep fascia The base of the trochanter is chiselled across, the joint is exposed, and the head of the femur separated from the acetabulum and shaped up so as to move freely in the deepened and smooth socket A flap of fascia is then carefully wrapped round the head of the femur and stitched in position Divided ligaments are re-united, the trochanter is nailed back in position, and the wound closed The limb is placed in a position of abduction with weight extension, and passive movements are commenced in ten days

Hip-Joint Disease.

Although the term ' hip-joint disease ' is usually applied to a tuberculous arthritis, it is not the only affection involving this articulation, as rheumatic, gonorrhœal, or pyæmic affections are not very uncommon Acute arthritis is also met with secondary to an acute infective osteomyelitis of the upper end of the femur, and is evidenced by all the ordinary signs of that affection, separation and necrosis of the upper epiphysis being a frequent result Osteo-arthritis is frequently seen (p 761), whilst Charcot's disease may also occur

Tuberculous Disease of the Hip differs in no respect from the same disease as it affects other joints, and hence no detailed notice of the pathological anatomy is required Suffice it to say that it may originate in the synovial membrane or bone, more frequently in the latter, and then commencing either beneath the articular cartilage or on the under side of the neck distal to the epiphyseal cartilage (Fig 445) The joint may also be affected from a primary focus occurring in the acetabulum (Fig 446) According to Pugh, the most common site is that part of the ilium forming the inner part of the acetabulum just above the Y-shaped cartilage Very rarely the dis-

ease becomes circumscribed in the neck of the bone, forming a chronic abscess, the diagnosis of which is exceedingly difficult More usually the disease spreads from the underside of the neck, and involves the synovial membrane, which passes into a state of pulpy degeneration The substance of the epiphysis is invaded, and caries of the head is thereby produced, together with necrosis or ulceration of the cartilage (Fig 426) The acetabulum undergoes similar changes, from the contact and backward pressure of the diseased head the posterior acetabular margin is absorbed and the cavity extended, whilst at the same time a new rim of bone forms beneath the adjacent periosteum at a slightly higher level, thus giving

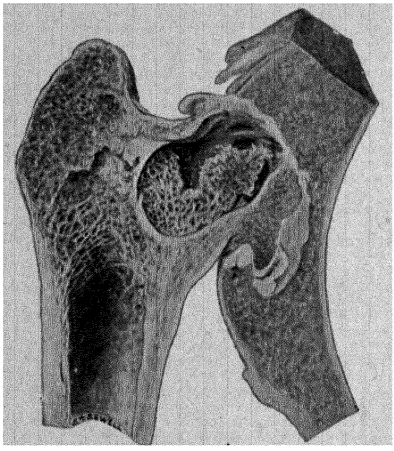


FIG 445 TUBERCULOUS HEAD AND NECK OF FEMUR WITH SEQUESTRUM LYING IN AN ABSCESS CAVITY (COLLEGE OF SURGEONS MUSEUM)

The condition was of old standing as evidenced by the absorption of the head the destruction of the joint cavity, and the chronic changes in the bone which surrounds the sequestral cavity

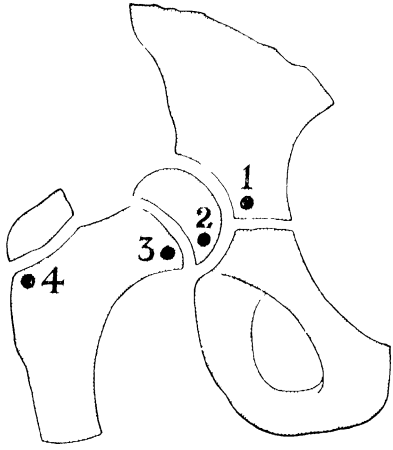


FIG 446—THE COMMON SITES IN WHICH TUBERCULOUS DISEASE OF THE HIP-JOINT MAY ARISE

(1) Acetabular, (2) epiphyseal, (3) juxta-epiphyseal, (4) subtrochanteric

rise to what is known as a 'travelling acetabulum' (Fig 447) In this way the socket is increased both in size and depth, travelling backwards and upwards with the head of the bone towards the dorsum ilii Other factors assisting in the displacement of the head of the bone are the tonic action of the muscles, keeping the limb in a position of flexion, adduction, and inversion, thereby causing a considerable portion of the head to project out of the acetabulum, and the early softening and destruction of the posterior ligaments, which are much thinner than those in front of the joint Occasionally a mass of protuberant granulations sprouts up from the centre of the cavity, and may also assist in this process Should the acetabulum be per-

forated, a tuberculous abscess is likely to form within the pelvis The adjacent pelvic bones may either become thickened by the deposit of osteophytes, or carious, if a pyogenic infection is superadded, necrosis may supervene

Clinical History —The patient, usually a child, is observed to limp, and may complain of pain either in the hip or more often on the inner side of the knee, the latter being due to the fact that both joints are supplied by the same nerves, *viz* the anterior crural, sciatic, and



FIG 447 —FEMUR AND ACETABULUM IN HIP DISEASE (KING S COLLEGE HOSPITAL MUSEUM)

The epiphysis of the caput femoris has been practically destroyed, and the acetabulum is enlarged by absorption of its posterior margin and displaced upwards (*travelling acetabulum*) The rami of the ischium and pubes have been removed



FIG 448 —EARLY STAGE OF HIP DISEASE (LEFT SIDE) IN A CHILD (FROM A PHOTOGRAPH)

The black line is drawn from one anterior superior spine to the other, and shows not only the amount of abduction present, but also the tilting down of the pelvis on the affected side

obturator trunks There may be some history of injury, but not necessarily On examining the limb in the *early stage*, it is usually found to be *apparently lengthened* (Fig 448), whilst the thigh is slightly wasted The nates are flattened and the gluteal fold lost, conditions partly due to atrophy of the muscles, partly to the flexion of the limb The joint is more or less rigid, and pain is produced on attempting to move it, or on jarring the leg, as by striking the heel or trochanter Direct pressure over the neck of the femur, *i e* over a spot just below

and internal to the anterior superior spine, causes pain in the earlier stages of active disease The position assumed in this early stage is one of slight and increasing flexion, abduction, and eversion (Fig 449, A), the reason for this being that thereby the ligaments, and especially the ilio-femoral, are most relaxed, and the capacity of the joint is at its greatest The latter fact has been demonstrated in the healthy cadaver by inserting the nozzle of a syringe into the joint through the acetabulum, and forcibly injecting fluid, when this position is at once assumed The flexion and abduction, however, are not always evident, since the flexion is masked by lordosis of the spine (Figs 450 and 451), and the abduction by the pelvis being tilted down on the affected side, producing thereby apparent lengthening of the diseased limb and lateral curvature of the spine, with its lumbar convexity towards the affected side (Fig 449, A and B) The sound

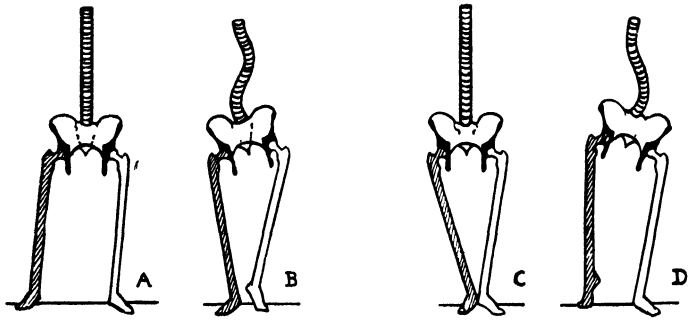


FIG 449.—DIAGRAM TO ILLUSTRATE THE POSITIONS ASSUMED BY THE LIMB IN THE EARLY AND LATE STAGES OF HIP DISEASE

A represents the position of abduction taken by the right limb in the early stage of hip disease, and B Nature's method of masking this by tilting the pelvis down on the affected side, while the other leg is adducted, the effect of this on the spine, in causing a lateral deflection, is also indicated C shows the same thing in the later stage, when adduction is present, and the pelvis is tilted upwards on the affected side, thus producing apparent shortening (D)

leg being brought into a position of adduction, the parallelism of the limbs is maintained The flexion can be demonstrated by any method which obliterates the lumbar curve of the spine, as by fully bending up the sound limb on the abdomen, the affected thigh rising at once from the bed and forming an angle which indicates the amount of flexion (Fig 450) The abduction is demonstrated by laying a rod across the two anterior superior spines, and placing another at right angles to its centre This will not correspond with the line of the body or of the limb, but makes an angle with it The eversion cannot be masked. The rigidity is easily demonstrable in that all movements of the hip-joint are greatly limited, thus if an attempt is made to bend the affected thigh on the abdomen, the corresponding side of the pelvis is raised with it from the bed

As the disease progresses, and the bones become more extensively affected, the pain increases, with nocturnal startings, whilst abscesses

form, and a certain amount of fever and constitutional disturbance is caused thereby The position of the limb also changes, for although the flexion is maintained, and even increased, adduction and inversion are now associated with it The pelvis is tilted up on the affected side (Fig 449, C and D), causing *apparent shortening*, lateral curvature with a lumbar convexity to the sound side, and abduction of the healthy limb No satisfactory cause for this position can be given, but it is usually attributed to the yielding of the posterior and outer part of the capsule, together with infiltration and weakening of the small external rotator muscles, allowing the adductors and internal rotators unopposed play (Fig 452)

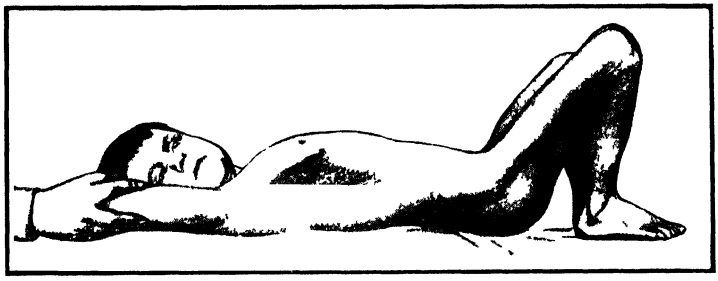


FIG 450 —HIP DISEASE WITH THE BACK FLAT ON THE COUCH AND THE LEG FLEXED TO A CONSIDERABLE DEGREE

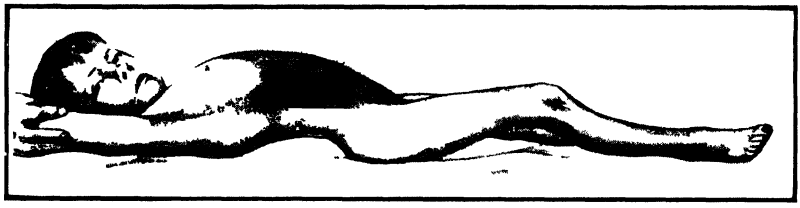


FIG 451 —ON PRESSING DOWN THE DISEASED LIMB THE SPINE BECOMES ARCHED (LORDOSIS) IN THE LUMBAR REGION, SO THAT THE HAND COULD BE READILY PASSED BELOW IT THE EVERSION OF THE LIMB IS VERY EVIDENT

When an abscess has formed, the most usual situation for it to point is a little in front of and internal to the great trochanter, close to the insertion of the tensor fasciæ femoris It may reach that spot either from an opening in the anterior part of the capsule, coming thus to the surface along the line of least resistance, or it may burrow from the posterior portion of the capsule along the rotator muscles and superior gluteal nerve Less frequently abscesses pass directly backwards to open in the gluteal region, or forwards along the pubo-femoral ligament, pointing on the inner side of the femoral vessels below Poupart's ligament As a rare complication, the tuberculous process may extend to the bursa under the psoas tendon, which sometimes communicates with the joint, leading to the formation of

an abscess in the upper part of Scarpa's triangle, and occasionally to a typical psoas abscess from extension upwards An intrapelvic abscess following perforation or disease of the acetabulum may either burrow upwards, and come to the surface above Poupart's ligament, or may gravitate downwards, and burst in the ischio-rectal fossa

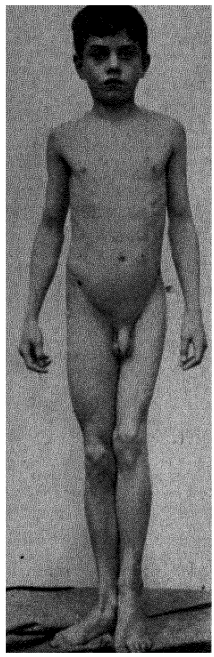
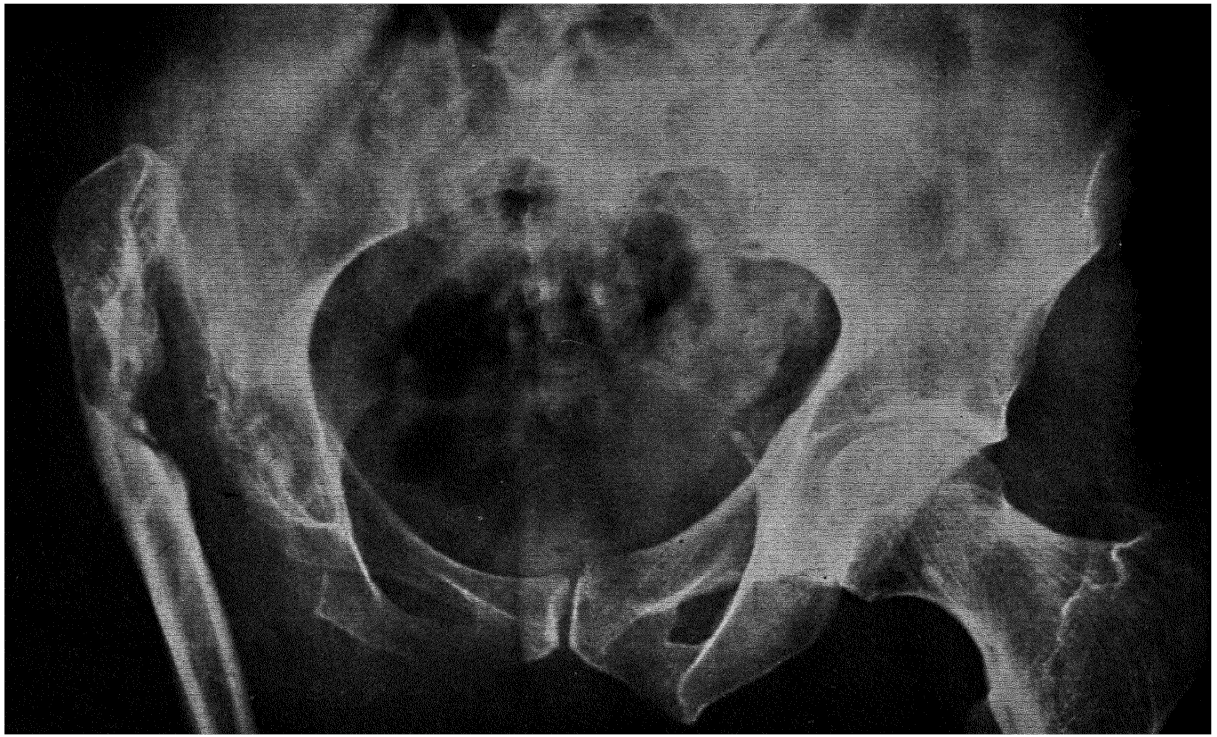


FIG 452 —TUBERCULOUS DISEASE OF THE LEFT HIP-JOINT

The flexion and adduction of the thigh are well seen also the wasting of the thigh muscles

The final stage of the disease is one of *real shortening*, due to erosion of the head of the bone and its displacement backwards upon the dorsum ilii The position assumed is one of increased flexion, adduction, and inversion, whilst if suppurating sinuses persist, hectic fever and amyloid changes in the viscera are likely to follow At any stage the active disease may become quiescent, fibrous ankylosis usually resulting, but unless the abnormal position has been corrected by extension, deformity is almost certain to be present, whilst interference with growth may increase the shortening (Plate IX)

The **Diagnosis** of hip disease appears to be a matter of considerable difficulty to some, if we may argue from the mistakes which commonly occur *Examination* of all cases of hip disease must always be thorough and methodical, if such errors are to be avoided The child should be examined stripped, and made to walk, if possible, so that the character of the limp may be observed Apparent lengthening or shortening of the leg, tilting of the pelvis, and the condition of the gluteal fold should reveal much as to the position of the limb The child is next placed on a flat couch with both legs extended, and the curvature of the lumbar spine noted Thomas's manœuvre (Figs 450 and 451) to obliterate the lordosis will reveal the amount of flexion of the hip The actual length of the limb, Bryant's measurement, and the relation of the top of the trochanter to Nelaton's line are next all noted The degree of fixity or freedom of the limb is carefully investigated as regards each movement—flexion, extension, abduction, adduction, and internal or external rotation, and here a caution is needed, *viz* that conditions vary much according to whether the child has previously been walking or resting A few weeks' rest will eliminate much of the muscular spasm in early cases, especially as regards flexion and extension, sharp abduction may then elicit muscular spasm in the adductors In the later stages, as cure is advancing, spasm is more and more difficult to detect, but the following plan suggested by Sir Henry Gauvain is valuable



OLD TUBERCULOUS HIP-JOINT

Note destruction of femoral head and neck and erosion of the ilium and upper part of femoral shaft, together with defective development of the left femur The left femur is displaced upwards and the acetabulum is small and deformed

If the femur on the affected side be grasped firmly in the region of the condyles, it will be found that the head of the bone may be gently rotated within the acetabulum, either inward or outward, through a varying but often considerable angle At the point where this movement is checked a further slight sharp rotation is instantly followed, if the disease is still active, by spasmodic muscular contraction, not confined to muscles about the joint, but extending to the abdomen and visible in the abdominal muscles, or still more easily demonstrated if the palm of the hand is placed on the abdomen between the iliac spines Quite a gentle and painless, but sharp, rotary movement is sufficient to provoke this reflex spasm of the abdominal muscles Failure to elicit it does not necessarily imply that there is no active disease, but its presence certainly indicates an active lesion

From disease of the *knee* or *opposite hip* mistakes can only arise as the result of carelessness and want of observation The diagnosis from *sacro-iliac disease* is given at p 782 *Spinal mischief* ought never to be a cause of error, even if a psoas abscess points at one of the situations ordinarily favoured by abscesses due to hip disease The presence of spinal deformity and the ability to perform the test movement for hip disease should readily enable the surgeon to make a correct diagnosis, but it must not be forgotten that the two conditions often co-exist If the limb can be put into what is known as the tailor's position—that is, flexion of the knee and thigh to a right angle, with marked abduction and eversion of the thigh—one may be practically certain that hip disease is not present

It is difficult to distinguish an *encapsuled abscess in the neck of the femur* from true hip disease A constant deep boring pain is complained of, which is increased by pressure over the neck, or by jarring the trochanter, but if the limb is manipulated gently, it can be proved that the movements of the joint are not really impaired

Radiography should be employed in all cases of suspected hip disease, and by its means such conditions as coxa vara (p 504) and pseudo-coxalgia (p 780) are readily recognized It is, however, sometimes difficult to be certain as to the nature of the inflammatory attack following a *slight injury* The patient is treated as for the graver affection, and if it gets well in a week or two, probably it is not tuberculous

The **Prognosis** of hip disease is by no means unfavourable if the condition is properly treated Of course, the patient is liable to develop acute tuberculosis or tuberculous disease elsewhere, or, if abscesses are allowed to become septic, serious complications—such as pyæmia, toxæmia, hectic and amyloid disease—may ensue Apart from these, however, no serious consequences affecting life need be feared, although the usefulness of the limb may be seriously crippled from shortening or ankylosis, especially if the latter occurs in a faulty position

The **Treatment** of hip disease follows along the usual lines for dealing with tuberculous lesions The *general* treatment of the patient should be of the sanatorium type, or as closely adapted to it as possible (p 175)

Locally, prolonged rest and extension are the essentials in all stages, although modifications must be introduced in the various degrees Any deformity present must be gradually corrected, and the possibility of its development or increase during treatment must not be forgotten The means of rest and extension now generally employed is the Thomas's splint (p 547) Strips of adhesive plaster taken well up above the knee are employed for extension purposes, together with a weight and pulley, or attached to the cross-bar The limb should always be slung, either from a pole at the end of the bed or from a Balkan beam Gradually the muscles relax, and the limb returns to the normal position If there is at first marked deformity, the leg has extension applied in that direction, but before long, if the extension is effective, it will be possible to place the limb in a good position The relations of the limb to the pelvis must be carefully watched throughout treatment, or an unsuspected adduction may develop In some cases it may be desirable to employ Bradford's abduction splint in place of the ordinary Thomas, with which it corresponds as regards the possibility and method of extension, but it has an additional pelvic attachment which tilts the affected limb into an abducted position

In the simpler cases, where these appliances are not available or desirable, all that is requisite may be secured by weight extension to the affected limb, and the application of a Liston's splint to the sound side The extension strapping must always be carried well above the knee, so as not to damage the ligaments of that joint, and only enough weight must be used to prevent painful starting of the limb If the amount of flexion is slight, the limb may be allowed to lie on the bed in a horizontal posture, this will probably induce some compensatory lordosis, but as the spasm decreases the curvature of the spine disappears

When the disease has passed the acute stage, as indicated by absence of pain and muscle spasm, a plaster cast is applied extending from the axillæ and including the whole of the affected leg The extension or immobilization in plaster is maintained for a period of about a year or more, when the patient is allowed to move about in bed without the presence of any apparatus X-ray photographs must be taken periodically, but it is extremely difficult to be quite sure whether the disease is absolutely quiescent from their appearance A good delineation of the joint surfaces, an increase in the density of the bone, and an absence of change in the X-rays taken at three-monthly intervals are indicative of quiescence In addition the general appearance of the child, the freedom from pain and spasm, and the increase in the musculature about the joint are all good signs The child is then fitted with a walking-caliper and allowed to get up At first a patten is fixed to the sound boot, the patient being prevented from bearing any weight whatsoever on the affected hip and getting about with the aid of crutches These are used for the first three to six months, the patten then being removed and the patient uses the walking-caliper alone for a further period of some twelve months

Operative Treatment.—On account of the prolonged period of immobilization necessary for the cure of this disease, extra-articular arthrodesis after an initial period of extension, to relieve the acute symptoms and to diminish the deformity, has been advocated Where there is necrosis of the head of the femur and evidence of fragmentation of bone in the joint a mixed intra- and extra-articular operation is the best A period of immobilization in plaster will be required following the operation, but the time required for the cure of the disease is about half that of the more conservative procedures In young children conservative treatment should always be employed, but in those over the age of ten, where the disease has broken out again after a period of apparent recovery, or where after some eighteen months' treatment the disease does not appear to be healing, extra-articular arthrodesis may be advised

Some authorities believe that recurrence of the disease is so common that following the apparent cure of the condition in children by conservative means extra-articular arthrodesis is advisable

Operation will also be required where healing has been allowed to occur in a bad position, and for this sub-trochanteric osteotomy is best *Arthroplasty should never be carried out in a tuberculous joint owing to the danger of lighting up the disease*

Abscesses are dealt with by aspiration or tapping, in accordance with the general rules already given (pp 177 and 745)

In the *later stages*, when the case has been neglected and sinuses have formed in the gluteal region or behind the trochanter, *excision* by the *posterior* method is sometimes required, this is usually an easy matter, since the head is probably eroded and displaced The sinuses should, if possible, be included in the incision, but under any circumstances must be opened up and scraped When the acetabulum is extensively implicated, the disease can only be satisfactorily dealt with by removing the head of the bone, and the posterior method affords the best means of subsequent drainage, of course, this presumes that the general condition of the patient has not been seriously undermined, and that there is a good prospect of gaining a useful limb Otherwise *amputation* through the hip-joint is required, especially when the mischief has extended into the pelvis, or when, after excision, a weak, flail-like limb results or osteomyelitis supervenes It is also needed when after excision sinuses persist and lead down into the acetabular cavity, from which there is a plentiful secretion of pus, and over the entrance to which the upper end of the femur is drawn, thereby obstructing the escape of the discharge, and rendering dressing both difficult and painful The operation often gives most excellent results, the patient's condition rapidly improving Removal by the anterior racquet method is perhaps the most convenient, in that the division and ligature of the vessels can sometimes be accomplished through a separate incision, or at any rate at a spot where drainage is most complete and infection least likely to occur Happily, amputation for hip disease, and even the posterior type of excision, are at the present time only of historical interest

Pseudo-coxalgia or **Coxa Plana** (*Syn* Osteo-chondritis Deformans,

Legg's, Perthes' or Calvé's Disease, Quiet Hip Disease, etc) This condition is a disease affecting the epiphysis of the upper end of the femur whereby this undergoes a process of rarefaction and fragmentation The disease is commonest in children between the ages of five and ten, and affects males more often than females Usually only one side is affected, but in some cases both sides suffer The cause of the condition is obscure, but various ætiological factors have been suggested Amongst others Legg believed the condition to be trau-

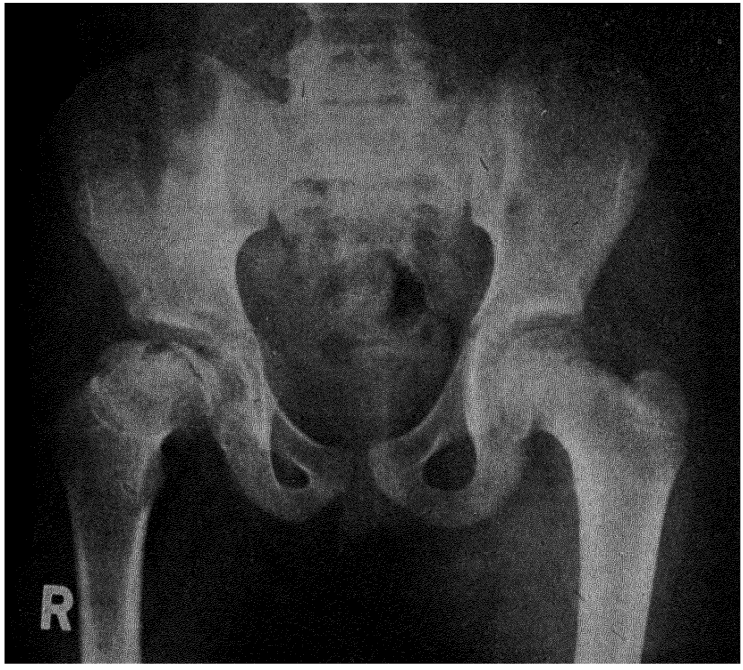


FIG 453 —PSEUDO-COXALGIA

Note flattening and fragmentation of right femoral epiphysis, thickening of the femoral neck, and diminution of the normal angle between the neck and shaft

matic in origin He considers that the blood-supply of a part of the epiphysis is interfered with, resulting in subsequent atrophy Appearances suggestive of this disease have been produced experimentally as a result of cutting off the blood-supply of the epiphysis in animals In support of this explanation is the fact that the disease is more common in boys in whom one might expect trauma to be more frequent Against this theory is the fact that these traumata must be experienced by many who do not develop the disease, and following such trauma to the hip associated with the reduction of a dislocation very

rarely is the disease seen Others believe the condition is an infective one and support their theory by the fact that often the affected hip is tender, swollen, and hotter than on the opposite side, and a rise of temperature may accompany the disease Moreover, in cases which have been operated on, staphylococci have sometimes been isolated from the joint, and small areas of the head of the bone removed for biopsy have shown changes exactly similar to those associated with chronic infection Disturbances in the secretions of some of the endocrine glands have been suggested in a vague way as explanatory

The disease usually starts with pain in the affected hip, perhaps referred to the knee, associated with a limp Gradually the pain passes off, but the limp persists There may be associated signs of a febrile disturbance On examination the limb is seen to be held in a position of slight adduction and flexion, attempts to overcome which are met by spasm of the adductor and flexor muscles Even when this spasm is slight there is marked limitation of flexion, abduction, and internal rotation There may be some slight degree of coxa vara, and the great trochanter feels thickened antero-posteriorly After some eighteen months or so the condition seems to clear, but the patient may be left with a residual limp and a hip-joint in which movements are limited The early onset of arthritis at a future date further interferes with the functioning of the joint

X-ray examination shows as the earliest change a flattening of the epiphysis (Fig 453) This then becomes increased in density and fragmented, and at the same time the superior aspect seems to grow out over the neck towards the great trochanter At this time changes in the neck are also seen, areas of rarefaction appearing and the whole tending to become expanded Later changes show the fragmented head uniting and the density gradually approaches normal Eventually a rather flattened deformed head is left as a residue of the disease

This condition must be diagnosed from tuberculous disease, but in the latter condition the early deformity is one of abduction, not adduction Later, when adduction supervenes, the very marked wasting, spasm, and pain, will suggest the diagnosis Slipped epiphysis occurs at an older age, and X-rays will enable a diagnosis to be confirmed

Treatment.—Although by some it is claimed that no treatment is of benefit in this condition, yet modern opinion is on the whole in favour of treating these cases for a month or so with extension in abduction followed by the use of a walking-caliper or a plaster spica for six to nine months

Disease of the Sacro-iliac Joint.

Tuberculous disease of this joint is met with most commonly in adults, but rarely in children It may commence in the synovial membrane, but is frequently the result of mischief starting in the pelvic bones, especially the ilium The **Pathological Anatomy** calls for no description, inasmuch as it follows the ordinary course of tuberculous disease

The **Clinical Signs** consist of pain and a sense of weakness in the lower part of the back, increased by standing, walking, or any movement—such as coughing, sneezing, and the like—which calls the flat abdominal muscles into sudden action and drags on the ilium It is of a very unpleasant character, a sensation as if the pelvis were coming to pieces being experienced by the unfortunate individual Owing to the fact that the lumbo-sacral cord passes in front of the articulation, pain is often referred to the gluteal region or down the leg Movements of the limb cause pain if the pelvis is not supported, but can be freely performed if the pelvis is steadied Compression together of the innominate bones, or their forcible separation, is the means of demonstrating most effectually the existence and situation of the pain The patient is unable to stand or to put any weight on the affected limb, and hence limps during walking, allowing his body to lean forwards, and making use of a stick There is apparent lengthening on the affected side, but on measurement from the anterior superior spine to the internal malleolus the leg is found to be of the same length as its fellow This appearance is due to the fact that the whole innominate bone is tilted downwards and forwards, so that the anterior superior spine is at a lower level and more prominent than that on the opposite side The region of the synchondrosis is often swollen, puffy, and tender, whilst after a time abscesses form, which may either point immediately over the articulation, or burrow upwards into the lumbar region, or forwards into the iliac fossa, or downwards into the pelvis, opening perhaps in the ischio-rectal fossa The last is a most serious complication, since it is almost certain to introduce a pyogenic element

The **Diagnosis** needs to be made from sciatica, hip disease, spinal disease, and some other sources of pelvic pain *Sciatica* is known by the character of the pain, which shoots down the back of the thigh in the course of the great sciatic nerve, which may be distinctly tender on pressure There is no apparent elongation of the limb, and compression together of the pelvic crests is painless From affections of the *hip-joint*, sacro-iliac disease is recognized by the fact that, if the pelvis is supported, the thigh may be moved in all directions without great discomfort, whilst compression of the pelvis in hip disease causes no pain Moreover, in the advanced stages of hip disease there is apparent or real shortening and deformity, conditions never noticed in the sacro-iliac affection From *spinal disease*, the diagnosis should not be difficult if a careful examination of the spine and pelvis is made When pain is the most marked symptom, the surgeon must exclude other possible sources, *e g* rectal or uterine carcinoma, it is a useful rule to remember that in all such cases a rectal or vaginal examination should be made It is quite possible in certain cases of sacro-iliac disease to detect a fulness on the anterior wall of the synchondrosis

The **Prognosis** is not necessarily unfavourable if asepsis is maintained, the admission of pyogenic bacteria constitutes the main danger In young women it may lead to subsequent deformity of the pelvis and trouble in parturition

Treatment in the early stages consists in absolute rest in bed, with

the application of a pelvic support, and attention to the general health Abscesses may be dealt with in the usual conservative fashion, *viz* by aspiration, tapping or drainage, but it is sometimes necessary to lay them freely open, and deal with the diseased bone by scraping or gouging it away, allowing the wound to heal by granulation Occasionally the posterior part of the iliac crest in the neighbourhood of the posterior superior spine must be removed in order to gain access to the diseased area, this may be accomplished by the chisel or trephine through a vertical incision, and excellent results often follow this proceeding

Sacro-iliac Strain.—This term is applied to a tender and painful condition of one or both sacro-iliac joints, which may render standing and even lying uncomfortable, and is a genuine source of backache It usually occurs in women, and may have some relation to the pelvic movements which admittedly occur in parturition, in other cases it is attributed to strain, and may be due to some slight displacement of the ilium When the position of the sacrum in relation to the pelvic circle is considered, *viz* that it is slung on the upper wall with a natural tendency to drop forwards, the strength of the ligaments passing between it and the spine must be great, inasmuch as they transmit the weight of the trunk Displacement can obviously be very slight, but it is suggested that in this condition the upper part of the sacrum usually swings backwards on its third segment as an axis If this be so, the lumbar curve is lessened, the back becomes straight, and the sacral nerves are dragged on The pain varies from a slight ache to a severe crippling sensation, and is referred partly to the joint, partly to a spot just to the side of and below the umbilicus, and so may suggest appendicitis **Treatment** consists in attempting replacement of the ilium by hyperextending the thigh with the patient in the prone position Replacement is sometimes accompanied by a definite click The buttocks are then compressed together by strapping or a strip of webbing, or in bad cases by encircling the pelvis, trunk, and upper parts of the thighs in plaster of Paris for a few weeks In intractable cases fixation by a bone graft may be employed

Excision of Joints

Excision of joints is an operation which at the present time has been to a large extent replaced by other procedures, *e g* arthroplasty (p 768), or its necessity has been obviated It has, however, a place in modern surgical practice, and in suitable conditions is useful and beneficial The chief articular lesions for which excision, partial or complete, may be required are as follows (1) For various forms of injury in the neighbourhood of joints where ankylosis is likely to follow, and either interfere seriously with the utility of the joint or fix it in a bad position the shoulder and elbow are the joints most frequently dealt with in this way, (2) for some forms of congenital or old-standing dislocation which cannot be otherwise remedied, (3) in the later stages of acute arthritis to prevent ankylosis, (4) in tuberculous arthritis, where conservative treatment has failed to cure the

disease, or where it is advisable to deal with it in the earlier stages in order to shorten its course, (5) for ankylosis of certain joints, consecutive to arthritis, especially if in a bad position, (6) for osteo-arthritis in special regions

The results to be attained necessarily vary in the different joints, and according to the particular cause Sometimes ankylosis in a good position is all that can be expected, in others a freely movable pseudo-arthrosis, in some cases the removal of certain diseased tissue is the primary object of the operation, whilst in others no disease is present All these varying conditions must be taken into consideration in determining the nature and extent of any excision

In a small textbook like this we must perforce limit ourselves to a description of the methods most commonly adopted, and refer students to special works on Operative Surgery for further details *

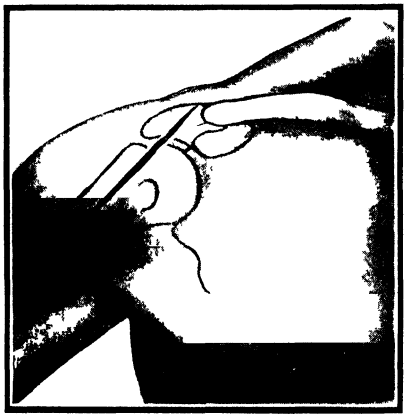


FIG 454 —INCISION FOR EXCISION OF SHOULDER

Shoulder —The patient lies on the back, the shoulder projecting somewhat over the edge of the table, and with a sandbag beneath the scapula to steady it The arm being slightly rotated inwards, an incision is made from a point midway between the coracoid process and the acromion, extending downwards and outwards for 3 or 4 inches through the fibres of the deltoid muscle (Fig 454) It is better to incise the deltoid than to pass between it and the pectoralis major, the cephalic vein and accompanying artery being thus uninjured The wound is thoroughly opened up by means of retractors, and the bicipital groove looked for, an incision is made along its outer border, and the long tendon of the biceps, if still present, turned out, and held to the inner side by a blunt hook A twig of the anterior circumflex artery will here be divided, and need a ligature The arm is now thoroughly everted, and the tendon of the subscapularis and the anterior part of the capsule, with which it is incorporated, freely divided, where practicable, the attachments of the muscle to the bone should be separated subperiosteally, a proceeding presenting no difficulty where inflammation has previously existed The arm is now everted and held downwards by the side of the table, so as to bring the great tuberosity into view, the muscles attached to this process are dealt with in a similar way, and the upper part of the capsule freely opened The head of the bone is then protruded into the wound, and removed by the saw It will often suffice to apply the saw obliquely through

* See Treeves and Wakeley 'Handbook of Surgical Operations' Cassell and Co , 1938

the substance of the tuberosity, this is to be preferred to removal of the whole tuberosity by a horizontal incision at a lower level The synovial membrane and glenoid cavity are dealt with as circumstances may dictate, and it is often advisable to make a counter-opening through the posterior axillary fold for the insertion of a drainage-tube, the anterior wound can then be entirely closed In applying the dressing, care must be taken to put a good pad in the axilla, so as to keep the arm from being drawn forcibly inwards by the muscles attached to the bicipital groove There is no need to commence passive movements before the end of the first week Fibrous union usually results, and the movements of the shoulder are generally very good, with the possible exception of abduction

Excision of the Elbow may be required for simple or compound fracture-dislocation, or for subsequent ankylosis, especially if the limb is in a bad position, for tuberculous arthritis, and possibly in the later stages of acute arthritis The best plan of operating is as follows A single longitudinal incision, 5 inches in length, is made in the middle line of the posterior aspect of the joint, extending for equal distances above and below the tip of the olecranon, and a little to the inner side The limb is held across the patient's body, the surgeon standing on the affected side The incision extends through the substance of the triceps down to the bone The origin of the flexor carpi ulnaris and the inner half of the triceps tendon are detached, and the hollow between the olecranon and the internal condyle cleared, the knife being kept close to the bone, and the soft parts effectively retracted By this means the ulnar nerve escapes injury, and, indeed, is often not seen at all The internal lateral ligament should be divided, and the common origin of the flexors detached from the front of the inner condyle The outer half of the joints is then dealt with in a similar way, the anconeus being divided close to its insertion to the ulna, the continuity of the triceps with the deep fascia covering it being also maintained The origin of the extensor muscles is separated from the back of the outer condyle, and the external lateral ligament severed The joint can now be freely opened by dividing any of the fibres of the posterior ligament which remain intact, and the denuded ends of the bones protruded from the wound The lower end of the humerus is thoroughly cleared, and the articular surface removed, the section passing through the centre of the olecranon fossa The olecranon, together with the upper articular surface of the coronoid process and the head of the radius, are next sawn off, care being taken to draw aside and protect the soft parts by retractors, especially those covering the ulnar nerve The synovial membrane can be dealt with as may be necessary Even if the head of the radius is free from disease, nothing is gained by leaving it intact, since ankylosis is very likely to follow unless plenty of bone is removed As a general rule, a gap of $2\frac{1}{2}$ inches should intervene between the divided ends of the bones, but the interposition of a flap of fascia between the bone ends enables the surgeon to take away less bone The wound is carefully sutured, and a drainage-tube inserted for a few hours The limb is kept on a hinged angular splint for a week, by which time union of

the external wound should be complete, but the position is altered each day. After a week the splint may be dispensed with, and the limb kept at rest on a pillow, free passive movement, both angular and rotatory, being daily practised Considerable attention is needed in order to obtain a good result, but in a successful case every movement of the joint is perfectly restored As a rule, the lower end of the humerus develops two lateral bony processes, like malleoli, within the grasp of which the upper rounded ends of the radius and ulna are able to move

The **Wrist-joint** is only excised for extensive tuberculous disease when abscesses and sinuses are present Ankylosis of the articulation, though a troublesome condition, is not sufficiently so to require such treatment In the majority of cases an arthrotomy of the scope indicated at p 748 suffices to give good results, only rarely is a more complete excision required, and that associated with the name of Lister is the best For a full description, larger textbooks must be consulted

The **Hip-joint** is rarely excised for conditions other than tuberculous disease, and even for this it is but seldom required There are two chief methods of operating, the anterior and the posterior

1 Excision by the *anterior method* is carried out as follows The incision extends from immediately below the anterior superior spine vertically downwards for 3 or 4 inches It passes between the tensor fasciæ femoris and sartorius muscles superficially, and between the glutei and rectus deeply, a small arterial twig from the external circumflex being divided at this stage The neck of the bone and capsule of the joint are exposed, and the latter is freely incised along its attachment to the anterior intertrochanteric line, so as to allow of the admission of the finger, whereby the joint can be explored The neck of the bone is cut through *in situ* by means of an osteotome or saw, the incision through the bone being placed obliquely downwards and inwards The head of the bone is now either prised out of the acetabulum by an elevator or grasped by lion forceps and twisted out, a matter easily accomplished where the articular structures are diseased, but a proceeding of some difficulty in the normal joint of a cadaver As much of the infected synovial membrane as possible is clipped away with scissors, and the acetabulum scraped, if necessary The external wound is either closed, with the exception of an opening for a drainage-tube, or packed with 'bipped' gauze The limb is put up in a position of abduction so as to keep the neck of the bone in the acetabulum

2 Excision by the *posterior method* is at the present day so seldom required that it seems unnecessary to describe it here (p 779)

The **Knee-joint** is excised for tuberculous disease, osteo-arthritis, or deformity due to osseous or fibrous ankylosis in a bad position. A horseshoe-shaped incision is made, extending from the back of one condyle to the other, reaching downwards nearly as far as the tubercle of the tibia The limb is flexed, the ligamentum patellæ divided, and the joint opened The skin and subcutaneous tissues are then separated from the anterior surface of the patella, which may be at once removed by a curved incision above it, communicating on either side with that already made below, the subcrureal pouch of synovial membrane being

also removed during this dissection The flexion is now increased, and the lateral ligaments divided, by this means the interior of the joint is exposed, so that the attachments of the crucial ligaments to the tibia can also be severed The lower end of the femur is then cleared of diseased synovial membrane, so as to allow of the application of a broad excision saw The usual rule given as to the direction of the saw-cut in the bone is that the exposed bony surface left after removing its articular end should be absolutely horizontal, supposing the patient to be standing upright, some surgeons prefer to make the sections so that the limb shall be left slightly flexed and in-kneed, a position which greatly adds to the subsequent comfort of the patient To accomplish this the saw must be applied parallel to the articular surface, *i e* at right angles to the axis of the body, not of the femur, and with a slight upward slant from before backwards The bone should be partially sawn through by a side-to-side movement, but the posterior surface of the condyles should be divided by raising or depressing the handle of the instrument, so that the structures lying behind in the intercondyloid notch are not encroached upon Sufficient bone should be sawn off in the adult to include the greater part of the articular cartilage, but as little as possible consistent with removing all the disease, otherwise the limb is shortened to such an extent as to interfere with its subsequent usefulness The head of the tibia is then protruded, and cleared from the neighbouring soft parts, it is held absolutely vertical, and a saw applied in a horizontal position, the bone being divided from before backwards All diseased synovial membrane is dissected away, special attention being directed to the posterior aspect of the joint Hæmostasis having been effected, the bones are fitted together, and, if considered advisable, secured in position by thick silver wire, nails, or screws, or by an autogenous bone peg, if wire is employed, it should be introduced horizontally through the bones from side to side rather than antero-posteriorly The limb is placed in a half-box splint or in one made of Gooch's material reaching from the ankle to the hip, in this it remains until sound healing has occurred, after which an immovable case either of plaster of Paris or water-glass is kept on for eight or ten weeks

The **Ankle-joint** requires excision so seldom that it is unnecessary to describe the operation

CHAPTER XXIV

INJURIES OF THE SPINE.

THE spinal cord is protected from injury in a most complete and efficacious manner (*a*) Its position between the bodies and the laminæ with the spinous processes arising therefrom is itself mechanically advantageous, since, whether the spine is forcibly flexed or extended, the cord remains midway between the points of chief compression or extension, and hence in a position of rest (*b*) The buffer-like action of the intervertebral discs, and the varying curves of the column, serve to distribute some part of any force that reaches it (*c*) There is ample space in the spinal canal, in which the cord with its membranes is slung by prolongations of dura mater around the issuing nerves, whilst the cord itself hangs loosely within the dura mater, suspended by the ligamenta denticulata, and surrounded by cerebro-spinal fluid (*d*) The cord terminates, in an adult, at the lower border of the first lumbar vertebra, a spot well above the junction of the fixed base and the movable upper part, a point where the effect of jars and wrenches is mainly felt (*e*) Nature has, moreover, introduced a whole series of buffers and other means of preventing shock to the spine when a person falls on his feet, *e g* the arches and elasticity of the foot, the changes in direction of the bones at each joint, the interarticular cartilages of the knee, etc

The parts of the spine most exposed to injury are those where a fixed and movable portion meet, *e g* the dorsi-lumbar and the cervico-dorsal regions Moreover, the upper part of the dorsal curve, which projects backwards, is relatively a weak spot, and fractures are not at all uncommon about the fourth dorsal vertebra The close proximity of the head explains the frequency of lesions about the upper cervical regions

Sprains of the spine are very common accidents, a fact not to be wondered at when its complicated muscular and ligamentous arrangements are considered They are produced by any sudden or unexpected movements, such as falls, especially from horseback, railway accidents, and the like The injury affects most frequently mobile parts of the spine, *e g* the cervical and lumbar regions, and may be limited to either ligamentous or muscular structures, or may involve both The resulting **Signs** are simply those of a severe but localized trauma, *viz* pain, tenderness, and perhaps a little swelling or bruising, the subjective phenomena are much increased by movement, so that the spine is kept rigidly quiet If only the posterior muscles or interspinous ligaments are involved, pain is elicited by flexion of the spine, as it puts these structures on the stretch, active extension is also pain-

ful, but passive backward extension is painless Similarly unilateral lesions are productive of pain on stretching the injured structures If the trouble is limited to the external muscles and ligaments, no further consequences are likely to arise, but when the ligamenta subflava are lacerated and the spinal canal is thus opened, pressure symptoms may arise from blood finding its way into the canal outside the dura mater, leading possibly to a temporary or permanent paraplegia Inflammation of the damaged fibrous tissues may extend to the meninges and cord, and cause organic disease Moreover, in patients of a tuberculous temperament spinal caries may follow such injuries, syphilitic or malignant disease has also been known to ensue

In the *cervical* region, sprains may occur as a result of severe blows on the head, causing rupture of the intertransverse ligaments, and the displacement may be so great as to simulate dislocation The head and neck are held immovable and rigid, and there is often considerable loss of power, the patient being sometimes unable to lift the head spontaneously from the pillow Sprains in the *lumbar* region are very common, both as a consequence of overlifting, when the quadratus lumborum is most likely to be affected, and as a result of railway injuries, when they are often associated with nervous symptoms (p 802) The back is kept fixed and rigid, the patient being unable to turn or stoop without pain Sometimes hæmaturia results from injuries in the lumbar region, arising from an associated contusion of the kidneys

Treatment —The patient should be kept at rest, and fomentations applied to the injured part When the painful or inflammatory symptoms have disappeared, massage with stimulating liniments is needed In the severer cases the individual should be kept in bed for six or eight weeks, and in the cervical region some form of mechanical support may be subsequently necessary The appearance of inflammatory symptoms involving the meninges calls for even greater care, the patient should then be kept as much as possible in the prone position, and a spinal icebag applied The onset of paraplegia, due either to hæmorrhage or inflammatory exudation, would raise the question of laminectomy (p 808)

Penetrating Wounds of the Spine are, fortunately, uncommon in civil practice, being generally due to stabs with pointed instruments, such as bayonets, or to gunshot wounds They occasionally result from falls, the unfortunate individual becoming impaled on area railings, branches of trees, etc The **Symptoms** produced are (*a*) those due to the wound in the soft parts, which may also involve the peritoneal and pleural cavities, or damage to some of the viscera, in the neck, the vertebral artery is exposed to injury from this type of accident, leading to serious hæmorrhage, (*b*) various forms of fracture, the cord being compressed by fragments of bone which have been driven inwards, or by extravasated blood, (*c*) those due to laying open the spinal membranes, *e g* loss of cerebro-spinal fluid, or at a later date may determine the patient's death by setting up diffuse septic meningitis (p 801), and (*d*) those due to wounds of the spinal

cord, which depend upon whether the cord is completely or incompletely divided, upon the level or segment of the lesion, and upon the actual area damaged in an incomplete division, thus a hemisection of the cord will produce the Brown-Séquard syndrome (p 807). The effects of a total transverse lesion at different levels of the spine are given at p 806 Of course, the cord may escape entirely, nerve roots or trunks only being involved, and in the lumbar or sacral regions the mischief may be limited to the cauda equina

Treatment consists in exploring thoroughly the wound under an anæsthetic, removing foreign bodies or displaced fragments of bone, and attempting to render it aseptic Wounds of the vertebral artery or other structures are dealt with *secundum artem*, and special attention is naturally given to the cord and its membranes Should the dura mater have been opened, and the cord have escaped injury, an attempt may be made to close the wound in the meninges, and the patient should subsequently be kept in the prone position and with the head low, so as to prevent, as far as possible, the escape of cerebrospinal fluid If the cord itself is divided or lacerated, it is useless trying to unite it, since its function in conducting impulses from the brain downwards is inevitably destroyed Where, however, the cauda equina has been injured, it is perfectly justifiable to lay open the spinal canal to a sufficient extent to expose the divided nerve trunks, and then to suture them

Fractures of the Spine.—The spine may be broken as the result of (*a*) *direct violence, e g* a fall on the back over some projecting body, such as a carpenter's bench or a railing, or a blow on the back with a heavy stone or with a swinging baulk of wood, or a gunshot wound This type of accident may involve any part of the spine, and, excluding those arising from gunshot, is less frequent than the class next to be described Of necessity, the spine breaks at the point struck, the posterior parts of the vertebræ are most likely to be damaged in this form of injury (*b*) Fractures are also due to *indirect* violence, then usually occurring in the lower cervical or upper dorsal regions They are caused by forcible acute flexion of the spine, as by a fall downwards with the head doubled up, or by taking a 'header' in shallow water, or when a man, being driven under a bridge, omits to stoop, and so is caught between the arch and the cart, or sometimes by the fall of a heavy weight on the back of the neck or shoulder The spine may break across more or less cleanly at its weakest point, or the lesion may be limited to one or two bodies, which are crushed and broken The latter type (compression fracture) is often limited to the bodies, the former usually involves injury to the cord

Fractures of the spine may be divided into two main classes, according to whether or not they are complete—that is, according to whether the continuity of the column is destroyed or not

(A) **Incomplete Fractures** may be met with in various forms, and are most frequently due to direct violence

(1.) *Fracture of the Spinous Processes* rarely occurs except in the lower cervical or dorsal regions In the upper cervical region the

spines are short and retracted to allow of extension of the head, whilst in the lumbar they are also short, but very strong The fracture is almost always due to direct violence, and is characterized by the signs of a local trauma, together with great mobility, perhaps crepitus, and irregularity in the line of the spines The broken fragment is occasionally much depressed, and may even cause paraplegia by being driven into the spinal cord

(ii) *Fracture of the Laminæ* is not an uncommon accident, always resulting from direct violence If only one lamina is broken, the signs

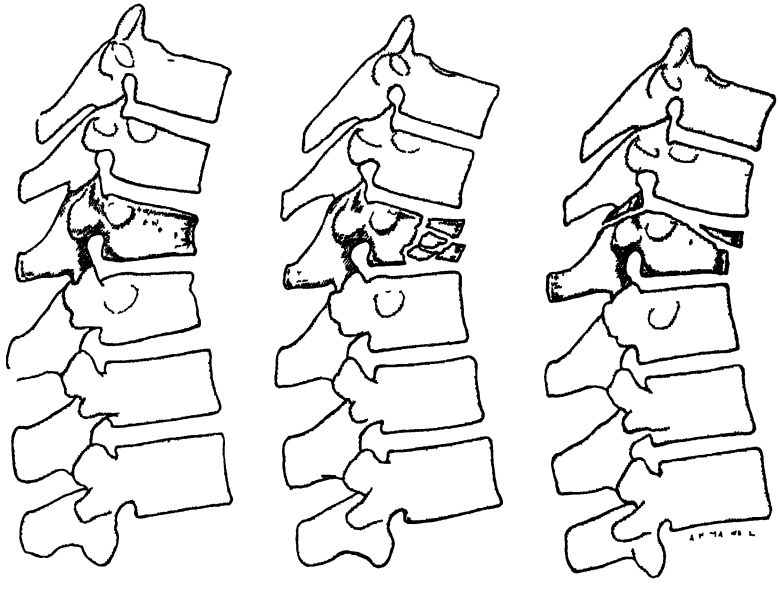


FIG 455 —THREE TYPES OF FRACTURE OF THE SPINE

A Simple wedge fracture
B Comminuted fracture by acute angulation
C Dislocation of the intervertebral joint with fracture of the neural arch
(After Watson-Jones)

are not very distinct, and cord symptoms are rare When both laminæ yield, the posterior part of the neural arch, carrying with it the spinous process, is very likely to be depressed to a sufficient extent to compress the cord and give rise to paraplegia Crepitus is often obtainable, and a gap in the line of the spinous processes can usually be felt

(iii) *Fracture of the Transverse Processes* is occasionally met with in the lumbar spine, and is frequently not diagnosed, the symptoms usually being attributed to myalgia

(iv) *Partial Fractures* through the bodies are not very uncommon and take the form either of an incomplete fissure with little or no

displacement, or of a compression fracture The latter results from falls on the head or shoulders with the spine flexed, as in falls from horseback, or from being blown up, as by gas explosions or shell bursts in military operations One or more vertebræ may crumple up more or less, with or without displacement, but usually without loss of continuity There may be some irregularity of the spine, with tenderness over the spinous processes, but a definite diagnosis can only be reached by very accurate and clear stereoscopic radiography Pain and rigidity are experienced, with a variable degree of nerve-root irritation, and the condition may be followed by traumatic spondylitis (p 831)



FIG 456 —LATERAL SKIAGRAM OF THE SPINE, SHOWING A CRUSH FRACTURE OF THE FIRST LUMBAR VERTEBRA

Fractures of the vertebral body fall into three definite types (1) Wedge fractures (Fig 455, A), which account for 60 per cent of cases, they are caused by forcible flexion of the spine and usually more vertebral bodies than one are fractured (2) Comminuted fractures (Fig 455, B) account for 13 per cent of the cases, they are the result of still more acute flexion, and the anterior part of one body is crushed, together with the disc above and below it (3) Fracture dislocations (Fig 455, C), accounting for 27 per cent of cases, and are usually complicated by paraplegia

In any of these cases symptoms of involvement of the cord may arise, either immediately from concussion, or at a later date from hæmorrhage, and are then sometimes of the gravitation type (p 801)

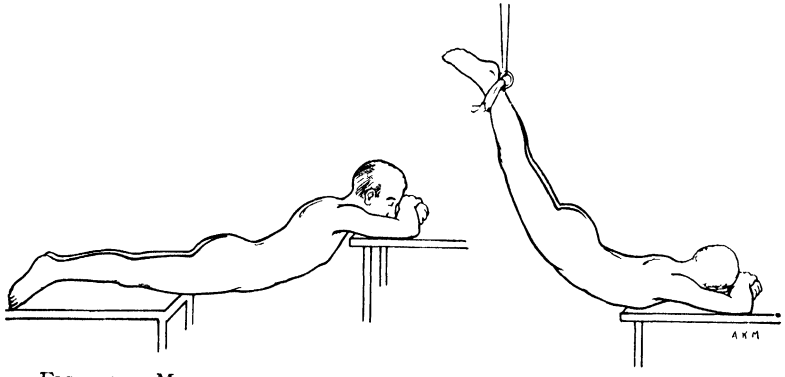


FIG 457 —METHODS OF PRODUCING HYPEREXTENSION OF THE SPINE

Treatment —In all cases of fracture of the body of a vertebra it is very important to avoid flexion of the spine, because flexion increases the angular deformity, therefore the case should be transported face downwards on the stretcher If an X-ray film confirms the diagnosis

of a compression or crush fracture of the spine (Fig. 456), the sooner a plaster jacket is applied the better. This jacket must keep the spinal column in the extended position No anæsthetic is given to the patient, as the extended position can be maintained more easily by the conscious patient Watson Jones has devised a very practical method of treating these fractures in the extended position The patient is given one-third of a grain of morphia half an hour before the plaster jacket is applied Then two tables are arranged end to end with a considerable space between them The front table is then raised on blocks so that it is some two feet higher than the other. The patient is carefully lifted face downwards on to the lower table and a double layer of stockinet is pulled over the trunk and fixed over the shoulders and beneath the perineum by means of a few stitches The bony prominences, *i e* spinous processes and iliac crests, should be protected by pads of sorbo sponge By means of two assistants the patient is now assisted into such a position that he is gripping the edge of the higher table with his abducted arms, while the lower table supports his lower limbs (Fig 457) This position causes hyperextension of the spine Plaster of Paris bandages are applied at once, and should extend up to the neck, down to the sacrum, and over the trochanters of the femur (Fig 458) When the plaster is dry the patient is encouraged to move about in bed After ten days the patient is allowed up, but the vertebral column must be protected for four months



FIG 458.—PLASTER JACKET FOR CRUSH FRACTURES OF THE SPINE

An alternative method may be used by elevating the legs while leaving the trunk unsupported, the pelvis tilts forward and the lumbar spine must sag to the limit of hyperextension (Fig 457)

Non-recognition of this type of accident is one of the causes of the persisting backache which so often follows accidents to the spine, where no gross lesion can be detected Slight displacements of the bodies of the lumbar and dorsal vertebræ, presumably accompanied by slight unrecognizable fractures, can also be demonstrated radiographically now and then, and cause traumatic spondylitis on the one hand, or be the physical basis of numberless nerve symptoms, often designated as traumatic neurasthenia, on the other Nerve-root phenomena may also be prominent (p 422)

(B) **Complete Fractures** are usually associated with displacement and loss of continuity of the spinal column, and hence are often termed **Fracture-Dislocations.** They result either from direct or indirect violence, and are most common in the lower cervical or upper dorsal region There is always a tolerably extensive lesion (Fig 459), thus, the spinous processes and laminæ may or may not be fractured, the ligamenta interspinosa, supraspinosa, and subflava torn, the articular

processes fractured in the lumbar and dorsal regions, or displaced without fracture in the cervical, and either the intervertebral substance is torn across, or the bodies of one or two adjacent vertebræ are broken, thus severing the spine into two halves The upper or movable portion is usually driven forwards over the lower or more fixed fragment, and impaction or comminution is often present The spinal cord is compressed between the upper end of the lower fragment and the laminæ of the upper fragment, and although the displacement may be naturally remedied by the falling back of the bones into position ('recoil'), yet the effects of the crush on the cord are usually irremediable In slighter cases the spinal membranes may be merely punctured by a splinter of bone, or hæmorrhage may occur either within the membranes or outside them in the fatty theca vertebralis Excessive indirect violence may lead to an associated fracture of the sternum

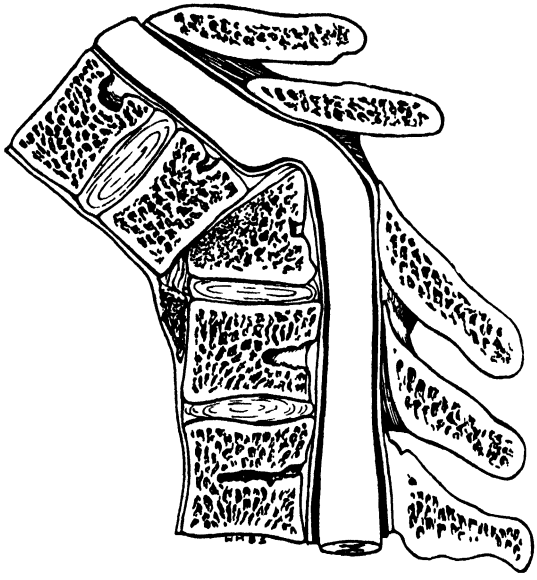


FIG 459 —COMPLETE FRACTURE-DISLOCATION OF THE SPINE IN THE LOWER DORSAL REGION, WITH DISPLACEMENT AND COMPRESSION OF THE CORD

The **Signs** of a complete fracture are usually very evident, consisting of local pain, swelling, and bruising, and a certain amount of angular deformity, although the latter often disappears when the patient is laid flat on his back for transport to his home or to the hospital It may be possible to elicit crepitus if the parts are not impacted, but all unnecessary movement should be avoided for fear of adding to the injury of the cord Paraplegia below the part injured is present in most cases, and with it some amount of general shock When the cord is disintegrated or divided, complete flaccid paralysis of the parts below is developed, together with anæsthesia, and a fatal issue often occurs at an early date from toxæmia, preceded by septic cystitis or sloughing of the nates Lesions of the cervico-dorsal region in which the cord is extensively damaged quickly become dangerous to life in that they cause paralysis of the muscles of respiration, with the exception of the diaphragm, and hence predispose to static pneumonia. Complete lesions at or above the level of the fourth cervical segment are usually fatal at once from involvement of both phrenic nerves. The general mortality of fracture-dislocations of the

ɔine is about 70 per cent The special phenomena of paraplegia at ifferent levels are dealt with at p 805

The **Prognosis** of these cases turns largely on the situation of the ıjury and the amount of mischief sustained by the cord The higher ıe lesion, the greater the danger, although patients with paraplegia om cervical fracture may live for years, and even partially recover, the cord has not been totally disintegrated

The **Treatment** naturally varies with the character of the case 'he patient is carefully placed on a prepared bed, the greatest gentleess being used in handling and lifting him, for fear of increasing the amage to the cord The bed must be firm, though not hard, perhaps he best type to employ is a divided horsehair mattress placed over racture-boards, nothing more soft or yielding is permissible Spring ɔeds and wire-wove mattresses are most undesirable A water-bed ɔ required in the later stages, but should not be used at first, as it is carcely firm enough The shock resulting from the accident is treated n the usual way by warmth and, if need be, by stimulants, but it nust be remembered that anæsthetic regions of the body can be asily blistered or burnt by hot-water bottles, unless carefully guarded ɔy flannels When reaction has occurred, a more thorough examinaıon of the patient can be made, and the subsequent course of treatnent decided on

(*a*) In a small minority of cases, *operative treatment* is justifiable, ınd has for its object either the immediate fixation of the fracture Albee's operation), or the relief of pressure on the cord (laminectomy) For details of these proceedings, see p 807

(*b*) When displacement persists owing to impaction of the fragnents, *reduction* under an anæsthetic may possibly be undertaken, ɔrovided that the lesion is not in the cervical region and the paraɔlegia not complete Of course, if other internal injuries are present which render the case hopeless, nothing active should be done Great :are must be used in attempting reduction, since any undue violence nay readily increase the mischief, in the lumbar region, however, considerable force may be employed without much danger Whether ·eduction is accomplished or not, the further treatment must be lirected in accordance with the indications given in the next section Where the surgeon fails to reduce the deformity, it may sometimes be advisable to make gradual weight extension from the feet or neck

(*c*) In many cases, as soon as the patient is laid flat on a bed, the displacement remedies itself, especially if the spine has been comminuted, and then the treatment must be *symptomatic*, as also after reduction or operation where the paraplegia persists or is only slowly recovered from He is kept in bed, absolutely flat, and with the head low, perhaps some form of mechanical support, *e g.* a plaster-of-Paris or leather jacket, may be desirable, but its application is a matter of difficulty unless a special table is available, and in the early stages it does but little good Food is regularly administered, and at first must be light and readily assimilable

The chief care of the attendants must be directed to the skin, bladder

and bowels *Bedsores* are extremely liable to form on all points of pressure, and hence the nates and heels must be carefully guarded In turning the patient to attend to the nates, the body must be rolled over as a whole, and not merely the pelvis twisted When the *bladder* is paralyzed, the urine may be withdrawn by a catheter One of the chief dangers that the patient runs is from the supervention of septic cystitis, and the extension of the inflammation upwards to the kidneys This is generally due to infection from without, and the greatest care must be taken to prevent it The penis should be thoroughly purified, and in the intervals between instrumentation wrapped in a dry sterile dressing Only soft rubber catheters are employed, and these must be boiled before use, and lubricated with some sterile material Should infection occur, the bladder is irrigated twice daily with some mild antiseptic, such as Condy's fluid, boric acid, boro-glyceride (1 in 20), or sanitas (1 in 20), whilst urotropine or some other urinary antiseptic is administered Probably, in spite of all precautions, the condition will persist, and prove fatal from extension to the kidneys Recognizing this fact, it has been recommended by some authorities to allow the condition of distension with overflow to occur in order to avoid the passage of catheters, the urine is permitted to flow away into sterile flasks frequently changed It has, however, been proved that massage of the prostate, as recommended by the late J B Murphy, is effective in determining reflex micturition, and if suitable male attendants are available, this method should always be employed, but it is useless if once catheterization has been started The *bowels* are always obstinately constipated, and must be opened either by purgatives or simple enemata

Under such a régime the patient may gradually recover, but more often succumbs to chronic toxæmia or exhaustion Occasionally he may live for a long time, although paralyzed, not unfrequently developing some amount of reflex micturition if the lumbar centres are not involved Varying degrees of restoration of power in the lower limbs are observed if the cord is not completely divided

Dislocations of the Spine can only occur in the cervical region The reason for this depends partly on the greater fixity of the dorsal and lumbar vertebræ, and partly on the direction of their articular processes In the cervical region these look mainly upwards and downwards, with a slight slope forwards and backwards, so that it is not difficult for one to slip over the other, in the dorsal and lumbar region they are placed nearly vertically, and dislocation is impossible without a serious concurrent fracture, although slight displacements may quite well occur (p. 790)

Any part of the cervical region may be the seat of a dislocation The *occiput* has been displaced from the *atlas* in a few cases, resulting in sudden death, but if incomplete, life has been prolonged for a few hours or days Dislocation of the *atlas from the axis* has followed blows on the neck, or has been the cause of death in hanging, whilst the attempt to lift a struggling child by the head has sometimes led to this calamity. In almost all cases the odontoid process has been fractured or the transverse ligament torn, causing instant death from

compression of the cord, owing to the head and atlas slipping forwards Lateral displacement from rotation has also been observed, the cord symptoms then being of a milder type

Dislocation may occur between any two of the *lower five cervical vertebræ*, but perhaps most frequently between the fifth and sixth It is most commonly unilateral, and almost invariably the result of forcible flexion of the head and neck, together with rotation The head and upper portion of the spine are displaced forwards and twisted, so that the articular process of the upper vertebra involved slips over the front edge of the lower opposing articular process, and becomes caught by it so that it cannot return

When the lesion is *unilateral*, the head is turned towards the opposite side, and more or less fixed, and the ear is raised There is no evidence of compression of the cord, although tingling and neuralgic pains are caused by pressure upon and stretching of the nerve-roots of the intervertebral notch The spinous processes may be irregular and displaced laterally, and the line of the transverse processes is similarly altered Such signs are, however, very difficult to make out in thick necks, and in consequence the condition is sometimes overlooked and left unreduced, giving rise to deformity, and permanent neuralgia may result However, a good skiagram will often clear up the diagnosis In early cases *replacement* may be accomplished The patient is anæsthetized, the body fixed, and traction made upon the head and neck away from the side of the dislocation, so as to unlock the edges of the articular processes Reduction may be effected with a definite snap or catch In old-standing cases an operation may sometimes be attempted to relieve pressure on the nerves, but it is impossible to replace the bones



FIG 460.—DISLOCATION OF THE CERVICAL SPINE (COLLEGE OF SURGEONS MUSEUM)

The fourth cervical vertebra is displaced forwards, projecting in front of the fifth, the body of which compresses the spinal cord

If the condition is *bilateral* and complete (Fig 460), there is a more serious involvement of ligaments, and the anterior displacement of the upper segment is such as to lead to grave pressure upon the cord and paraplegia Occasionally, however, the lesion is only partial and then the cord may escape without immediate injury, owing to the large size of the canal in this region, although hæmorrhage and inflammation may subsequently cause grave symptoms **Treatment** is of but little avail in most of the cases of complete double dislocation, since probably the cord is irretrievably damaged, but when paraplegia is incomplete, it is possible that benefit may arise from early inter-

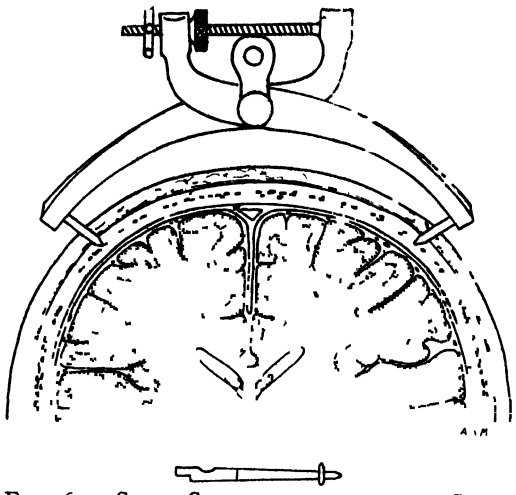


FIG 461 —SKULL CALIPERS APPLIED TO THE SKULL
Two small burr holes are made with a drill which pierces the outer table only (The flanged drill is seen at the bottom of the picture)

ference Replacement by traction on the head with the neck flexed may be first carefully tried, and, failing that, open reduction should be attempted Continuous traction can be maintained by the use of calipers, which are inserted into the skull (Figs 461 and 462) The requisite amount of traction can be maintained in the flexed position for any length of time Patients tolerate this form of treatment extremely well and do not complain of any pain Open operation consists in stripping the muscles from the bones, when the surgeon will see the two cartilage-covered surfaces of the upper articular processes of the lower vertebra standing out clearly behind the laminæ of the displaced bone Upward traction on the head may now again be made, and reduction thus secured, but if this does not succeed a small portion of the upper margins of the exposed articular processes is excised in order to allow of the unlocking of the bones If the whole processes are removed, reduction is easier, but recurrence is certain unless a bone graft is inserted.

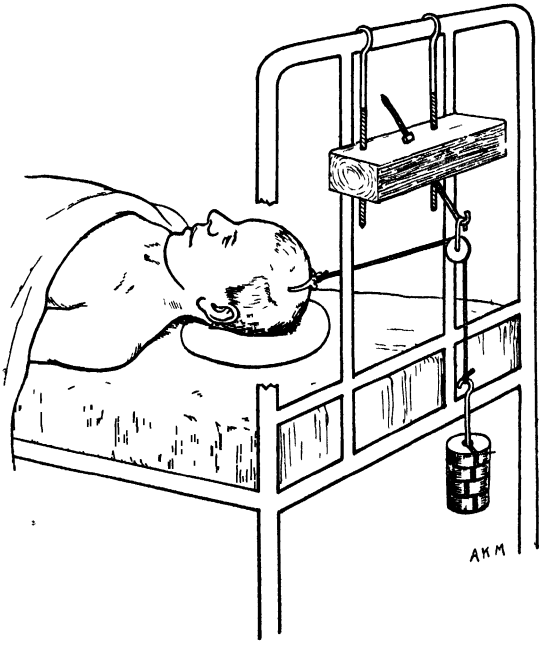


FIG 462 —SKULL CALIPERS IN SITU WITH WEIGHT TRACTION IN THE FLEXED POSITION FOR A CASE OF DISLOCATION OF THE CERVICAL SPINE

Affections of the Cord associated with Spinal Injuries.

Injuries of the spinal column are frequently associated with, or followed by, conditions affecting the cord and its membranes which may lead to the gravest results, even when the local lesion to the spine has been comparatively slight These are frequently blended with one another in the most puzzling fashion, but for simplicity's sake we shall discuss them here separately without attempting to describe the various combinations In the adult the spinal cord

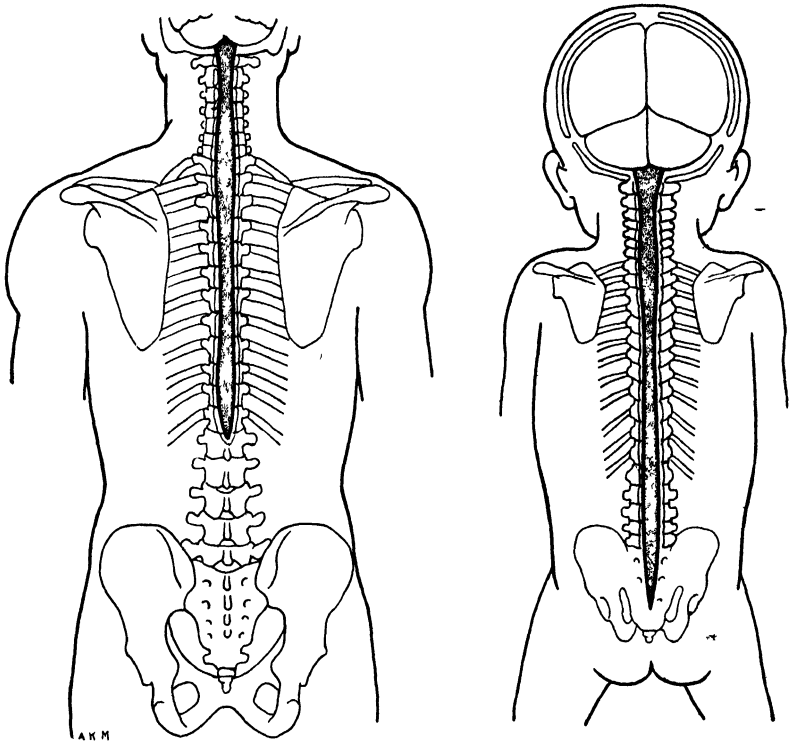


FIG 463 —DRAWING SHOWING THE EXTENT OF THE SPINAL CORD IN RELATION TO THE SPINAL COLUMN IN AN ADULT AND A SIX MONTHS' FŒTUS

terminates at the lower border of the first lumbar vertebra, but in infancy it finishes at a lower level (Fig 463)

Direct Concussion.—This condition may be due to severe blows on the back, which do but little damage to the spinal column, or may be caused by accidents which lead to the infliction of greater mischief, but without any serious displacement of parts There can be little doubt that the condition is due to the presence of minute extravasations in the cord.

The *Symptoms* produced are those of loss of function of that portion of the cord situated below the point struck The patient is usually prostrate from general shock, and the reflexes are absent Death may be caused at once by a blow in the cervical region, or varying degrees of loss of power and sensation may be produced in any or all of the limbs In the lumbar and dorsal regions the patient complains of weakness of the legs, and loss of control over the sphincters Priapism never occurs in simple concussion The temperature of the body is depressed, the pulse is rapid and weak, and the respirations are shallow The *Prognosis* is generally good, the patient recovering after a time, it is unusual for organic disease to follow

In the *Treatment*, absolute rest to the spine is of the greatest importance, and this should be maintained if possible in the prone position, so as not only to diminish static congestion, but also to remove any pressure on the spine, and to allow topical applications to be made A spinal icebag may be applied, or the back may be dry-cupped, and the patient is kept on a low diet The bladder and bowels may require attention, but no special drugs are necessary

Spinal Hæmorrhage can here only be discussed as resulting from injuries It occurs, however, apart from traumatism, and then most frequently in young persons between the ages of ten and twenty The bleeding may take place either into the cord itself or outside it, and hence the two following varieties are described

(*a*) **Intramedullary Hæmorrhage,** or spinal apoplexy (*hæmatomyelia*), is usually met with in the lower cervical region, and results from some accident that causes acute flexion Extravasation into the cord is rarely extensive, and may occur in the form of one clot, generally not larger than an almond, or more commonly in many spots, the grey matter being more or less ploughed up The white matter is compressed, and sometimes the blood bursts through it into the subarachnoid space Should the patient survive, secondary degenerations are established, and run the usual course. The patient is suddenly struck down with a more or less complete paraplegia, and with perhaps pain in the back, shooting round to the chest, and early followed by a rise of temperature The paraplegia consists of a flaccid paralysis of the arms due to destruction of these centres and of the legs from interference with the descending columns Some degree of recovery follows, especially in the legs, but the parts supplied from the damaged portion of grey matter, *i e* the arms, are likely to remain paralyzed In slighter cases only involving the grey matter, the arms alone may show signs of paralysis from the first The *Diagnosis* of hæmorrhage turns on the rapid onset of paralytic symptoms without spinal irritation; fever may ensue for a few days, and if the cervical region is affected, extreme contraction of the pupil (myosis) may result from destruction of the cilio-spinal centre There is retention of urine and fæces, and priapism is common The *Prognosis* depends on the size and situation of the clot, hæmorrhage in the cervical region may be immediately fatal by interference with the respiration, whilst in the lumbar region it is unfavourable on account of the effect upon the sphincter centres. The outlook is best when the dorsal portion of the

cord is affected The *Treatment* is the same as was indicated for direct concussion, whilst the administration of a few doses of ergot may be beneficial

(*b*) **Extramedullary Hæmorrhage** (*hæmatorachis*) is a more frequent complication of spinal injuries, such as sprains or limited fractures, than the former The blood is extravasated between the bones and the dura mater, especially in the cervical region, but is occasionally found within the dura The symptoms are those of spinal irritation, *e g* pain, hyperæsthesia, spasms, cramps, etc , followed after a time by loss of power in the muscles supplied from the damaged area, or by 'gravitation paraplegia' (Thorburn), which gradually extends from below upwards, causing death by asphyxia, the whole series of phenomena being afebrile In intramedullary hæmorrhage the symptoms of paralysis are more violent, and those of irritation less marked If a diagnosis is made, ergotin may be injected subcutaneously and ice applied to the spine, or even laminectomy performed to relieve pressure, later on, prolonged rest is required to permit of the absorption of the clot

Spinal Meningitis may spread downwards from the head, or commence as a local affection Two forms are met with resulting from injury

(*a*) **Acute Spinal Meningitis** is usually seen in conjunction with a similar condition of the cerebral meninges, for even though it follows an infected wound of the spine, it quickly spreads upwards and the cerebral manifestations give the chief colour to the picture It affects the arachnoid and pia mater (leptomeningitis), which lose their polish and become hyperæmic, whilst an abundant effusion containing leucocytes and bacteria, and even lymph or pus, occurs, should the patient live, organization of lymph may lead to extensive adhesions *Clinically*, the disease is ushered in by a rigor and runs a markedly pyrexial course The special symptoms attributable to the spinal trouble are pain in the back, deep-seated, boring and severe, increased on all movements, and often extending down the limbs or around the body, rigidity of the spine and limbs, accompanied by painful cramps and muscular spasms, extreme hyperæsthesia, especially of the legs, and increased reflex excitability Limitation of the disease to the spine may be associated with the appearance of paraplegic symptoms and death from toxæmia, bedsores, or bladder troubles, more usually the patient dies from coma, due to the cerebral infection *Treatment* must be undertaken along lines similar to those employed for the cerebral form of meningitis, *viz* drainage of the effusion by repeated lumbar puncture, and possibly the introduction of suitable anti-sera into the meninges after withdrawal and bacteriological examination of the exudate Symptomatic treatment is required in order to gain sleep and to protect the nates, bladder, and rectum The spinal icebag may be of some service in relieving pain

(*b*) **Chronic Meningitis** is usually localized, and may involve either the arachnoid and pia mater (leptomeningitis), or be mainly limited to the dura mater (pachymeningitis) It may originate as a chronic affection, or is the sequela of an acute attack, and is more likely to

supervene in syphilitic individuals The membranes become thickened, and adhesions to the cord may occur, a chronic sclerosing myelitis is frequently associated with this affection The *Symptoms* are those of localized pain and rigidity in the back, increased on all movements, and accompanied by shooting pains and hyperæsthesia, and perhaps muscular pains and cramps The reflexes are usually exaggerated, and vesical complications may follow *Treatment* consists in prolonged rest with counter-irritation in the form of blisters or the button cautery applied to the back, mercury and iodides are administered internally

Spinal Myelitis may follow injuries of the spine, either as a direct consequence of depressed or displaced bone, or from hæmorrhage, it may also be caused at a later date by extension of inflammation from the meninges, or result from compression by lymph, pus, granulation or cicatricial tissue, or callus It may be acute or chronic In the former the cord becomes red and softened, the nerve elements are destroyed, and finally replaced by cicatricial tissue if the patient lives long enough In chronic cases the connective tissue becomes thickened, and the nerve structures compressed and disintegrated, whilst the meninges are always adherent and thickened

Symptoms—**Acute** myelitis is evidenced by the presence of pain in the back and along the course of the nerves arising from the inflamed area, soon followed by paraplegic symptoms, if these are not already present as the result of the injury Slight irritative symptoms sometimes precede the paralysis **Chronic** myelitis gives rise to a great variety of symptoms, but those most marked are a gradually increasing motor weakness, going on to paralysis, together with various sensory phenomena ending in anæsthesia, and there is trouble with the bladder and rectum

The *Treatment* of each of these conditions is mainly symptomatic

Spinal, or Traumatic, Neurasthenia (*Syn* **Railway Spine**).—Cases are not uncommonly met with in which, although there has been no direct injury to the spinal column or cord, and no immediate symptoms of importance, the fact is manifestly demonstrated in various ways that considerable commotion and disturbance have been produced in the nervous system Railway accidents are the most common cause of this condition, but it may arise from any jar to the spinal column, or even after injuries to other parts of the body The essential features are cerebral, and not spinal The reason why railway accidents are so often responsible for this state is that the forces concerned are very great, and the collision unexpected, so that the muscles and ligaments are taken at a disadvantage, being off their guard, whilst the shock, terror, and mental disturbance are also important factors Ligamentous and muscular lesions, *i e* sprains and strains, are the usual local phenomena produced by such accidents

In the majority of cases the symptoms are mainly due to excessive irritability and weakness of the spinal and cerebral centres, constituting a condition of nerve prostration, or **Neurasthenia,** and the history will usually be somewhat of this type The individual at the time of the accident is thrown from side to side, or severely shaken,

but does not lose consciousness, and, although feeling somewhat dazed, is able to alight without help, and may even assist others He perhaps continues his journey, and goes to his business, but finds in the course of a few hours that his back is painful, his head aching, and that he cannot apply himself to his work He returns home and goes to bed, sends for his doctor, who will probably prescribe rest and bromides His condition remains for a time unaltered, he complains of pain and tenderness over certain regions of the spine, especially the lumbar, and is unable to walk, or to undertake any serious mental or physical effort, whilst all excessive sensory stimuli, such as a bright light or noise, are unusually disturbing Neuralgia is often present, the pulse is weak, the urine may be retained or dribble away, sexual power is lost, and the temperature may be for a time subnormal Accommodative asthenopia (or the inability to accommodate for near objects), resulting in a temporary condition of presbyopia, is also a marked feature in many of these cases All the symptoms are aggravated by mental excitement and exertion, such as are produced by the necessary interviews with doctors and solicitors pending the financial compensation by the railway company The immediate improvement which often follows the satisfactory settlement of his claim for damages is not necessarily due to imposture, but may result from the removal of mental tension and anxiety

This condition of neurasthenia may develop immediately after the accident as an acute condition, the patient lying helpless and prostrate, or more often chronically, as in the more common type of case described above To it, however, is frequently added a considerable element of **Hysteria,** in the form either of an acute attack of hysterics, or of a chronic unconscious exaggeration of the sensory symptoms If the patient is examined in the supposed hyperæsthetic area whilst his attention is distracted, possibly no pain will be complained of

The *Prognosis* is generally favourable, the patient recovering in time, but in a few instances permanent effects may be produced, or even a condition of chronic myelitis

In the *Treatment,* a good deal of care is needed to judge rightly when the period has arrived for encouraging movement rather than rest, and thus to prevent the patient from developing a condition of chronic invalidism Rest in bed is to be recommended at first bromides given in moderation, and fomentations applied locally Later on, friction with liniments and massage should be employed, and when all chance of secondary inflammatory disturbance is at an end, movement should be encouraged, and change of air advised, whilst a course of strychnine and iron may be administered

Paraplegia has been mentioned so frequently in discussing the injuries of the spinal column and cord that a more detailed reference to it is essential

Causes.—(1) It may arise as the direct result of the injury, and then is due to displacement of bone or hæmorrhage (2) It comes on at a slightly later date as a consequence of extramedullary hæmorrhage (localized or of the gravitation type), and that usually without pyrexial phenomena (3) It may be due to the pressure of inflam-

matory exudate, *e g* lymph or pus, and then is late in its development, and preceded by the pyrexia and irritative phenomena of that condition (4) It may develop late in the case from the pressure of callus or cicatricial adhesions around the cord or its membranes (peri-pachymeningitis)

The **Phenomena,** whether due to injury or inflammation, are those of a total transverse lesion of the cord, absolutely destroying one segment The following symptoms result

1 Flaccid paralysis of the muscular area supplied by the destroyed segment, followed by rapid atrophy, reaction of degeneration, and loss of reflexes in this particular group of muscles

2 Flaccid paralysis of all the muscles supplied by the segments below that which has been destroyed The trophic condition remains normal, at any rate for a time, but later, when secondary descending degeneration in the antero-lateral columns has occurred, the muscles become contracted, tense, and rigid (late rigidity)

3 Complete anæsthesia of the sensitive area supplied by the destroyed segment, and of all the sensitive areas below, and loss of the muscular and thermal senses

4 A narrow zone of hyperæsthesia is found at the upper level of the anæsthetic area, due to the irritation of the nerve-roots at the site of injury (girdle-pain)

5 Total loss of all the reflexes, deep and superficial, occurs, with the exception of the tonic contraction of the sphincters of the bladder and rectum In the course of two or three weeks an extensor response appears to gentle plantar stimulation, and possibly this may in time elicit a ' mass reaction ' of the muscles of the leg and even of the abdominal wall The superficial reflexes may reappear, and occasionally the deep ones, but in the presence of septic complications they often disappear, and the limb relapses into a flaccid state, the extensor reflexes vanishing first

6 Vasomotor paralysis combined with trophic disturbances in the parts which are paralyzed

7 Visceral changes, especially in the bladder and rectum In the *bladder* two stages occur (*a*) The period of complete *retention*, due to the interference with the voluntary control, permitting the tonic action of the sphincters to be maintained, as a result probably of the micturition centre being situated in the sympathetic hypogastric mesenteric plexuses The bladder becomes distended, and, unless relieved by catheterism, incontinence with a full bladder follows (*b*) After a while the bladder wall begins to regain its tone, and small acts of expulsion of urine occur, although the catheter may still be required In time periodic reflex micturition develops, in which a varying quantity of urine collects in the bladder, and is unconsciously and involuntarily expelled This is the typical *automatic bladder* of a paraplegic patient, and occurs even in some cases where the lesion is limited to the cauda equina

Cystitis is only too liable to follow and is of a grave nature, possibly associated with sloughing of the vesical mucosa and hæmorrhage, and terminating in an ascending pyelonephritis and uræmia The cause

is almost always septic catheterism, occurring in an individual of low vitality and in tissues of diminished resistance

The *rectum* is also affected in the direction of incontinence of fæces and marked constipation This condition has to be carefully watched, as it will certainly predispose to bedsores

Phenomena of Paraplegia at Different Levels—1 **At the Upper End of the Sacrum.**—Total transverse lesions at this spot are not uncommon, they involve the cauda equina and cause paralysis of the sacral plexus The effects produced are (i) Paralysis of all the muscles of the legs, except those supplied by the anterior crural, the obturator and the superior gluteal nerves, whilst the perineal and penile muscles are also affected (ii) Anæsthesia of the penis, scrotum, perineum, lower half of the gluteal region, and the whole of the legs, except the front and outer parts of the thigh, which are supplied by the cutaneous branches of the anterior crural, and the region supplied by the long saphenous nerve (iii) The bladder and rectum are influenced as described above (Fig 464)

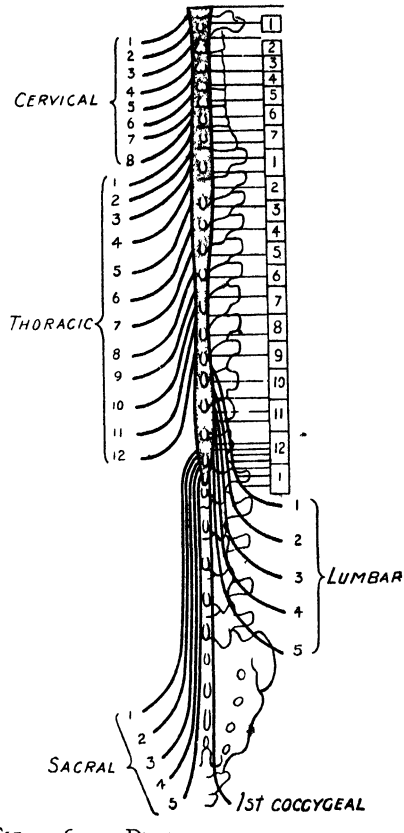


FIG 464 — DIAGRAM SHOWING THE RELATION OF THE SPINAL NERVES AND SEGMENTS OF THE SPINAL CORD TO THE VERTEBRAL SPINOUS PROCESSES

2 If the lesion is situated in the **Dorsi-lumbar** region, or passes through the lumbar enlargement, which corresponds to the twelfth dorsal and first lumbar vertebræ, there is complete paralysis of the muscles of both limbs, including those passing to them from the trunk, total anæsthesia of the legs, gluteal and perineal regions, and possibly the lower part of the abdomen

3 In the **Mid-dorsal** region the same phenomena are met with, but to them are added a more extensive region of anæsthesia, limited above by a hyperæsthetic zone, which feels like a tight painful girdle round the waist Paralysis of the flat abdominal muscles also occurs and is a most important addition to the gravity of the case, for all straining movements are thereby prevented, and thus coughing is embarrassed and defæcation hindered The gases developing from the stagnant fæces accumulate and cause distension of the belly

(meteorism), and thereby respiration may be seriously impaired The diaphragm, moreover, is hampered in its action, since the lower ribs cannot be fixed or steadied, and hence its contractions tend to pull them inwards, instead of increasing the dimensions of the thoracic cavity

4 In the **Cervico-dorsal** region all these phenomena are present, but the anæsthesia extends over nearly the whole trunk, and the hyperæsthesia may involve the arms, whilst the intercostal and spinal muscles are also paralyzed, and there is some weakness of the hand-grasp Respiration has to be carried on by the hampered diaphragm, with the assistance of a few of the accessory respiratory mu cles in the neck, and hence is much impeded, if bronchitis is presents it will prove fatal by asphyxia in a few days from the inability to, cough Priapism is a marked feature of cervical paraplegia, as also contraction of the pupil from interference with the lower cilio-spinal centre

5 In the **Lower Cervical** region the arms also become involved in both the paralysis and anæsthesia, and the patient is likely to die in thirty-six to forty-eight hours, or less, in a condition of hyperpyrexia If the lesion is situated at or above the fourth cervical vertebra, instant death results from paralysis of the phrenics and intercostal nerves, and consequent stoppage of the respiration If the fifth cervical segment is involved, the arms are usually found completely paralyzed, lying by the side of the trunk A lesion through the sixth segment causes the arms to be rolled out and abducted, the elbows being flexed and the hands supinated with the fingers semiflexed (Fig 465) Injury to the seventh segment results in the hands being half-closed, the elbows bent, and the forearms lie in a condition of pronation over the chest

Death from Paraplegia, therefore, may arise from a variety of causes and at various periods It may be immediate, from respiratory failure in lesions above the fourth cervical vertebra, or it may occur from accumulation of mucus or pus in the air-passages, when the lesion is in the upper dorsal region, or it may be delayed for weeks, or even months, and then be due to sloughing of the nates, or septic absorption from an inflamed or ulcerated bladder, which is often associated with suppurative pyelonephritis

The **Prognosis** and **Treatment** both depend on the position and character of the lesion causing the paraplegia, and on the previous habits and condition of health of the individual

Incomplete Division of the spinal cord is by no means uncommon, and opportunity of studying it has occurred frequently of late In the majority of cases the early phenomena cannot be distinguished from those of a complete lesion, being due presumably to concussion, and consisting of (*a*) Complete flaccid paralysis to the level of the lesion, (*b*) anæsthesia to a similar level, (*c*) loss of all reflexes, deep and superficial, and (*d*) retention of urine Evidence of the partial character of the lesion may be forthcoming in a few days or weeks by the reappearance of some degree of motion or sensation, or by spasticity of muscles Difficulty arises when the only early change is one of the reflexes, the initial loss is replaced by a reappearance of

the deep reflexes (patellar jerk and ankle clonus), of an extensor plantar response and a maintained loss of superficial reflexes Sphincter symptoms are not to be trusted as giving any indication of the completeness or not of the cord lesion, for automatic micturition may develop even in hopeless lesions of the cauda equina

Hemisection of the Cord —A lesion involving one lateral half of the spinal cord below the cervical region is not very unusual in military work The resulting symptoms are usually known as the Brown-Séquard syndrome, and consist in (*a*) On the side of the lesion motor paralysis of the leg with an extensor plantar reflex and active tendon reflexes, together with sensory symptoms referable to the division of the posterior column, *viz* loss of the sense of position and of vibration sense, etc , (*b*) on the side opposite to the lesion there is no motor



FIG 465 —DISLOCATION OF THE FIFTH CERVICAL VERTEBRA ON THE SIXTH SHOWING THE ATTITUDE THE ARMS ADOPT

paralysis, but there is loss of cutaneous sensation to temperature and pain

Albee's Operation, originally introduced with the object of fixation of the damaged vertebræ in tuberculous disease of the spine (p 828), has of late had its scope enlarged to provide fixation in other conditions, *viz* (1) in fractures of the spine with persistent non-union, (2) in progressive scoliosis, where the condition is increasing and resists treatment, or where it has attained such a degree as to cause constant pain and gross deformity, and (3) with suitable modifications for spondylolisthesis (p 492), where rest is insufficient to combat the symptoms

In fractures it is not often required, but when partial fractures exist which do not unite, and are a cause of continuous pain and discomfort to the patient, it is a justifiable and useful proceeding The patient is anæsthetized in the prone position, and an incision made over the affected area, the spinous processes being cleared of muscles,

etc , on either side The spines are then split longitudinally by a sharp osteotome A suitably shaped tibial bone graft is cut by means of a twin saw driven by an electric motor, and wedged in between

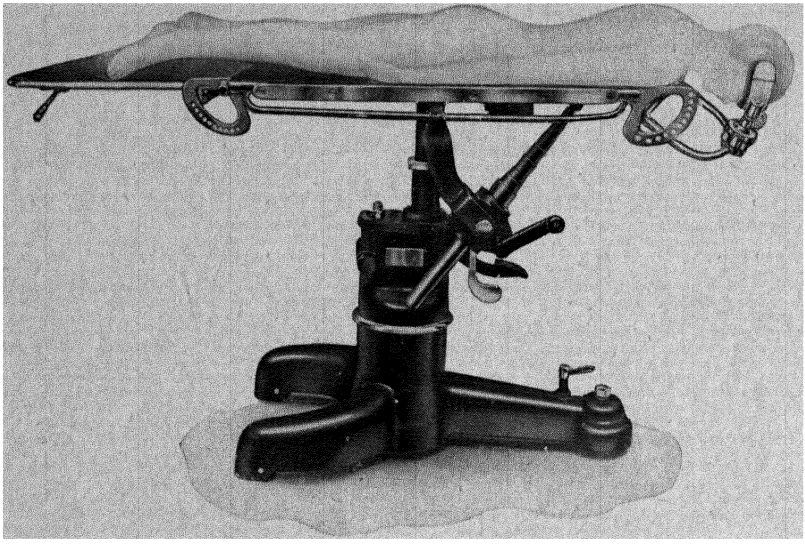


FIG 466 —POSITION OF PATIENT DURING THE OPERATION OF CERVICAL LAMINECTOMY

the divided segments of the split spinous processes, it is fixed in place by suturing the muscles and fasciæ of the back over it The patient is, of course, immobilized in a plaster bed for a time, and the graft usually unites well, thereby determining the fixation required It is

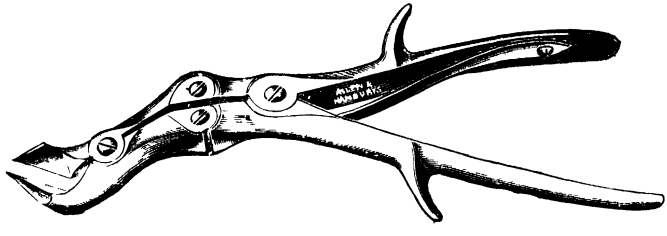


FIG 467 —A USEFUL TYPE OF LAMINECTOMY FORCEPS WITH DOUBLE ACTION

not a serious operation in careful hands, and good results may be anticipated

Laminectomy is an operation for the removal of the laminæ and spinous processes of one or more vertebræ, in order to relieve pressure on the cord, whether due to depressed bone, abscess, granulation tissue, excessive callus, cicatrices, or tumours The operation con-

sists in making a longitudinal incision in the middle line of the back The patient lies prone on the operating-table (Fig 466) The spinous processes are then removed by laminectomy forceps (Fig 467) The laminæ are next removed, it is a convenient plan to make an opening in the lamina with a small trephine and then enlarge the opening with a double-action laminectomy forceps In order to get a good exposure of the spinal membrane and to remove any irregularities of the cut laminæ Hudson's forceps are used (Fig 468) A smooth cut bony surface is thus obtained, and if bleeding from the bones is evident it can be readily checked with bone wax The posterior surface of the dura mater is thus exposed, and if necessary it can be incised in the mid-line and a small grooved director inserted into the opening (Fig 469), and the membrane opened for a considerable distance Any laceration of the dura mater due to injury is inspected, and the various conditions which may be present are dealt with according to circumstances In this place we have merely to consider the use of this operation after injury to the spine For its employment in other conditions, see Chapter XXV, p 833

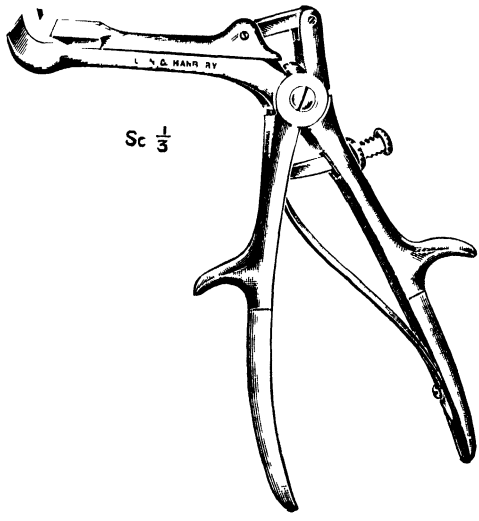


FIG 468 —HUDSON S LAMINECTOMY FORCEPS

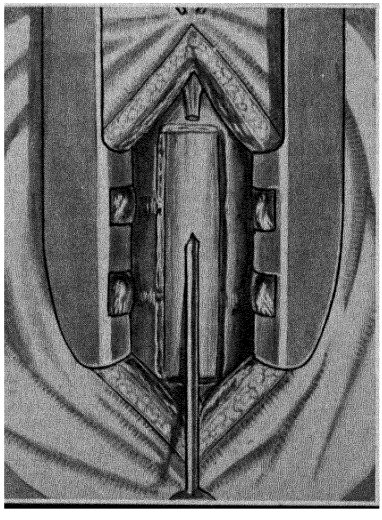


FIG 469 —LAMINECTOMY METHOD OF OPENING THE DURA MATER

It must be remembered as a fundamental principle that repair is impossible after the spinal cord has been divided, or any one segment totally disintegrated, and hence, if it is certain that a total transverse lesion of the cord has been caused by an accident, it is absolutely useless to operate except to relieve pain due to root pressure

This question as to the special features of complete and incomplete lesions has already been alluded to, but one would again emphasize the fact that it cannot be absolutely settled in the early stages of the case, as it is at first impossible to say whether the symptoms are due to concussion, hæmorrhage, or bony pressure Fortunately, delay does not appear to be so prejudicial to the patient's welfare as one might at first expect, and many cases are on record in which a good result was obtained even after months One is therefore justified in waiting a while in doubtful cases In spite of this, however, there will always be a certain number of patients in whom it is a matter of doubt as to whether or not any benefit will accrue from operation The final decision under such circumstances depends on the general state of the patient

Apart from these doubtful cases, the following are generally admitted as being suitable for operation (1) Penetrating wounds or fractures with displacement which involve the spine below the first lumbar vertebra, the cauda equina is present below that level, and not the spinal cord, and it is reasonable to treat it in the same way as one would treat a single peripheral nerve, (2) when the injury is mainly limited to the neural arch, which has been driven in by direct violence, (3) in all cases of bilateral dislocation of the cervical spine where the patient is not moribund, (4) if paraplegia arises with or without inflammatory symptoms, when an interval has elapsed since the accident, the pressure in such cases may be produced by blood or inflammatory exudations, and benefit may possibly arise from the operation, if, however, it is due to a total transverse myelitis, no good can follow (5) When symptoms of irritation or paralysis supervene at a later date, from contraction of cicatrices around the cord or its membranes (peri-pachymeningitis), or from excessive callus formation, laminectomy may be performed with good hopes of a successful result

CHAPTER XXV

DISEASES OF THE SPINE.

Spina Bifida.

By **Spina Bifida** is meant a condition of imperfect development of some portion of the posterior aspect of the spine, with or without a similar affection of the spinal cord and membranes

It must be remembered that the spinal cord is developed as a linear involution of the epiblast, the edges of this medullary groove growing up and uniting so as to include a passage lined with epithelium, and subsequently known as the central canal The cord is gradually separated from the overlying skin by an intrusion of mesoblastic elements, from which the vertebræ, together with the spinal muscles and ligaments, are developed The ossification of each vertebra originates in three main centres—one for the body, and one for each half of the neural arch, whilst epiphyses are developed as plates above and below the body, as also for the transverse and spinous processes

The following are the chief forms of spina bifida

1 A **Myelocele** results from non-closure of the primitive medullary groove It is characterized by the appearance on the lumbo-sacral region of a raw surface, which consists of the spread-out structures of the cord, at the upper part of which opens the central canal The condition is incompatible with life, and the child, if not stillborn, as is usually the case, does not live beyond a day or two

2 A **Meningocele** (Fig 470) is characterized by a protrusion of the membranes, containing cerebro-spinal fluid, through a defect in the posterior walls of the vertebræ, the spinal cord and nerves being in their normal position This variety is not very common

3 A **Meningo-Myelocele** (Fig 471) is due to a development of fluid within the membranes which remain adherent to the skin, the spinal cord or nerves of the cauda equina passing down the posterior aspect of the cavity as a strap, and the nerves traversing and perforating the sac to reach the intervertebral foramina

4 A **Syringo-Myelocele** (Fig 472) arises from a distension of the central canal of the cord, the posterior portion of which usually remains adherent to the skin, from which it has never been separated, owing to defective development of the mesoblastic tissues The spinal nerves travel round the walls of the cyst in order to find their way to the intervertebral foramina Trophic phenomena are nearly always a prominent feature of these cases

Of these forms, the meningo-myelocele is that most frequently seen in living children, although, according to Bland-Sutton, the first is really the most common

Clinical Characters.—A spina bifida (except of the myelocele type) is recognized by the presence of an elastic swelling in the middle line of the back (Fig 473), most commonly involving the lower part of

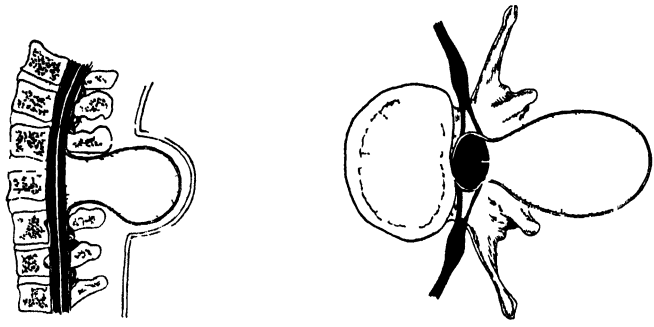


FIG 470.—HORIZONTAL AND VERTICAL SECTIONS OF A SPINAL MENINGOCELL

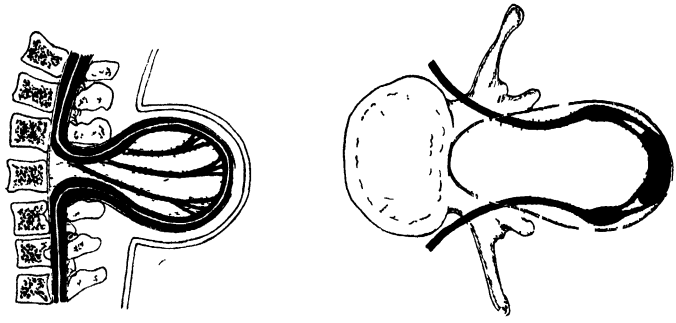


FIG 471.—DIAGRAM OF A MENINGO-MYELOCELE

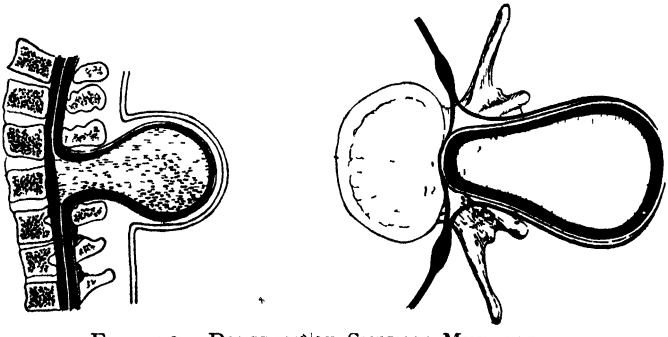


FIG 472.—DIAGRAM OF SYRINGO-MYELOCELE

the spine, it may be covered by normal skin from which may arise an abnormal growth of hair, but usually that over the convexity is thin and translucent, and not unfrequently a number of small dilated

vessels are seen coursing over it On compressing this swelling, its size can sometimes be diminished, and then in infants distension of the anterior fontanelle may be felt, showing that the sac is filled with cerebro-spinal fluid, there is usually a distinct impulse on coughing or crying The margins of the defects in the vertebræ can often be felt at the base of the swelling Other deformities may be associated with spina bifida, especially hydrocephalus and paralytic talipes, whilst perforating ulcer, ankylosis of phalanges, and other trophic phenomena, are frequently developed at a later date

The **Diagnosis** is usually evident, but sometimes in the cervical region a small tense meningocele is not readily recognized Radiography may be of assistance in demonstrating the defects in the vertebræ

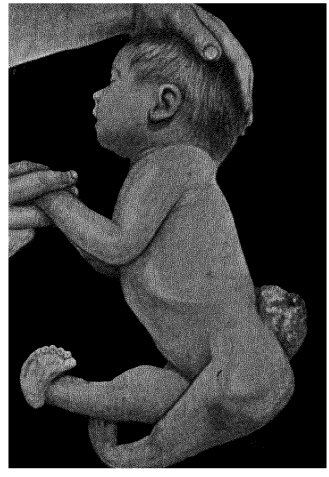


FIG 473 — LUMBO SACRAL SPINA BIFIDA SHOWING DEFORMITIES OF THE FEET

The **Prognosis** of the case depends mainly on the thickness and character of the overlying skin If it is thin and atrophic, as in many cases of meningo-myelocele, the sac is likely to give way, causing death from sudden escape of cerebro-spinal fluid or from infective meningitis If the spina bifida is small, and covered with healthy skin and subcutaneous tissue, the patient may reach adult life, but even then trophic phenomena may supervene, possibly as the result of the presence of foci of nævoid tissue, which have been known to develop in the canal when the cord is absent Occasionally a meningocele, with only a small aperture of communication with the spinal canal, is cured spontaneously by gradual growth of the bones

Treatment —Some cases are best left alone, the tumour being merely guarded from injury by the application of a suitable cap, but if the sac is thin and gradually increasing in size surgical intervention is absolutely necessary Acupuncture or tapping through the healthier integument around the base, repeated perhaps several times, and followed by compression, may lead to a cure in favourable cases

Operative treatment is chiefly applicable in the meningocele type, and infants or those suffering from trophic phenomena do not stand it well An incision is made over the sac, either in the middle line if the cord is not there, or to one side if it is The child should be kept with the head low, so as to limit, as far as possible, the loss of cerebro-spinal fluid In a meningocele, the membranes are cut away, after tying or suturing carefully the pedicle, and the spinal muscles drawn together, so as to create an extra protective barrier, in addition

to the skin and subcutaneous tissues When the cord runs down the back of the sac, it is freed by incisions on either side, and if it cannot be separated from the skin, the whole strip is replaced in the vertebral canal, the membranes are closed over it, and finally the muscles and skin The results in the treatment of meningoceles have been most encouraging

Spina Bifida Occulta is the term applied to a condition in which the posterior portion of the vertebræ is absent, but without any protrusion of the cord or its membranes The overlying skin may be cicatricial in character, or a large growth of hair may arise from it (Fig 474), occasionally a lipoma develops in this situation, and by its growth compresses the spinal cord or drags upon it, and causes paraplegia Unless such a condition is present, spina bifida occulta calls for no treatment, but an exploratory operation should always be undertaken when nervous phenomena supervene



FIG 474.—SPINA BIFIDA OCCULTA IN A GIRL AGED TEN YEARS

Congenital Sacral or Coccygeal Tumours

The majority of these arise from what is known to embryologists as the *neurenteric canal* In early fœtal life the neural and alimentary canals are continuous, the passage of communication being known by the above name Ordinarily, it disappears entirely after the union of the proctodeum with the intestine, but evidences of its existence are occasionally met with, either in the form of a cicatricial dimple adherent to the tip of the coccyx (*post-anal dimple*), or as one of the following conditions

(i) A *dermoid cyst*, containing the usual mixture of sebaceous material and epithelial cells, and often a tuft of hair, it develops in the space between the rectum and coccyx, and may either project below or by the side of the coccyx, or open into the rectum, the tuft of hair may then find its way out of the anus The cavity may actually communicate with the spinal meninges

(ii) A *congenital adenoma* of the post-anal gut (Fig 475) is occasionally found in the same region It is characterized microscopically by the existence of alveoli, lined by cuboidal epithelium, held together by connective tissue, it may attain a large size, but is quite innocent

Various other tumours are met with in infants in this region, and the same title of congenital sacral or coccygeal tumour has sometimes been applied to them

(*a*) A *spina bifida* of the meningocele type, which may communicate with the subdural space, or may have been shut off by a natural process of cure

(*b*) A *lipoma* may also form here, and in some cases has simulated by its shape a caudal appendage

(*c*) A partially-developed fœtus may be met with, enclosed within the subcutaneous tissues of the sacral region, and known as a *teratoma* (p 225)

(*d*) A growth of a mildly malignant character, known as a *chordoma*, may also be found in this region, developing from notochordal tissue A similar development is sometimes seen at the other end of the notochord, *viz* in relation to the basi-sphenoid It is encapsuled and lobulated, and may not only cause absorption of neighbouring bone, but also interfere with the pelvic viscera The histological characters are somewhat indefinite and often of a mixed type



Fig 475 — Congenital Sacro-coccygeal Tumour of Adenomatous Type

Inflammatory Affections of the Spine

I **Acute Osteomyelitis of the Spine** is uncommon It usually affects the mobile portions of the spine in young people, and may involve the bodies of the laminæ It is characterized by severe pain in a localized portion of the back, and fever, deformity is not marked, since necrosis occurs, and not a gradually destructive caries Abscesses form early, and when the arches are involved there is great danger of an extension of the inflammation to the spinal meninges, leading to a fatal issue The prognosis is bad, owing to this latter complication, and the only possible treatment consists in early incisions to give exit to the pus Sequestra can be removed from the back of the vertebræ, but from the front only in the lumbar and cervical regions A subacute form is occasionally met with, usually a metastatic infection with a primary staphylococcal focus Treatment with a spinal jacket gives relief from the acute pain, and the prognosis is favourable

II **Tuberculous Disease of the Spine or Spinal Caries** (*Syn* **Pott's Disease, Angular Curvature**) —The above names are applied to a tuberculous disease of the vertebræ, originating almost invariably in their bodies, which are more or less destroyed, leading to the so-called 'angular curvature' It was first accurately described by Percival Pott in 1779

The **Causes** are much the same as those of tuberculous affections elsewhere, and, indeed, it is often associated with other manifestations of the same disease It most frequently occurs in children under the age of ten years (75 per cent of all cases), and of these it has been demonstrated that 60 per cent are due to infection with the bovine type of tuberculous organism It may, however, arise at any age, and equally in either sex Any part of the spinal column may be involved, but the lower dorsal is by far the commonest The cervical region is rarely attacked, except in children and young adults, whilst in adults the dorsi lumbar vertebræ are the favourite seat

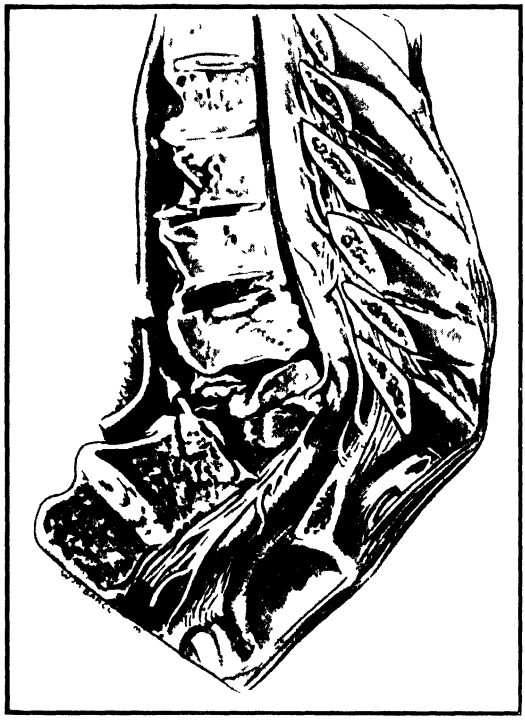


FIG 476.—TUBERCULOUS DISEASE OF SPINE, SHOWING DESTRUCTION OF THE BODIES OF THE VERTEBRÆ AND ABSCESS FORMATION BENEATH THE ANTERIOR COMMON LIGAMENT (SPECIMEN IN COLLEGE OF SURGEONS MUSEUM)

Pathological History —The disease commences either as a periostitis or an osteomyelitis The *periosteal* variety rarely occurs, except in adults It involves the anterior surface of one or more vertebræ, and spreads under the anterior common ligament from one bone to another, whilst the intervertebral discs are also attacked and destroyed The *endosteal* form is much the more common, and is almost invariably the type seen in children The tubercle is deposited in relation with the plate-like epiphyses of the bodies, and produces its usual effect in softening and disintegrating the osseous tissue The anterior parts of the bodies are affected more than the posterior, and hence deformity is common and nervous affections rare The deformity is more or less of an angular type, due to the bodies falling together, either from the weight of the trunk, or from muscular action, or when the patient has been in the recumbent position from the cicatricial contraction which is associated with the healing of the granulation masses in the front of the bodies The disease spreads to adjacent vertebræ, either through the intervertebral discs, which are destroyed in the process,

or by extension under the anterior common ligament, when it may become widely diffused, body after body being eroded, and the cartilages suffering even more than the bones (Fig 476) In such a case the deformity is not angular, but rather of a general kyphotic nature Occasionally the disease starts simultaneously in many foci, so that the bodies of several vertebræ become pitted and carious, without producing general destruction In other cases the process is limited to the bodies and intervertebral discs of two adjacent vertebræ, the periosteum being but little affected This variety is, perhaps, most common in the lumbar region, where the bodies of the vertebræ are large and permit a limiting zone of sclerosed tissue to form, it is also not uncommon in this situation to find definite sequestra in adults (Fig 477) Unequal crumbling and falling in of the sides of the vertebræ will lead to lateral deformity, but this is not very common

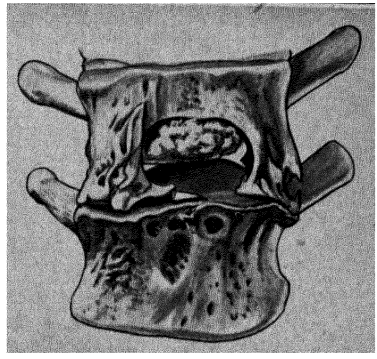


FIG 477 —TUBERCULOUS DISEASE OF TWO LUMBAR VERTEBRÆ SHOWING SEQUESTRUM ON THE ANTERIOR ASPECT AND LATERAL THICKENING PREVENTING ANGULAR DEFORMITY (COLLEGE OF SURGEONS MUSEUM)

Natural cure is effected by the bodies of the vertebræ falling together and becoming ankylosed, so that apart from treatment a deformed and immobile condition of the spine is the best result that can be anticipated The new bone thus formed becomes in time sclerosed and very dense, and the synostosis also involves the spines and laminæ In favourable cases this occurs without suppuration, but not unfrequently abscesses form Occasionally the tuberculous process extends backwards through the body of the bone, so as to implicate the posterior common ligament, and symptoms from pressure on the cord may then arise

In the upper cervical region the disease usually starts in the large joints, either between the occiput and atlas, or between the atlas and axis For a time it may be limited to one side, but the body of the bone is attacked at an early stage, and the trouble then spreads to other joints A special complication of this variety will be mentioned hereafter (p 823)

The **Signs and Symptoms** produced by tuberculous caries of the vertebræ vary considerably in different situations, but for practical purposes may be described under the following five headings

1 **Pain** is a constant and invariable accompaniment of the disease, although in the early stages it may not be specially prominent, being only elicited by careful examination It is of two main types, the local and the referred *Local pain* is often not severe, but can usually be elicited by pressure or percussion over the spines, or perhaps more effectually by pressing upon the transverse processes so as to induce

rotation of the vertebral bodies one on another Movements of the spine, bending or twisting, are similarly painful, whilst the same result can be brought about by jarring the spine, as by a blow on the head or nates *Referred pain* is produced by pressure upon, or irritation of, the roots of the nerve as they emerge from the intervertebral foramina, consequently its distribution is governed by the arrangement of the nerve-root area of the affected spinal segment (p 423) If the lumbar region is affected, the pain is referred down the legs, in the dorsi-lumbar region it may follow the last dorsal nerve, and be noticed in the lower part of the abdomen, or in the gluteal region, in the lower dorsal region pain is referred to the epigastrium, children who are unable to differentiate its precise nature complaining of 'belly-ache', in the cervico-dorsal region the pain often extends into the arms

2 **Rigidity** of the spine is a constant accompaniment of Pott's disease In the *early* stages it results from muscular spasm, the object being to fix and immobilize the painful part If the lower portion of the spine is involved, the back is held stiff and straight, the patient abstaining from all movements which would bend or stretch it Thus, in order to pick up an object from the floor, the knees and hips are flexed, and the patient gradually lets himself down with an absolutely rigid back into a sitting or squatting posture, the body is raised in a similar manner by resting the hands upon the thighs, the patient, as it were, climbing with extended arms up his own legs In a small child rigidity in the dorsi-lumbar region can be demonstrated by laying him on his face with legs together, grasping the two ankles with one hand, and ascertaining the amount of movement in that region by lifting the legs from the table, and also by moving them from side to side, the other hand steadies the body above the suspected lesion In a healthy child the legs can be elevated, and the spine bent back in the dorsi-lumbar region, nearly to an angle of 60 degrees, whilst lateral mobility to the extent of 30 or 40 degrees on either side of the median line is obtainable When caries is present, neither of these movements can be made without including the thorax and dorsal spine In cervical caries the patient steadies the head, and at the same time raises the shoulders by the help of the trapezius and sterno-mastoid muscles, whilst the chin is often supported by one hand, and the patient twists his whole body in order to look sideways

In the *later* stages, when repair is taking place or has occurred, rigidity of the spine is due to osseous ankylosis After a cure has been established, compensatory movements of other portions of the spine mask to a certain degree the localized rigidity

3 **Deformity** is necessarily present in almost all instances owing to the character of the reparative process The amount of the deformity depends on many circumstances, and perhaps chiefly upon the number of vertebræ affected Where only two bones are involved a true angular deformity may result, the body of the upper vertebra being welded to that of the lower, so as to produce a wedge-like mass, compensatory curves of the spine above and below enable the patient to assume the erect posture When a large number of vertebræ are affected the curvature is never angular, but the whole region becomes

bent forwards, and that sometimes very acutely (Fig 478) In the lumbar region (and to a less extent in the cervical) loss of the normal forward convexity is often the most marked feature, the vertebræ being piled, as it were, one above the other, so as to constitute an absolutely vertical column (Fig 479) When the affection is limited to two lumbar vertebræ, there is usually little or no displacement, as the disease occupies the centres of the bones, so that the sides may escape altogether In the dorsal region the deformity is usually well marked, as several vertebræ are often involved, the length and obliquity of the spinous processes make the posterior projection very considerable In the cervical region there is rarely much deformity, owing to the small size of the vertebral bodies, but if several bones are involved, the head may be carried forwards and flexed, necessitating considerable compensatory changes in the dorsal, or even lumbar regions

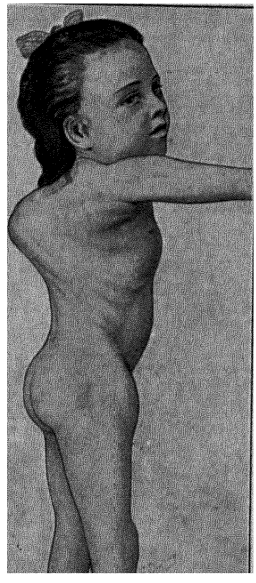


Fig 478 Advanced Tuberculous Disease of Spine in Dorsal Region

Secondary changes in the shape of the thorax accompany advanced cases in the dorsal region, the sternum becoming convex anteriorly so as to compensate for the diminished vertical measurement of the thorax, and the ribs crowded together The lower floating ribs may, however, retain their normal position, and thus a horizontal groove may be produced corresponding to the line of the tenth rib In such cases the patient becomes much stunted in growth and dwarfed, constituting the typical 'hunch-back'

4 **Abscess** is the most serious result of spinal disease, for, owing to its deep origin, it often attains considerable dimensions before it is recognized or treated, whilst it is usually impossible to deal with the causative lesion in the bones It is relatively more common in adults than in children The pus collects primarily on the anterior aspect of the vertebræ beneath the anterior common ligament (Fig 476), which may be stripped from the bones for a considerable distance It thence finds its way to the sides of the bodies after perforating the ligament, and burrows in various directions, according to the portion of the spine involved

In the cervical region a *chronic retropharyngeal abscess* is first formed, it pushes the posterior pharyngeal wall forwards, and may be detected from the mouth as an elastic fluctuating swelling, which, by its size, often leads to some difficulty in swallowing and breathing, whilst œdema of the glottis may be induced Left to itself, it may burst into the pharynx and suffocate the child, or at best pyococcal infection follows, and the osseous lesion is thereby aggravated Not unfrequently the pus finds its way to the side of the neck, behind the vessels

and sterno-mastoid, being guided to the posterior triangle by the prevertebral fascia, behind which it is situated Less frequently it pierces this fascia, and presents in the anterior triangle, or travels down towards the mediastinum, or along the brachial nerves to the axilla

In the dorsal region the abscess starts in the same way in front of the vertebræ, and usually extends backwards between the vertebral ends of the ribs to form a *dorsal abscess*, which points 3 or 4 inches from the spinous processes, and has an impulse on coughing Sometimes it comes to the surface at the spot where the lateral cutaneous branches are given off, and then they cause tuberculous disease of the ribs, leading to caries or necrosis, or even a localized empyema In

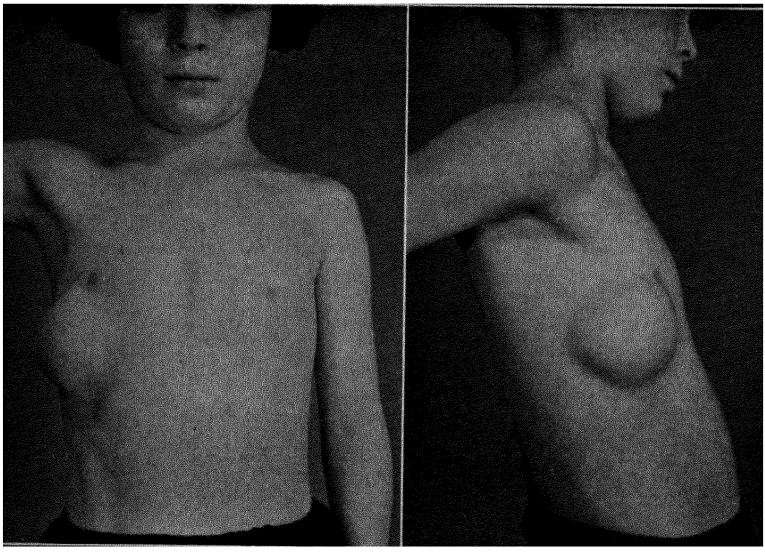


FIG 479.—LARGE TUBERCULOUS ABSCESS ASSOCIATED WITH DISEASE OF THE FIFTH AND SIXTH DORSAL VERTEBRAL BODIES

disease of the lower vertebræ the abscess generally burrows downwards, passing under the ligamentum arcuatum internum of the diaphragm, and giving rise to a psoas abscess

In disease of the dorsi-lumbar or lumbar regions, either a lumbar or a psoas abscess may result A *lumbar abscess* is due to the passage backwards of the pus along the posterior branches of the lumbar vessels and nerves to the outer border of the erector spinæ, and usually presents superficially in Petit's triangle, *i e* between the adjacent borders of the latissimus dorsi and external oblique muscles It there forms a tense fluctuating swelling, with an impulse on coughing A *psoas abscess* (Fig 480) lies within the sheath of the psoas muscle, the pus being usually superficial to the muscular fibres, some of which

are probably destroyed It is often preceded by a condition of spasmodic contraction of the muscle with limited extension of the thigh, which may disappear after a period of rest In time a resistant mass of a fusiform shape is felt placed deeply in the abdomen, as it enlarges, it usually burrows outwards under the fascia iliaca to form a tense rounded swelling in the iliac fossa (Fig 481) It thence travels under Poupart's ligament, behind and external to the common femoral vessels, being constricted at this spot so as to form a narrow neck The sac then expands behind the common femoral sheath, the vessels being often displaced forwards, and the vein flattened out and compressed Thence passing along the tendon of the ilio-psoas to the neighbourhood of the lesser trochanter, the abscess usually burrows amongst the adductor muscles, forming a large swelling on the inner side of the thigh, and comes to the surface at or near the saphenous opening to the inner side of the main vessels, and hence may be mistaken for a femoral hernia Occasionally the pus follows backwards along the internal circumflex artery, and may point behind the great trochanter, in neglected cases the abscess has been known to extend down the leg, and has even been evacuated by the side of the tendo Achillis In a few instances the pus finds its way into the pelvis, and then points in the ischio-rectal fossa, or possibly burrows through the sacro-sciatic foramen

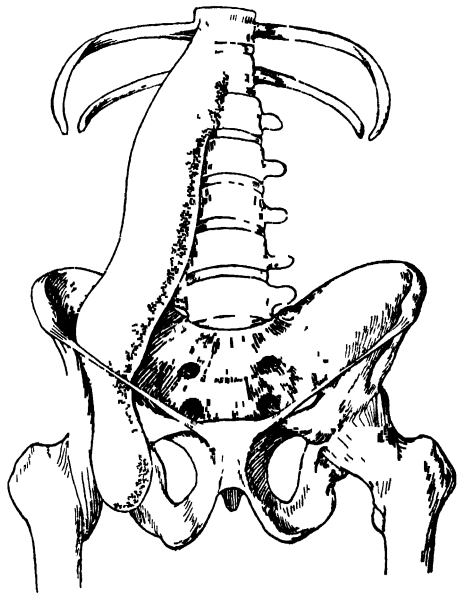


FIG 480 —DRAWING TO SHOW A PSOAS ABSCESS IN RELATION TO SPINE AND PELVIS

In the most typical variety, *viz* with a pouch both above and below Poupart's ligament, communicating by a narrow neck, cross-fluctuation can be detected in the lower pouch by compressing the upper, or *vice versa* There is, of course, an impulse on coughing in the portion below Poupart's ligament

The constitutional disturbance associated with the formation of these abscesses is usually but slight, and there is no leucocytosis, perhaps there is a small rise of temperature at night, but if, as occasionally happens, auto-infection with pyogenic organisms occurs, this becomes more marked As the pus comes to the surface, considerable pain may be experienced from the tension and irritation of the soft parts

5 **Nervous Symptoms** occur in about one out of every thirteen patients, and then generally in bad or neglected cases They are

scarcely ever due to the acuteness of the curve, but have been known to result from fracture of the spine, the integrity of which had been weakened by the inflammatory process The usual cause is an extension backwards of the disease, so that a nodule or button of tuberculous material forms beneath the posterior common ligament, or pushes through it, compressing the cord against the laminæ, and actually invading the dura mater Occasionally an abscess burrows backwards and compresses the cord, and then the symptoms may be relieved by opening the abscess even at a distance

The effect produced varies with the rapidity and acuteness of the process When the pressure is rapidly developed, granulation tissue springs up around and involves the theca, and a subacute myelitis ensues, but more frequently it is of a chronic or sclerosing type The cord is then constricted or indented by the tuberculous mass, and perhaps reduced in size, its texture is firmer than normal, and the colour greyish The onset of symptoms may be suddenly induced by hæmorrhage or displacement of bone, but is usually gradual The dorsal region (about the eighth vertebra) is most often involved, since there is plenty of space in the cervical region, and in the lumbar the cord has broken up into the cauda equina

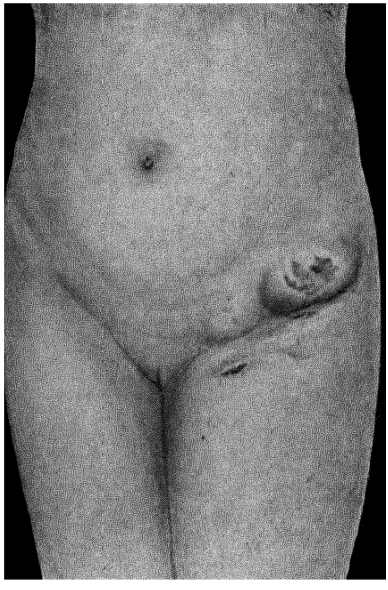


FIG 481 —PSOAS ABSCESS POINTING IN THE ILIAC FOSSA AND BURROWING AMONGST ADDUCTOR MUSCLES

The symptoms arising from pressure on the cord must be distinguished from those due to irritation of, or pressure on, the nerve-roots The latter causes neuralgic pain within the area of distribution of some nerve-roots, possibly in the later stages associated with anæsthesia (*anæsthesia dolorosa*), or a limited motor weakness if the anterior roots are involved In compression of the cord the signs are usually of a paraplegic type, which come on suddenly or gradually The latter is the more common, and the onset is at first marked by dragging of the toes on walking, the weakness increasing and spreading upwards, until all power is lost Anæsthesia may or may not accompany the paralysis, but when it does, the limbs become flaccid, sphincter disturbance develops, and the deep and superficial reflexes are usually diminished or lost If there is no sensory loss, the limbs are as a rule spastic, and sphincter disturbance is not a prominent feature Spas-

ticity is usually associated with active deep reflexes, extensor plantar response, and absence of other superficial reflexes

Tuberculous disease of the upper two vertebræ usually originates in one or more of the large articulations on either side of the atlas, if these joints become disorganized, displacement may occur at any moment, and in this way the occiput slips forwards upon the atlas, and may lead to gradual or sudden compression of the cord and consequent death The disease sometimes spreads to the body of the axis, and by this means the odontoid process becomes detached, or the transverse ligament gives way, in either case, the weight of the head carries the arch of the atlas forwards, and death ensues at once from compression of the medulla

Course of the Case and Prognosis.—Left to itself, the disease usually progresses more or less steadily, the bone lesion becoming gradually more marked, and abscesses are likely to develop If treated efficiently, and taken in hand early, repair by ankylosis may be confidently expected Even when an abscess forms, prolonged rest may lead to its disappearance, the fluid part of the pus being absorbed, and the solid elements becoming inspissated and dry, forming a putty-like mass lying on the front of the vertebral column, this may subsequently undergo liquefaction, probably owing to infection with pyogenic cocci, constituting what is known as a *residual abscess* Should, however, the abscess burst or be opened, and become septic, symptoms of chronic toxæmia supervene, and the patient is sooner or later exhausted by the discharge, and dies from asthenia If dealt with judiciously and sepsis avoided, the abscess may be cured, and if at the same time the spine is kept at rest, and suitable hygienic measures are adopted, the lesion in the bones is able to consolidate The onset of paraplegia must not be looked on as rendering the case hopeless, since with prolonged rest the paralytic phenomena usually disappear entirely Sphincter control is regained first, sensation reappears, and finally motor power is restored Septic cystitis and bedsores may of course arise as complications, and by their progress may cause death As in tuberculous disease elsewhere, the patient also runs the risk of developing acute miliary tuberculosis, whilst other organs, *e g* the lungs, brain, or kidney, may become affected In spite of these possibilities, however, the prognosis is good as regards life in cases free from complications, and where suitable treatment is practicable

The **Diagnosis** of spinal caries is rarely a matter of difficulty when the characteristic deformity exists, but in the early stages, when the displacement is not evident, or if there is only a very slight prominence of the spinous processes, it is likely to be mistaken for a simple rachitic or static curve, whilst if neuralgic pain is a prominent symptom, it may possibly be looked on as a case of spinal or intercostal neuralgia, or as rheumatism, or even be ascribed to renal affections Tumours of the spine, such as cancer or hydatid cysts, syphilitic disease, and aneurismal erosion, also produce symptoms somewhat resembling those of spinal caries, and in adults it may be impossible from the local phenomena alone to determine which of these conditions is present, but a careful consideration of the general history and of the

onset of the symptoms and a radiographic examination should settle the matter (Plate X)

Treatment—The **general** treatment for tuberculous cases outlined at p 175 must be instituted and carried out in as thorough a manner as possible Every effort must be made to secure sanatorium treatment for these patients, treatment at home is usually very unsatisfactory and liable to be ineffective

Local treatment is designed to secure the development of a suitable and sufficient synostosis with a minimum degree of deformity, and to this end three essentials must be maintained for a lengthy period, often extending into years, *viz* dorsal recumbency, immobilization of the spine, and, in case of need, hyper-extension, to prevent or cure deformity (Gauvain) It is obvious that these desiderata can be best obtained in special institutions where treatment is standardized and the means for securing educational advantages, etc , can also be provided, but if this is impossible, the practitioner must use his ingenuity to assist the child and must require the intelligent co-operation

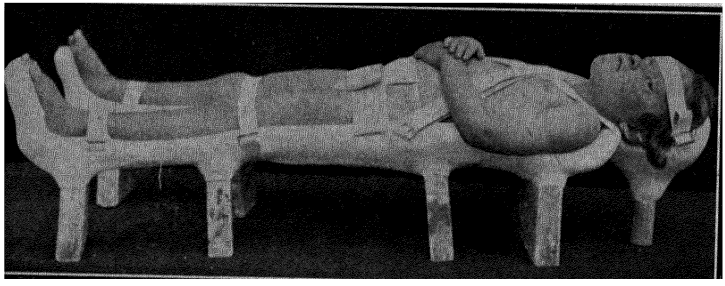


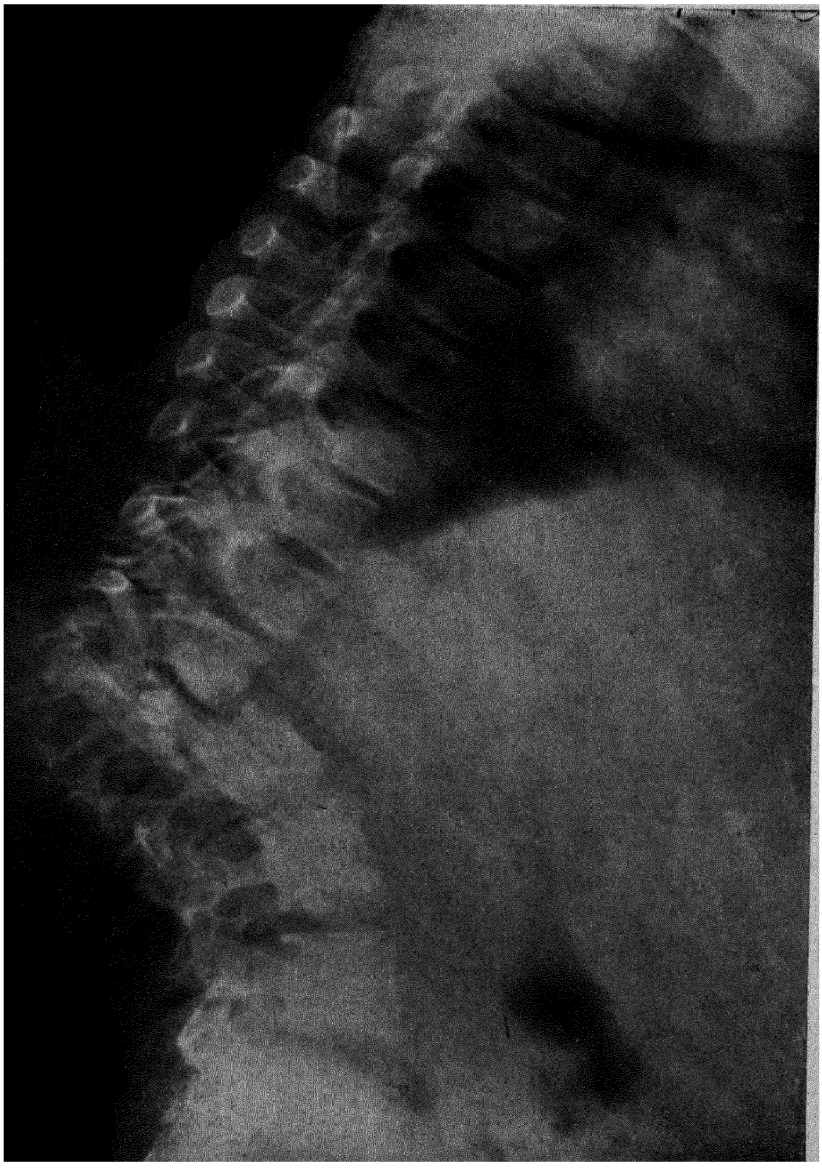
FIG 482—PLASTER BED (SIR H GAUVAIN)

of parents and nurses The actual details of the methods adopted vary enormously in their minutiæ, which it is impossible to discuss here, only general principles can be considered

Recumbency and *Immobilization* can be secured in many different ways Thus (1) The patient is kept in bed lying on his back without a pillow, and with sheets passing over the trunk and thighs, secured by sandbags on either side and between the legs If thought necessary, extension by weight and pulley may be added, together with counter-extension from above by a weight attached to a chin-strap and occipital band, which are united just above the ears For children, a weight of three pounds attached to each of these usually suffices to tire the muscles and prevent serious deformity The child is kept lying down in this way until all signs of active disease have disappeared In cervical disease the head and neck must also be secured with sandbags, or a plaster bed to include the head and neck may be utilized, or even a box splint for the head with a back-board attached may be employed

(2) A double Thomas's splint is employed by some, or a Bradford's

PLATE X



SPINAL CARIES (LATERAL VIEW)

Note the nearly complete destruction of the body of the first lumbar vertebra with consequent angulation of the spine

abduction frame, but in institutions the Berck board and jacket, or some modification of it, is most commonly utilized

(3) Immobilization in plaster is used by some surgeons from the earliest stage, either in the form of a jacket or a plaster bed (Fig 482)

Where a plaster bed is used, the patient is fitted with a vest and turned on to his face Felt, or dressmaker's wadding, is then placed over the whole back, buttocks, and thighs Plaster bandages are applied so as to form a mould over the whole back, and reaching round to the flanks and side of the chest, strengthened when necessary by bands of plaster bandage The mould is then removed and trimmed, the edges being made firm by strips of adhesive plaster It is allowed to dry, and extra padding with gamgee tissue applied

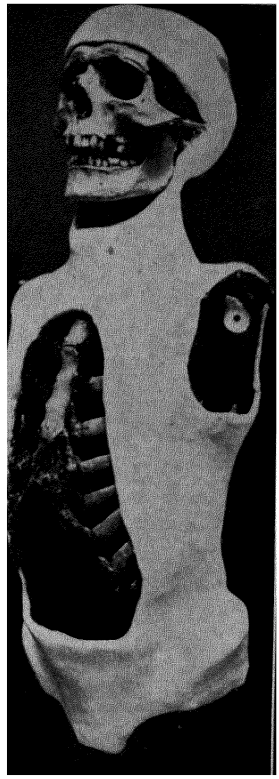


FIG 483—PLASTER JACKET APPLIED FOR TUBERCULOUS CARIES OF UPPER DORSAL SPINE, ILLUSTRATING FIXATION OF HEAD AND NECK BY A COLLAR AND METHOD OF TIGHTENING THE JACKET BY CUTTING OUT A PORTION (SIR H GAUVAIN)

Hyperextension may be secured in any of these various methods without difficulty by the insertion of suitable pads beneath the spine, or by dropping the upper part of the bed in such a manner as will tend to open up the curve When the deformity has not appeared, or is comparatively slight, there is little risk in this manœuvre, although it must be remembered that in itself it delays healing, but under suitable conditions when the child is being trained and educated, this is not a matter of great importance But when the deformity is severe and involves a considerable number of vertebræ, the attempt to undo the kyphosis ought only to be undertaken by specialists who have a trained band of assistants to help them

After the active disease has come to an end and repair is being established, as indicated by complete disappearance of pain, increasing weight and absence of temperature, as also by radiographic examination, the time has come for considering the question of allowing the patient to walk This can only be permitted if the spine is satisfactorily supported, and to effect this the application of a *plaster jacket* is perhaps the most satisfactory plan If the disease exists in the lower dorsal region, the jacket must extend from the axillæ to just below the iliac crests, if situated above the mid-dorsal region, the head also must be immobilized by the formation of a plaster collar (Fig 483) If the disease is in the

lumbar region, the jacket may be applied with the patient in the horizontal position, but above this level the patient must be vertical so as to extend the spine This is best secured by suspending him by means of a bridle attached to the head in a tripod or gallows, and the toes may be allowed to touch the ground The jacket may be reinforced to meet particular strains, but should always be subsequently lightened by cutting away unnecessary portions, *e g* over the abdomen

Some authorities prefer to use celluloid jackets instead of plaster, and certainly they are cleaner and more durable Others employ a brace instead of a jacket in these later stages of the case, and perhaps among the most satisfactory is *Taylor's brace* (Figs 484, 485) Should the cervical or cervico-dorsal region be involved, a ring or collar

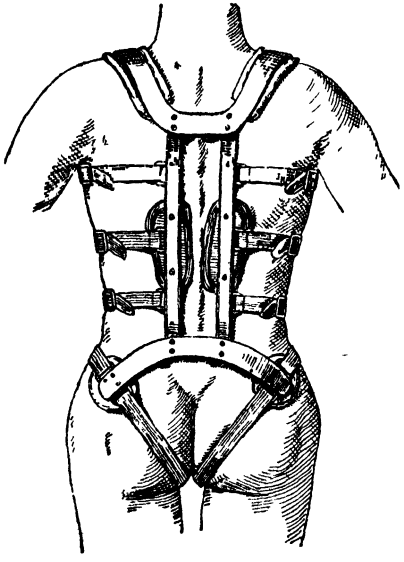


FIG 484 —TAYLOR'S BRACE (POSTERIOR VIEW)

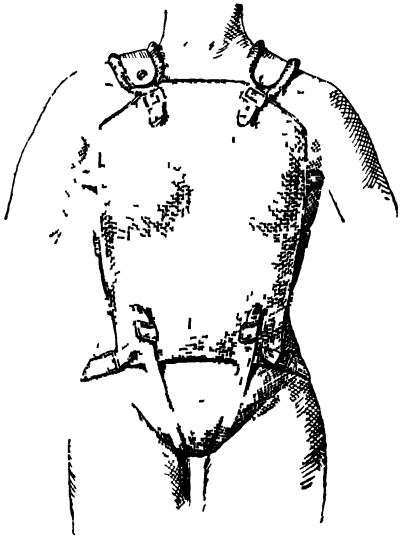


FIG 485 —TAYLOR'S BRACE (ANTERIOR VIEW), WITH LEATHER APRON APPLIED

to support or carry the chin in a suitable position of extension, and fixed by a vertical rod to the brace, must be added to the apparatus

☛ There has been much discussion as to the place and value of *Albee's Operation* in the treatment of tuberculous spines Not a few surgeons who have had abundant opportunity of seeing it and its results do not recommend it, and amongst these may be mentioned Sir Henry Gauvain, others still practise it Obviously it is possible by this means to secure immobilization of the affected area of the spine by the introduction of an internal splint, and this should be of value But it must not be forgotten that the spine, though rigid, is not healed, and that the absorption of the graft or its fracture may lead to subsequent deformity It is generally agreed that it should never be attempted in children under eighteen years of age, and never in the

active stage of the disease, moreover, recumbency for a period of at least six months is almost a necessary part of the after-treatment Under these circumstances the advantages of the proceeding dwindle considerably, but there are a small number of adult patients in whom it is justifiable and helpful, especially when the lumbar region is involved, these cases are mainly such as demand from a pecuniary standpoint the earliest possible return of the patient to normal habits of life Of course, plaster jackets or other external supports are subsequently required just as if no operation of this type had been performed Another method of producing natural ankylosis is by Hibbs's operation, which consists in exposing a number of the spinal processes over the diseased segment, fracturing them, and turning them down so that they interlock The result is a bar of callus fixing the affected area of the spine

The **Treatment of Chronic Abscesses** in connection with this disease must be conducted along lines similar to those indicated at p 177, in other words, they should be recognized and treated at such a stage that opening is unnecessary, and that aspiration should suffice If need be, aspiration can be repeated more than once, and with care the formation of a sinus should be prevented Again, we would emphasize the immense gravity associated with the admission of sepsis to conditions such as these, the patient's life being at once placed in the gravest jeopardy

A *Retropharyngeal Abscess* should always be dealt with from the neck

A *Dorsal, Lumbar,* or *Psoas Abscess* should be aspirated, or tapped with a large aseptic trocar and cannula, and then irrigated and closed without drainage Occasionally a cure can be obtained in this way by one tapping, but seldom when active disease is present, and only when the patient's general health is good, more commonly the fluid will re-collect, and the same process may need to be repeated two or three times Sometimes the fluid finds its way along the track of the cannula, and a sinus results, which must be dressed aseptically until cicatrization has occurred The best position in which to tap a psoas abscess is at a spot just above and internal to the anterior superior spine, the child is rolled towards the opposite side, and the abdominal contents displaced by gentle manipulation If a trocar is to be used, a small incision is made through the skin and muscles, so as to make certain of the absence of intestine and large blood-vessels An abscess should never be left to point below Poupart's ligament, but if such a condition occurs, it may be necessary to deal with it there, perhaps in addition to tapping it in the usual place

The **Treatment of Paraplegia** arising in the course of Pott's disease consists in maintaining the immobilization of the spine by recumbency, combined with weight extension applied to both legs At the same time, extra precautions should be adopted in order to prevent bedsores over points of pressure Should any difficulty in micturition arise, regular catheterism may be required

Laminectomy (p 808) is very seldom needed at the present day, as few cases fail to respond to the modern helio- and aero-therapeutic methods adopted in sanatoria The development even of paraplegia

does not indicate more than a more efficient and thorough employment of these methods If, however, paraplegic symptoms come on so rapidly as to suggest the rupture of an abscess without external manifestations, it may be justifiable to explore the cord and relieve pressure If symptoms persist without improvement for over three months in spite of treatment, exploration is desirable, and relief of the pressure on the cord should be secured The late appearance of symptoms, characteristic of a fibro-cicatricial development around the cord (peri-pachymeningitis), might also warrant operative interference Costo-transversectomy has been advocated as a better route for the exposure of abscesses and granulation masses pressing on the cord This procedure, together with a laminectomy and a bone graft, has been used with success by Girdlestone It must be emphasized that operations for relief of paraplegia in children are never required under modern conditions of treatment, and in adults the cases are rare

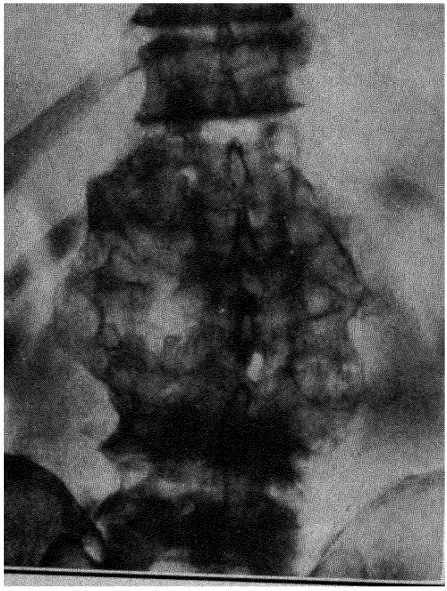


Fig 486 —X-Ray showing Charcot's Disease of the Lumbar Spine (Mr Robert Milne's Case)

III **Syphilitic Disease** is characterized by the development of gummata, commencing beneath the periosteum which covers the bodies, it is of unfrequent occurrence, and gives rise to symptoms somewhat similar to those of tuberculous caries, from which the diagnosis is not always easy, apart from the history and its reaction to treatment It usually occurs in adults, and is said to affect mainly the cervical vertebræ Cases have been recorded in which a gumma opened into the pharynx, and portions of bone were discharged therefrom and expectorated The co-existence of a syphilitic history and of specific lesions elsewhere, together with a positive Wassermann reaction, will determine the nature of the affection

Actual diminution in stature may occur in cases of Charcot's disease of the vertebræ (Fig 486)

Treatment consists in the administration of suitable anti-syphilitic drugs, and in the use of a spinal support

IV **Rheumatic Spondylitis** is a condition occasionally met with

arising from the same causes, and associated with much the same phenomena as rheumatism elsewhere It may involve either the ligamentous or muscular tissues, or may attack the intervertebral joints Any part of the spine is involved, but perhaps the most marked features are presented in the cervical region Considerable impairment in the movements of the head is then produced, and the neck may be laterally deflected, somewhat simulating torticollis If untreated, adhesions form between the bones, and the loss of movement may be permanent Considerable pain of a neuralgic type, due to implication of or pressure upon the nerve-roots, is usually experienced The **treatment** is of an ordinary antirheumatic nature, combined perhaps with the use of a support

The so-called **Gonorrhœal Rheumatism** also affects the spine occasionally, and brings about much the same results

V **Traumatic Spondylitis** is the term applied to a painful condition of the spine which follows injuries, and possibly due to a slight unrecognized displacement or compression fracture of one of the vertebræ (p 792) After the period of rest necessitated by the severity of the injury, the patient returns to work, but his back is persistently painful, and after a time some slight deformity of a localized kyphotic or scoliotic type may appear The reparative changes following on the injury involve a certain degree of congestion of the body of the vertebra, rendering it incapable of sustaining the superincumbent weight of the trunk, and hence it crumples up to some extent, the actual result being governed by the position and severity of the lesion, until the patient is given sufficient rest, the pain will persist and deformity may increase **Treatment** involves the most careful radiographic examination of the spine and its immobilization by suitable apparatus A slight displacement of the cervical vertebræ may justify an attempt to reduce it by manipulation under an anæsthetic, or even an open operation to fix the vertebræ by a bone graft of the Albee type (p 807)

Painful Sacralization of the fifth lumbar vertebra is the term applied to a painful condition of the sacro-iliac region of one or both sides usually attributable to strain It is primarily due to an elongation and enlargement of the transverse process of the fifth lumbar vertebra which encroaches on, articulates with, or even fuses with the lateral wing of the sacrum or adjacent ilium Slight lateral flexion of the spine in such a case may pinch the tissues between the bones, or strain the ilio-lumbar or other ligaments, or even compress the anterior root of the fifth lumbar nerve which passes through this interval The pain produced is of variable type, often simulating sciatica and sometimes renal colic There is always a tender spot just above the sacro-iliac joint, and the pain and tenderness are both improved by rest Radiography is a most important adjuvant in diagnosis, so as to ensure the absence of a urinary cause for the pain **Treatment** consists in rest, the support of a pelvic band and local diathermy, if these fail, manipulation under an anæsthetic frequently gives relief, open operations are usually unsuccessful, although pain may be lessened for a time.

VI **Spondylitis Deformans** is the term applied to a condition of the spine which results in rigidity and kyphosis It is seen most frequently in old people, who become bent and shorter than formerly, but it also develops in those who have had to follow laborious occupations, especially in the bending position, and hence is not uncommon in country workhouses and infirmaries amongst those who have had to live and work in the fields or mines It is akin to osteo-arthritis, and characterized by very similar anatomical changes The spine is stiff and rigid (hence the name 'poker-back' sometimes applied to it), and this results from absorption of the intervertebral discs, from synostosis of the vertebral bodies, sometimes with the formation and interlocking of osteophytes, and especially from ossification of the spinal ligaments Pain is often a marked feature of the case, and is then due to irritation of nerve-roots A large portion of the spine is usually involved, and general kyphosis is the result Two chief varieties have been described (*a*) Von Bechterew's variety is one in which the upper cervical and dorsal regions are mainly involved, producing a limited kyphosis, with flattening of the chest and fixation of the ribs In many of these cases evidences are present of degenerative changes in the posterior columns of the cord and of irritation of the nerve-roots (*b*) The Strumpell-Marie type, sometimes known as *spondylose rhizomelique*, is characterized by the affection first attacking the lower portion of the spine, but it also involves the hip and shoulder joints In both forms there is a gradual extension of the process through the whole length of the column, and finally it attacks the articulations between the ribs and the vertebræ, when these become fixed, the respiratory movements are considerably impaired, and hence death is likely to ensue from pulmonary disease Treatment must follow along the lines laid down for osteo-arthritis



FIG 487.—SKIAGRAM OF SECONDARY CARCINOMA IN THE CERVICAL SPINE

The primary growth was in the prostate There is gross destruction of the upper cervical vertebræ

Tumours of the Spine are usually malignant in character, and most commonly secondary to cancer or sarcoma elsewhere Cancers of the breast and prostate are very likely to metastasize in the spine and gross deformity may result (Fig 487) Simple tumours, such as chondroma, osteoma, and hydatid cysts, occur, as also primary sarcoma

The chief symptoms are severe and localized pain, which is constant, and unrelieved by rest in the recumbent posture, together with early excurvation and paraplegia Deformity is, however, by no means constant Neuralgic pain and motor spasms, due to involvement of the nerve-roots, may considerably aggravate the patient's sufferings These phenomena manifesting themselves in an adult should always suggest the presence of a morbid growth, and the more rapid the onset the more likely is a diagnosis of malignant disease Treatment necessarily is but rarely feasible, although an exploratory operation is quite justifiable if the disease is primary and the patient not profoundly cachectic.

Protruded Intervertebral Disc.—Quite recently cases have been reported in which spinal compression has been caused by enchondrosis of the intervertebral fibro-cartilage Such a tumour is due to a herniation of the nucleus pulposus through the annulus fibrosus (Fig 488) Several hundred cases have now been reported, and it is important that such a condition should be recognized Quite often a history of trauma may be obtained By far the commonest site for herniation to occur is the lower lumbar region, and quite a definite syndrome is produced The syndrome consists of sciatic pain, usually unilateral, with accentuation of the pain on coughing and sneezing Low backache is another constant feature, and quite often there is a diminution or absence of one or both Achilles tendon reflexes In some cases there is a loss of sensation with muscular weakness and incontinence The normal lumbar curve is lost, and there may be a prominence of the spinous processes of the third, fourth, and fifth lumbar vertebræ

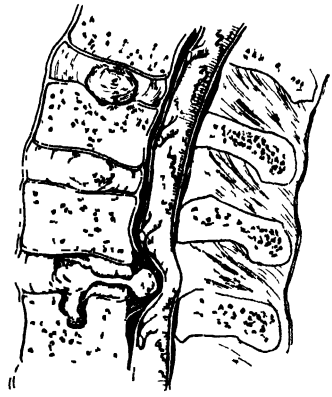


FIG 488.—HERNIATION OF THE NUCLEUS PULPOSUS PRODUCING COMPRESSION OF THE SPINAL CORD

Examination of the cerebro-spinal fluid will show an increase in the total protein When the protrusion occurs in the cervical or thoracic region, there is nearly always some degree of subarachnoid block and Queckenstedt's sign is positive

Treatment consists in laminectomy with removal of the protruded portion of the intervertebral disc There is quite often associated hypertrophy of the ligamentum flavum, and this factor probably contributes in some measure to the symptoms produced

Tumours of the Spinal Cord and Membranes develop in several situations, and the symptoms are thereby somewhat modified. (*a*) Outside the spinal dura (extra-thecal) lipoma and sarcoma are here most often seen, and the symptoms of cord pressure, such as loss of power and sensation, are preceded by those of spinal irritation, *e g* neuralgic pain increased on movement, and are often limited for

some time to one side Multiple neuro-fibromata of the nerve-roots are by no means uncommon (*b*) They may grow inside the dura mater (extramedullary intrathecal), and thus produce symptoms of cord pressure and meningeal irritation concurrently Fibroma, endothelioma, and gumma are the commonest forms of neoplasm in this situation (*c*) From the spinal cord itself (intramedullary) gliomata and vascular tumours may originate The symptoms are those of paraplegia combined with some localized and referred pain or tenderness, and either bilateral from the start, or sometimes of the crossed type, anæsthesia being marked on one side of the body, and paralysis and hyperæsthesia on the other, *i e* on the side of the tumour (Fig 489) The exact localization of the tumour is of great importance, and assistance can be derived as to its level by the introduction of lipiodol* into the subarachnoid space above the growth The fluid (1 to 1 5 c c) is slowly injected after cisternal puncture If there is a spinal block, the lipiodol is held up and the level determined by X-rays The

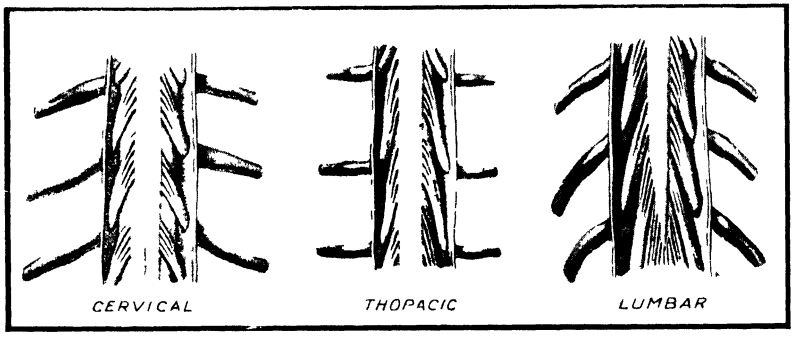


FIG 489 —DRAWING TO SHOW THE INTRADURAL AND EXTRADURAL COURSE OF THE POSTERIOR SPINAL ROOTS

introduction of air has also been used, but is not so satisfactory as lipiodol Although the oil is said to be non-toxic and unirritating, a number of cases of chronic meningitis have been attributed to it, and its use should be limited to those cases in which there is difficulty in accurate localization

An examination of the cerebro-spinal fluid below the level of the lesion is of the utmost importance in these cases, yellow-coloured fluid (xanthochromine) with a high percentage of albumen and increased globulin is pathognomonic of tumour of the spinal cord Examination of the pressure of the fluid above and below the lesion is also of great assistance , manometers introduced by cisternal and lumbar punctures should show similar variations in pressure on compression of the jugular veins, coughing, etc , if, however, there is a spinal block, the variations in pressure will differ (Queckenstedt)

* *Lipiodol* is a colloidal solution of iodine in oil of poppy in the proportion of 0 54 cgrm of iodine to 1 c c of the oil, it is non-toxic and unirritating and opaque to X-rays

Dumb-bell Tumours of the Spine.—These tumours may arise from any tissue, muscle, nerve ganglia, central nervous tissue, cartilage, or bone They form benign, capsulated growths as a rule, but some may undergo malignant change The tumours can arise primarily either intra- or extra-spinally, or even in the intervertebral foramina (Fig 490)

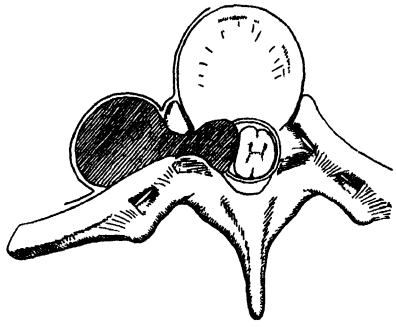


FIG 490.—DUMB-BELL TUMOUR OF THE SPINE

There are three main types of these tumours

(1) **Solitary Neurofibromas** — These are the commonest and are either fibromas of the nerve sheaths (perineural fibroblastomas) or tumours of the cells of Schwann (so called schwannomas) These tumours contain no nerve fibres

(2) **Multiple Neurofibromas** occurring in some cases of von Recklinghausen's neurofibromatosis Such dumb-bell tumours are made up of a diffuse overgrowth of the connective tissue nerve sheaths and contain a few scattered nerve fibres

(3) **Ganglioneuromas** are the rarest type and arise as a rule in the sympathetic ganglia, but they may arise in the posterior root ganglia Unlike the other types, these tumours are true tumours of nerve cells and fibres

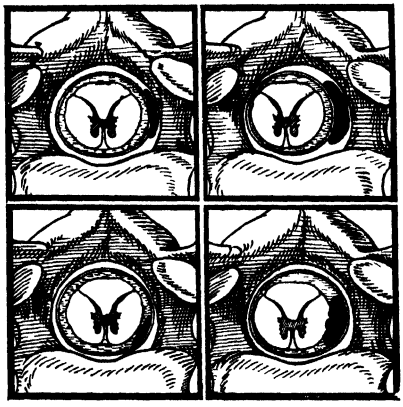


FIG 491

The two upper drawings depict how an extradural tumour compresses the cord, while the lower ones show the compression caused by an intradural tumour

The symptoms these tumours produce are those of spinal compression and severe root pains X-ray examination may be of value in the diagnosis, as destruction of a rib or part of the vertebral body may be seen, and it is important that the differential diagnosis of this condition and that of tuberculosis of the spine should be made out

Treatment consists of laminectomy and removal of both intra- and extra-spinal projections of the tumour In the past recurrences have been due to the fact that these cases have not been diagnosed correctly

A large proportion of spinal tumours are amenable to surgical extirpation The possibility of the disease being syphilitic in origin must not be overlooked, but a negative Wassermann reaction in both blood and cerebro-spinal fluid is good enough evidence to disprove

this The cord is exposed by laminectomy (p 808) after localization has been determined A minimum of three laminæ should be removed and the search for the tumour initiated by careful examination for an extradural cause of compression Extradural tumours compress the spinal cord much less and more evenly than intradural ones (Fig 491)

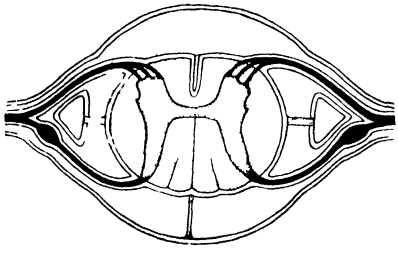


FIG 492 —A TRANSVERSE SECTION OF THE SPINAL CORD AND ITS MEMBRANES, SHOWING THE POSITION OF THE LIGAMENTUM DENTICULATUM

Before the dura mater is incised it should be gently palpated up and down for any irregularity which might be an underlying tumour An absence of pulsation of the cord at the site of or below a tumour may be of help to the surgeon in revealing its situation (Fig 492)

The commonest situation for the tumour is posterior or posterolateral, but if none is found the cord must be rotated by traction on a ligamentum denticulatum (Fig 494) Posterior nerve-roots may require section in order to expose and remove the tumour If a tumour is not found in the area of cord exposed, more laminæ should be removed There is always a tendency for the exposure of the spinal cord to be made too low, and it is a good plan to remember that the lowest lamina to be removed should be at the level of the highest root involved

Intramedullary tumours are generally irremovable When dealing with this type of tumour a two-stage operation should as a rule be performed In the first a longitudinal incision is made into the spinal cord immediately over the tumour, which can be recognized by the oval enlargement of the cord (Figs 496, 497) At the second operation in ten to fourteen days' time, partial extrusion of the tumour may have taken place, and it may then be removable (Fig 498) It is essential in the case of intramedullary tumours to follow the operation with an intensive course of deep X-ray therapy

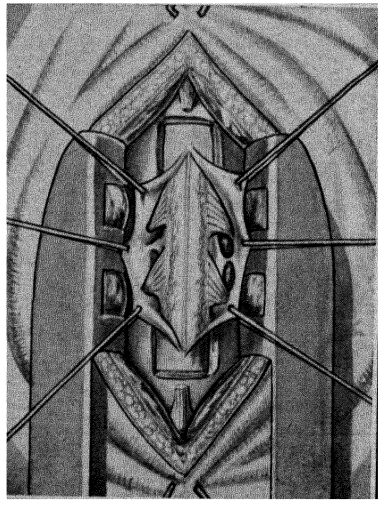


FIG 493 —DRAWING SHOWING EXTRAMEDULLARY TUMOUR SITUATED ON THE POSTERO-LATERAL SURFACE OF THE CORD

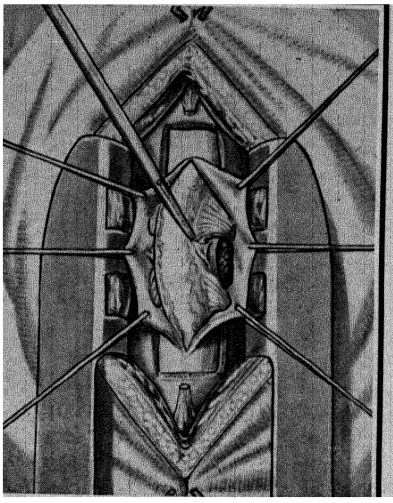


FIG 494

Division of the ligamentum denticulatum and traction on same gives a better exposure of the tumour

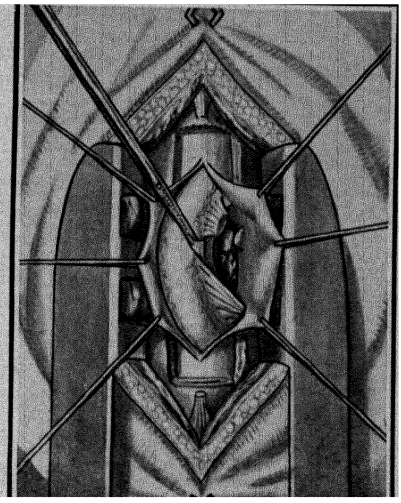


FIG 495

Quite often the tumour cannot be adequately exposed until after division of one of the posterior nerve-roots in addition to that of the ligamentum denticulatum

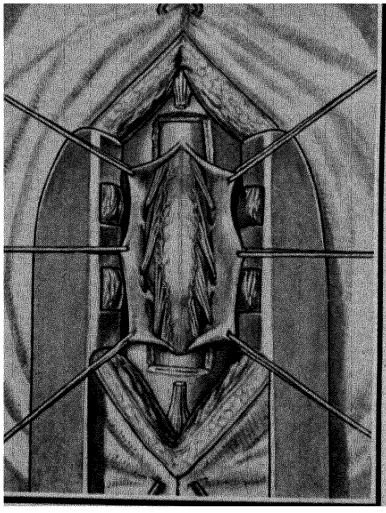


FIG 496.—EXPOSURE OF INTRAMEDULLARY TUMOUR

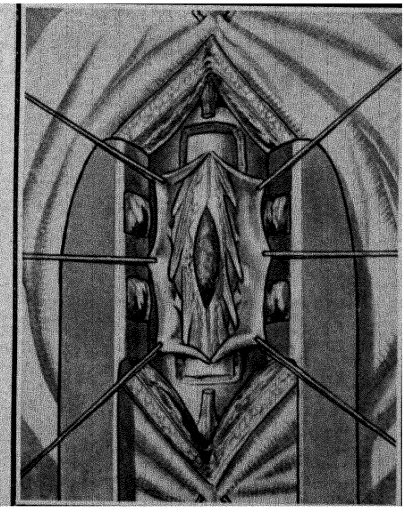


FIG 497.—INTRAMEDULLARY TUMOUR AFTER INCISION INTO THE CORD

The operative results of tumours of the spinal cord are good, owing to the high proportion of simple tumours (50 to 70 per cent.) being capable of total removal, and if the case has not been left too long before exploration there is complete recovery from paralytic symptoms.

Tumours of the Cauda Equina are generally meningiomata. The clinical picture may vary according to the site and extent of the compression. Pain is the earliest and most constant symptom, and it is frequently diagnosed as sciatica. The pain is of a dull aching character, and is often accompanied by slight twitchings of the muscles of one or both legs. These tumours are often attached to one of the nerve-roots or the membrane surrounding them (Fig. 499). Cauda equina tumours can usually be removed entirely, and the prognosis is excellent.

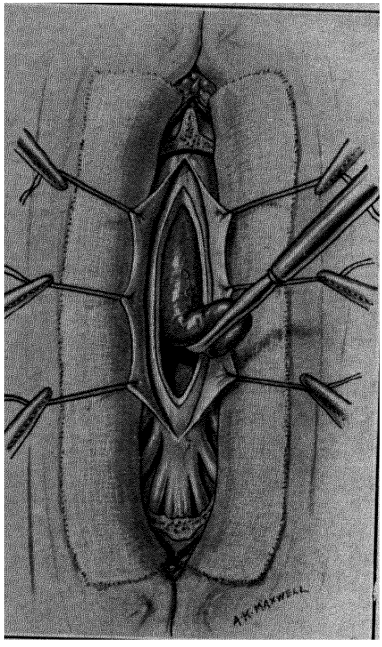


FIG. 498.—INTRAMEDULLARY TUMOUR REMOVED FROM THE LUMBAR CORD. Drawing made at time of operation.

Meningitis serosa circumscripta is a condition characterized by a localized effusion within the meninges, the limitation being due to adhesions of various types which may grasp and constrict the cord, or may drag it aside, and thus interfere with its function. It may be the consequence of a general infection of the membranes which becomes limited, or the outcome of a localized traumatism. The cerebro-spinal fluid varies much with the completeness of the block, and there does not seem to be any characteristic change. The *symptoms* are those of a compression paraplegia, coming on in a somewhat irregular fashion. It usually affects the lower cervical or upper dorsal region, and is most common in the fifth and sixth decades of life. Subjective sensory rather than motor phenomena manifest themselves in the early stages, but the symptoms vary much and quickly, and the pain is more widespread than in spinal tumours. Motor phenomena become more prominent in the later stages, and especially weakness of the legs, ending in complete paralysis, irritative spasms may also be present, not limited to one root segment. Vesical and rectal troubles do not arise till late in the case. *Treatment* is required either for persistence of symptoms or for spread of the trouble, and consists in laminectomy with free opening of the membranes

and removal of the causative adhesions so as to set free the cord

Syringomyelia—In certain cases of syringomyelia surgery can offer some relief of the distressing symptoms of this disease The greatly distended central canal in the cervical region (Fig 500) is exposed by laminectomy, and an incision is made into the cord to one side of the

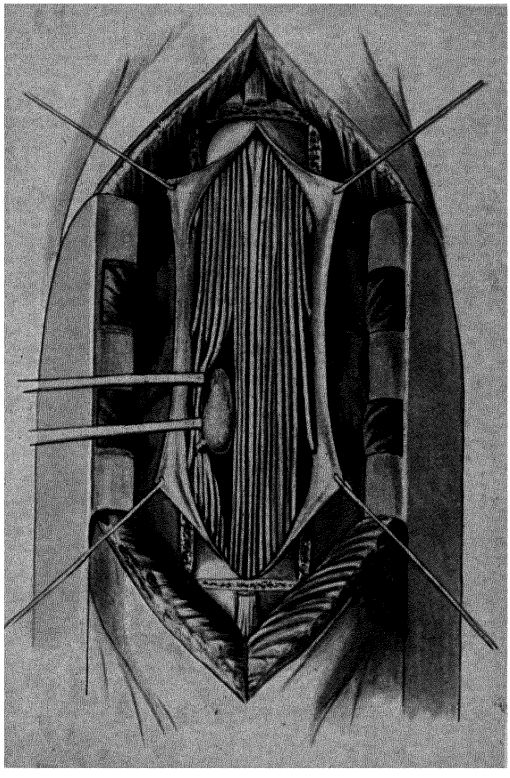


FIG 499—DRAWING MADE AT THE TIME OF OPERATION SHOWING A MENINGIOMA OF THE CAUDA EQUINA

middle line, so as to avoid the vessels (Fig 501) The fluid contents are aspirated, the cavity swabbed out with iodine, and the wound closed The operation can be performed in most cases without any anæsthetic at all, but the great difficulty after operation is to get the wound to heal, it frequently takes months before absolute healing has taken place Patients themselves say they are better after this operation

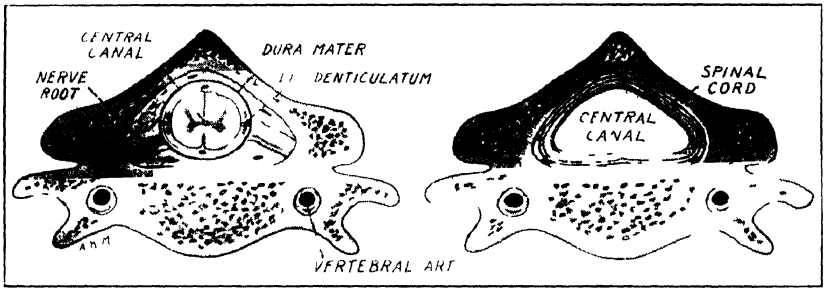


FIG 500.—SECTIONS THROUGH THE CERVICAL CORD IN THE NORMAL AND IN A CASE OF SYRINGOMYLIIA

The enormous dilatation of the central canal can be seen in the latter

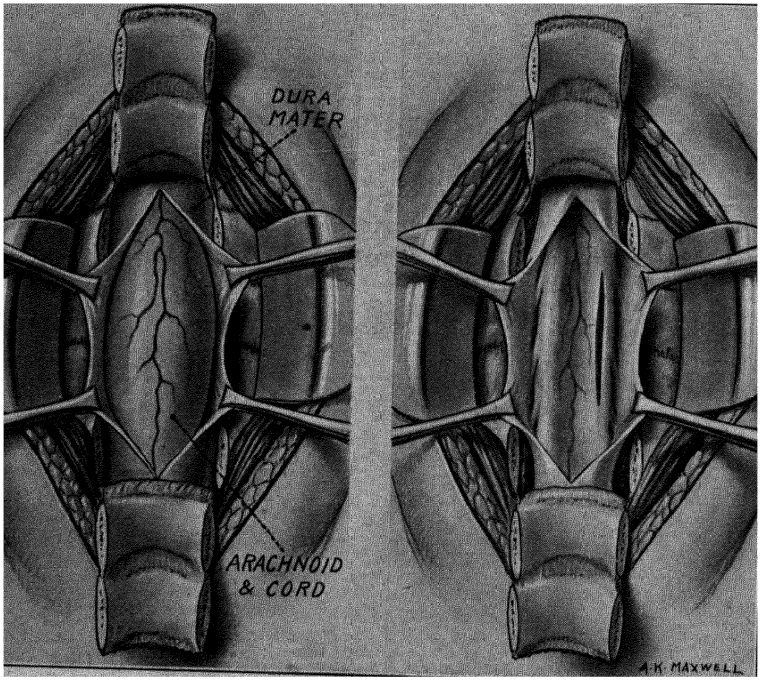


FIG 501.—EXPOSURE OF THE CERVICAL CORD IN A CASE OF SYRINGOMYELIA

An incision has been made into the cord and the fluid from the central canal aspirated allowing the cord to collapse