PART I.—GENERAL
TUBERCULOSIS OF THE BONES AND JOINTS IN CHILDREN
AGENTS

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TO

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AND CHALMERS HOSPITAL, EDINBURGH, ETC.

THIS VOLUME IS DEDICATED

IN TOKEN OF HIGH ESTEEM AND AFFECTIONATE REGARD
SOME years ago, through the kindness of Mr. Stiles, I was enabled to carry out an investigation of a number of cases of tuberculous disease of the bones and the joints. The pathological and etiological aspects of these studies were presented as a Thesis for the degree of M.D. of Edinburgh University in the year 1912, and a number of isolated papers have been published in various periodicals.

The disease was also observed from the clinical aspect, and a combination of these two investigations has resulted in the publication of the present work. I recognised that a collation of experimental and pathological results were of little value unless combined with the more practical clinical side.

The present work deals with the disease purely as it occurs in children, and this accounts for the omission of regional diseases which do not occur in childhood, e.g. tuberculosis of the patella.

The book is divided into two portions: a consideration of the disease from the general aspect, and an investigation of it as it appears in individual regions. At the end of each section there is a compilation of the more recent literature dealing with the subject; the author wishes it to be clearly understood that he has not personally consulted all of these references, they are added to improve the value of the work from a consultation point of view.

I have dedicated this book to Mr. Stiles, surgeon to the Children's Hospital and to Chalmers Hospital, and I cannot make too complete acknowledgment of my indebtedness to him. He originally embarked me on the study; he gave me access to the valuable specimens which he has such a unique opportunity of obtaining; and during the pathological investigations he repeatedly gave me the benefit of his wide pathological knowledge. The illustrations, with few exceptions, I owe directly or indirectly to him. In fact one may say that to him the book owes any value.
it may possess, while he is in no way responsible for any errors or heterodoxy which it may contain. The experimental part of the work was carried out in the Laboratory of the Royal College of Physicians, and I owe thanks to Professor James Ritchie, the superintendent, for much encouragement and assistance. In the literary part of the work I have repeated kindnesses to acknowledge. Dr. John D. Comrie assisted me in the reading and arrangement of the proofs, likewise Dr. Seelenmeyer. Dr. John Spence and Dr. Archibald McKendrick were good enough to give me the benefit of their advice in the compilation of that portion of the work which deals with X-ray examination. The index has been arranged by Dr. James McBain Ross. Sister Smith of the Surgical Out-patient Department of the Children’s Hospital has given me invaluable assistance in the photographing and arranging of the clinical studies. The illustrations have been produced by Mrs. Marshall Brown, Mr. Richard Muir, and the late Mr. Robert Lindsay. I have to acknowledge my indebtedness to the Editors and Proprietors of the Journal of Pathology and Bacteriology for permission to use a number of plates illustrative of an article published in their Journal. Much of the expense necessarily entailed in a work of this description has been borne by grants from the Carnegie Trust and the McCunn Scholarships. I make grateful acknowledgment of their assistance. To the Publishers I owe thanks for their courtesy and continued attention.

JOHN FRASER.

3 DARNAWAY STREET, EDINBURGH,
May 1914.
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ETIOLOGY

The actual causation factor in tuberculous disease as it affects the bones and the joints is the tubercle bacillus; but such a simple statement is by no means a dismissal of the matter, because bound up with it there are other factors which are important in their occurrence, and unfortunately much more difficult in their investigation and their elucidation. There are three of these related problems:

1. Is there any special importance in the identity of the bacillus? Is the human or the bovine bacillus more commonly at fault?
2. What are the routes which the organisms follow in reaching the bones and the joints?
3. Are there any factors which predispose certain parts to infection by the tubercle bacillus, more especially the relationship of injury to the later development of the disease?

The Type of Organism.—Pathologists have divided the tubercle bacillus as a group into four subdivisions—human, bovine, avian, and piscine. As far as the pathology of man is concerned one may neglect the two latter. Since the memorable dictum of Koch in 1897 endless investigations have been carried out to clear up the inter-relationship between human and bovine infection, and the dissimilarity or unity of the two organisms.

One may say, probably beyond question, that the human and the bovine bacillus, originally a common stock, have each acquired, by reason of their residential environments, definite characteristics which enable the observer to distinguish the one from the other. In tuberculous diseases of bones and joints, as in other forms of tuberculosis, careful investigations have been made to demonstrate the relative proportion of disease which is human or bovine in origin. The method of differentiating between the bacilli is tedious and prolonged, but it is necessary to give a summary of the technique by which the separation is carried out.

No attempt is made to isolate the bacillus by direct cultivation. Guinea-pigs are inoculated with the diseased material, a piece of tuberculous bone or synovial membrane being implanted beneath the skin of the flank. An animal so infected is permitted to live for four or six weeks. During this time the condition of the animal is noted and a careful weight-history kept. At the end of the period the animal is killed, and from the tuberculous organs, more especially the glands and the spleen, cultures are made upon suitable media. Experi-
ence has shown that plain egg medium (Dorset)\(^1\) and glycerin egg medium (Lubenau)\(^2\) are the most suitable. The diseased organ is rubbed upon the surface of the culture tube with a sterile spud. Tubes so inoculated are sealed with paraffin to prevent evaporation, and to diminish the possibility of infection by moulds. About ten days after inoculation a growth is usually apparent. With the successful growth of the organism in pure culture, the first stage of the investigation is completed, and it remains to decide to which class the organism belongs. To solve this question the organism is submitted to a series of tests.

In the author's original investigation a series of five different tests were employed: (a) The original culture test; (b) The morphological test; (c) The special culture test; (d) Theobald Smith's test; (e) The inoculation test.

(a) Original Culture Test.—Smith\(^3\) noted cultural distinctions between different strains of tubercle bacilli when they were grown upon blood serum. Ravenal\(^4\) described similar distinctions upon glycerin agar, and Dorset upon egg medium. The British Royal Commission\(^5\) found such a constant distinction that they formulated two classes: a eugonic, or readily growing class, and a dysgonic, or slowly growing class. To the first the great majority of human bacilli belong. Bovine bacilli are most suitably described under the second heading. This test cannot be considered absolute because a margin of error exists in those cases which are on the border line between eugony and dysgony, but it is useful in so far as it forms the first clue. A rapidly growing and profuse culture is likely to be human in type, while a weak and scanty growth is in all probability bovine.

The fallacies of the test have been discussed by Rabinowitsch,\(^6\) Fibiger and Jensen,\(^7\) Park and Krumwiede.\(^8\)

(b) Morphological Test.—At one time it was believed that structural differences between the strains of tubercle bacilli might prove of value as a distinguishing test. The human bacillus is usually considered to be slender, regular in shape, and long, while the bovine bacillus is squat and thick (Kossel, Weber, and Heuss).\(^9\) If these differences were constant the test might be a valuable one, but if the test is to be of any assistance the bacilli must be observed in an early and original culture; prolonged residence or multiple subculture tends to produce a common morphological mean. Dorset affirms that he found no such distinctive features between the bacilli, and his views are in agreement with those of Wolbach and Ernst.\(^10\)

\(^1\) M. Dorset, *Am. Med.*, 1902, iii. 555.
\(^5\) *Royal Commission on Tuberculosis, Second Interim Report*, 1907, Pt. I., 23.
\(^8\) W. H. Park and C. Krumwiede and others, *Studies from the Research Laboratory of the Department of Health of the City of New York, 1908–10*, iv. 7.
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If the observer is careful to examine the early and original culture, the test is useful as a suggestive one.

In tubercle bacilli there has been frequently noted the presence of deeply-staining, spore-like bodies, and they have been described in considerable detail by Coppen-Jones.¹ These are found occurring most constantly in bacilli from a human source, and their presence is best demonstrated by the use of Much’s stain.

(c) Special Culture Test.—The presence of glycerin has a restraining effect on the growth of the bovine bacillus (Moeller),² but it has rather a stimulating effect on the growth of the human bacillus. The glycerin is incorporated in such a medium as glycerin egg. This test must be employed from primary cultures, as the vegetative capacities of the bovine bacillus increase on frequent subculturing. One may say that cultures growing luxuriantly from the beginning upon glycerin egg medium are of the human type, while cultures growing sparsely or even not at all on this medium are bovine in character.

(d) Theobald Smith’s Test.³—By inoculating glycerin bouillon medium it is possible to produce upon its surface a pellicular growth of tubercle. The growth is easily started by loading a tiny cork raft with the culture mass, and floating it upon the medium. From this nucleus a growth soon extends over the surface. The rate of growth of the pellicle is an indication of the type of the bacillus, but the development of the pellicle gives rise to a change in the reaction of the medium which is valuable as a distinguishing test. Before the medium is inoculated its acidity is carefully estimated by titration and made up to a standard reaction by adding 0-05 N/5 of hydrochloric acid to glycerin bouillon neutral to litmus.

As the organism grows and the pellicle develops, in the human case the acidity increases, while in the instance of the bovine bacillus the acidity for a time diminishes, and the medium may even become alkaline. It is recognised that the reaction actually depends on the different rates of growth of the two varieties of bacilli.

From a medium so inoculated five cubic centimetres of fluid are removed every ten days, and the reaction estimated by titration. Smith recommends that the medium be titrated when hot; before titration it ought to be diluted to 10 per cent of its usual strength. The titration results may be graphically demonstrated by plotting them upon a curve.

(e) Inoculation Test.—It has long been noted that tuberculous material from different sources varied in its effects on bovines and on man. Villemin ⁴ observed the fact, and Smith may be said to have formulated it into a test; he published articles on the subject in 1896 ⁵ and 1898.⁶

The test may be stated as follows: If a rabbit with an average weight of 2000 grams is inoculated with a small known quantity of tubercle bacilli it will react to the inoculation in various ways. If a human bacillus is employed, the resulting lesions are small and few in number, and after a time they show a tendency to undergo retrogression. If death occurs, it is usually more than six months after the original inoculation, and frequently tuberculosis is not the cause of death. If a bovine bacillus is used, an acute disseminated tuberculosis develops which is rapidly fatal.

¹ A. Coppen-Jones, Centralbl. f. Bakteriol., 1895, xiii. 70.
² A. Moeller, Deutsche med. Wchnschr., 1902, xxvii. 718.
⁶ Loc. sup. cit.
The quantity of tubercle bacilli introduced varies according to the method of injection. 0.01 mgm. is a suitable amount for intravenous inoculation; 10 mgms. may be given subcutaneously.

Such bacteriological investigations have been carried out by the British Royal Commission (14 cases), Park and Krumwiede (71 cases), Buckhardt (29 cases), Kossel, Weber, and Heuss (36 cases), and the author (70 cases). The results of these different enquiries show a marked divergence of results. In Kossel, Weber, and Heuss’s series only one case—a percentage of 2.7—was due to a bovine infection, while in the author’s series of 70 cases a proportion of 60 per cent owed their origin to infection with the bovine bacillus. But these results, so apparently irreconcilable, can be perfectly understood. A large proportion of bovine infection is closely related to two other facts—an infected milk supply and a young age incidence.

Let us take the facts in their natural sequence. Until the age of twelve years milk forms a staple article of diet among the large majority of our population. If such milk be infected with the bacillus of bovine tuberculosis, as it most probably will be if it is obtained from a tuberculous cow, there will in all probability result from its ingestion tuberculous disease of the lymphatic glands, cervical or mesenteric. From this primary source the bones and joints become infected, and in such lesions bovine tubercle bacilli can be demonstrated. Therefore a large proportion of infection, due to the bovine bacillus, at once suggests to one’s mind that the real source of the trouble lies in a contaminated milk supply.

The considerable proportion of bovine infection is, in fact, explanatory of a fact which is discussed elsewhere, namely, the relatively great occurrence of osseous tuberculosis in the periods of infancy and youth.

Channels of Entry of the Bacilli into the Body.—One may neglect as a most unlikely possibility the question of a pre-natal infection by tubercle. In post-natal existence there are two obvious channels by which the disease gains admission—the respiratory tract and the alimentary tract. Both of these have had their champions, men who have urged each in its individual importance. Calmette and von Behring have contended that in the alimentary tract one has the medium through which the disease most commonly enters. Hamburger, Jacobi, and Holt have championed the claim of the aerogenous route. There is, however, no necessity to dogmatise. Both routes are available, and at varying periods of life the relative importance of each differs. In children surgical tuberculosis is usually the primary manifestation, and if pulmonary disease appears it is as a rule a secondary infection. In adult life the process is reversed, the

1 Royal Commission on Tuberculosis, Final Report, 1911, Pt. I., 13.
2 Loc. sup. cit.
4 Loc. sup. cit.
8 These contentions have arisen more especially in deciding the route of infection in phthisis.
lungs are most frequently the first to suffer, and from them infection extends to the bones and glands. And as the sequences differ, so probably do the channels of infection, the alimentary system in youth, the respiratory system in later life. In urging the importance of the alimentary infection, one must bear in mind that the apparent resistance of the mesenteric glands—the first to show signs in an ingestion infection—varies considerably in early and in later life. The mesenteric glands of a child are more readily infected than those of an adult. Through the latter tubercle bacilli may enter the body, and leave no sign of their passage (Guérin). Therefore one must not consider the alimentary routes of infection a monopoly of youth.

There are other less common means of entrance—the tonsils and the mucous membrane of the pharynx, the skin, the genito-urinary passages, and the teeth. We have frequently noted that tuberculous disease of the submaxillary group of lymphatic glands owed their infection to the presence of tubercle bacilli in the pulp of decayed teeth.

Tubby 1 believes that tuberculous dactylitis sometimes owes its occurrence to infection of overlying skin wounds with tubercle, the bacilli being obtained by crawling upon dirty floors.

Routes of Infection of the Bones and the Joints.—One may assume that direct infection of a bone or joint from without is rare in its occurrence, and negligible as an etiological factor. There therefore remain the more indirect routes of the blood stream and the lymph streams. These are the questions to be answered, Does one or do both of these routes provide the paths of infection? and, further, Are the bones and the joints equally liable to infection, or do they stand in relation to one another as primary and secondary infections?

It might be well briefly to epitomise the more important work which has been done to aid in the elucidation of these questions.

Schüller 2 in 1880 described how he injected tuberculous material, sputum, glands, etc., through a tracheotomy opening into the lungs of dogs and rabbits, coincidentally injuring one of the knee-joints of the infected animal; he succeeded in producing generalised tuberculosis and a tuberculous synovitis of the injured joint.

Müller 3 in 1886 injected the nutrient bone vessels of goats; apparently there resulted a multiple tuberculous osteomyelitis of the bone supplied by the infected blood-vessel with accompanying infection of the neighbouring joints. Müller quoted his results in demonstration of the hematogenous infection of osseous tubercle.

In 1891 Krause 4 published the results of his experimental work. He injected pure cultures of tubercle bacilli subcutaneously into guinea-pigs and intravenously into rabbits. Directly before or immediately after the inocula-

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1 Tubby, Tuberculous Disease of the Bones and Joints, ii. p. 6.
2 M. Schüller, Experimentelle und histologische Untersuchungen über die Entstehung und Ursachen der skrophulosen und tuberkulösen Gelenkleiden, Stuttgart, 1880.
3 W. Müller, Centralbl. f. Chir., 1886, xii. 233.
tion, or after a variable space of time, a joint was injured or a bone broken. In no case was there evidence of tubercle at the site of fracture, but in the instance of the joints many of them became tuberculous,—fifteen joints out of forty-four in guinea-pigs, and fourteen out of twenty-eight in rabbits. The uninjured joints with one exception remained healthy.

A number of experiments upon rabbits were carried out by Benda in 1899. He intimated his belief that the original lesion was an actual focus of tuberculous disease in the tunica interna of the blood-vessel, and from such a focus there was a continuous liberation of bacilli into the blood stream.

Lannelongue and Achard (1899) found that it was by no means an easy matter to trace experimentally the source and origin of osseous or joint tubercle. They inoculated guinea-pigs in various ways, and directly afterwards or some time later they produced local injuries of the bones or joints, but they failed to produce tuberculous lesions.

With a view to investigating the haemic routes of infection, Friedrich in 1899 introduced tuberculous cultures of low virulence into the left ventricle of rabbits. He succeeded in producing tuberculous joint affections. Certain of the joints had been previously injured, but he found that those subjected to traumatism were less likely to become infected than the apparently healthy ones.

What practically amounted to the antithesis of this view was expressed by Pietrzikowski (1903). According to this view 20 per cent of all tuberculous affections of bones and joints were connected with some forms of injury; this rarely amounted to a fracture or dislocation, but usually an injury of lesser degree, such as a sprain or bruise.

In 1904 Salvia injected virulent cultures of tubercle intravenously into rabbits; simultaneously various parts of the body were subjected to traumatism. He found that in the flat bones the violence practically always decided the localisation of tubercle; no localisation could be obtained in the long bones of the limb, but slight injuries to the parts sometimes resulted in tuberculous disease.

Out of such a mass of experimental evidence it is difficult to unravel certainties; there are so many apparent contradictions, but there are two facts which are clear, and they are: (1) That it is difficult to reproduce experimentally tuberculous lesions of the bones and the joints; (2) That trauma as a localising factor is slight in degree rather than severe.

The possibility of the lymph stream being an important route of infection one may dismiss; neither the bones nor the joints bear a close connection with the lymphatic system, and many authorities deny their presence in either structure. And further from the naked-eye and the microscopic appearance of the lesion in both situations there can be no shadow of a doubt that the blood stream is the main, in fact one would say the only route of infection. But there follows a question which is much more difficult in its decision, Are bones and joints equally susceptible to infection, or is the one more readily infected than the other?

5 E. Salvia, Polichinico, 1904, xi., sez. chir., 367.
As far as the relative percentage of occurrence is concerned, joints are to a slight degree more commonly affected than bones. During a period of ten years there were admitted to the wards of the Edinburgh Sick Children’s Hospital 464 cases of tuberculous joint disease, while the number of cases of pure bone tubercle amounted to 353 cases. Practically the only way in which such a question can be decided is by experimental research, and in such an investigation one must remember that one is not reproducing exactly the condition one finds clinically. The result of the most recent experimental work may be summed up in the following conclusions:

(1) The joints are more susceptible to infection by tuberculous disease than the bones.

(2) The joints are infected through the medium of the blood stream.

Predisposition by reason of Injury.—Every clinician must have noted the regularity with which one obtains in tuberculous disease of a bone or joint, the history of a previous traumatism. If such is not immediately forthcoming, a little detailed cross-examination rarely fails to extract it. There can, however, be not the slightest doubt that in a certain number of cases traumatism does play a part in the etiology. The trauma is not a severe one, it may be so minor as to have escaped the patient’s attention. The explanation of the minor degree of injury lies probably in this fact. An injury of some severity produces such a state of tissue reaction that the lodged organism is neutralised and destroyed. When the trauma is slight no reaction follows, but instead a small effusion of blood and lymph, a condition of affairs which, by a temporary local arrest of blood flow, favours a stagnation of the organism and the development of a definite pathological lesion.

There is another aspect to the influence which injury has upon the development of a tuberculous lesion. Not only may it favour its original deposit, but when it has developed it may very materially alter its further characteristics, and from this point of view the influence of traumatism is probably under-rated (Wilson). A form of disease which has hitherto remained defined and encapsulated may become, after the receipt of an injury, an actively-spreading and infiltrating tubercle; and on a larger scale, disease previously limited to the articular extremity of a bone, may be suddenly complicated by a wholesale infection of the near-lying joint, or of the surrounding soft parts.

These relations of traumatism to the spread of the disease are of much greater importance in their practical bearing than any influence they may have upon the original development of the disease.

Predisposition by Heredity.—Above twenty cases of apparent true congenital tuberculosis have been reported, and Baumgarten believes that the virus is actually transmitted to the subject during intra-uterine development. Baumgarten suggests that the developing tissues retard

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the growth of the infecting organism, which, lying latent, produces active tuberculosis in later post-natal life. This is a view which has aroused strong opposition. It would probably be more correct to say that the presence of tuberculosis in the parents leads to a weakening in the developing embryonic and fetal tissues, with a resulting predisposition to disease in any form. A special source of infection to tubercle exists in the person of the tuberculous parent, and the infection of the offspring is the all too frequent result.

The question of germinal infection is still very largely one of speculation.

**Predisposition by General Causes.**—There are many other factors which predispose to disease. The exanthemata are important. Their ravages are followed by a lowering of vitality and a surrender to the disease, and so it is with influenza. Then there are the questions of feeding, be it bad, insufficient, or improper, and unhygienic surroundings, want of fresh air and sunlight.

The Frequency of Affection of the various Bones.—During a period of ten years there has come under treatment in the wards of the Edinburgh Sick Children’s Hospital a total of 353 cases of bone tuberculosis (entirely exclusive of joint disease and spine disease).

The incidence of individual bones is represented in the following table:

<table>
<thead>
<tr>
<th>Bone</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bones of skull, mastoid and malar</td>
<td>81</td>
<td>23</td>
</tr>
<tr>
<td>Metatarsus, tarsus, and phalanges</td>
<td>80</td>
<td>23</td>
</tr>
<tr>
<td>Tibia</td>
<td>39</td>
<td>10</td>
</tr>
<tr>
<td>Ulna</td>
<td>26</td>
<td>7.3</td>
</tr>
<tr>
<td>Metacarpus, carpus, and phalanges</td>
<td>26</td>
<td>7.3</td>
</tr>
<tr>
<td>Femur</td>
<td>24</td>
<td>7</td>
</tr>
<tr>
<td>Humerus</td>
<td>21</td>
<td>6</td>
</tr>
<tr>
<td>Lower jaw</td>
<td>18</td>
<td>5.4</td>
</tr>
<tr>
<td>Rib</td>
<td>14</td>
<td>4</td>
</tr>
<tr>
<td>Radius</td>
<td>14</td>
<td>4</td>
</tr>
<tr>
<td>Fibula</td>
<td>10</td>
<td>3</td>
</tr>
</tbody>
</table>

The high percentage of disease affecting the skull bones is largely due to tuberculous conditions of the mastoid. Excluding these, the short bones are the most frequently affected, and those of the foot in a greater degree than those of the hand. Of the long bones, the tibia and the ulna are most frequently involved.

Vertebral disease has been purposely excluded. It of course forms by far the greater proportion of bone tuberculosis, yet the peculiar structure of the bone and the relation of the intervertebral discs lead us to consider it in a separate and distinct class (see p. 111).

The Frequency of Affections of the various Joints.—During the period above mentioned 464 cases of joint disease were admitted for treatment. The relative frequency was as follows:

[Table]
PLATE I.

\(a\), The normal anatomy of the end of a long bone, showing the articular surface, the epiphysis, the epiphyseal cartilage, and the metaphysis. \(b\), The articular end of the humerus. \(c\), The epiphyseal cartilage with epiphysis above and metaphysis below. \(d\), A Volkmann's canal piercing the cortical bone, carrying with it a blood-vessel.
Joint. | Number. | Percentage.
---|---|---
Hip | 171 | 37
Knee | 133 | 27
Elbow | 77 | 18
Ankle | 72 | 15.5
Wrist | 8 | 2
Shoulder | 3 | 0.5

The proportions are in keeping with those published elsewhere. The hip is the joint most frequently affected; the knee is slightly less common. The elbow and the ankle are very similar in the percentage of their infection.

**THE PATHOLOGY OF TUBERCULOSIS OF BONE**

**Normal Anatomy of Bone**

Bone is really a type of connective tissue in which the ground-work has become impregnated with salts of lime, and a comprehension of this fact simplifies considerably the apparent complexity of its structure. The connective tissue is a variety of areolar tissue, and the earthy salts are chiefly phosphate of lime.

Bone is said to be compact or cancellous according to the degree of interspaces in its structure. As a rule the outer layers of a bone are compact and the deeper tissues cancellous. The marrow occupies the interspaces.

Each bone is built upon definite architectural lines, and, more especially in the long bones and short long bones, a knowledge of the scheme of architecture is essential to an understanding of the pathology. The scheme is most complete, and is seen to its best advantage in any of the long bones. The greater portion of the length is formed by the shaft. At the end of the shaft there is the epiphyseal cartilage, and that portion of the shaft which immediately abuts upon the cartilage is given a special name, that of the metaphysis.

On the distal side of the epiphyseal cartilage there lies the epiphysis, and the free surface of the epiphysis is usually covered with hyaline articular cartilage. In all the long bones an arrangement such as is described occurs at both extremities of the shaft. In the short long bones, where there is only a single epiphysis, one end has such an arrangement, the other extends directly to the articular cartilage.

There are no special features in the formation of the flat and the short bones.

**Blood Supply of Bones**

Lexer traced the course of blood-vessels in bone by stereoscopic X-ray photographs. The vessels were injected with a solution of mercury.

in oil of turpentine, and the photographs were taken with the periosteum
and attached ligaments in situ. Under these conditions, while the periosteal
vessels were clearly visible, the intraosseal branches were indistinct and
blurred; these latter were shown in a second series of photographs taken
after removal of the periosteum.

The vascular arrangements differ in the long tubular bones, the short
long bones, the flat bones, the vertebrae and ribs, and such a composite bone
as the ilium.

**Long Tubular Bones.**—About the centre of the shaft the nutrient
vessel enters the bone. Just before its entry it becomes tortuous, an arrange-
ment which has a double purpose. It partly permits of an elongation of the
vessel, according to certain positions of the part, and further it reduces
the pressure before the blood stream bifurcates.

Having entered the bone the vessel divides almost immediately into
two divisions, which run in exactly opposite directions towards the extremiti-
ties of the bone. These vessels are the nutritiae; they do not long remain
single, they rapidly subdivide and extend to the epiphyseal cartilage in a
parallel and leash-like arrangement.

A second series of vessels pass into the bone immediately on the
diaphyseal side of the epiphyseal cartilage. They are usually derived from
the anastomosis around a neighbouring joint, and from their relationship
to the epiphyseal cartilage they are called the juxta-epiphyseal vessels. They
anastomose with the termination of the nutrient vessels in the metaphysis.

The third group is formed by the epiphyseal vessels, they also are
derived from the anastomosis around the joint, they perforate the epiphysis
and the epiphyseal cartilage, and their termination is an anastomosis in the
metaphysis. The scheme is completed by a complex anastomosis beneath
the periosteum. The ultimate anastomosis in the metaphysis of three
different groups of vessels is the point of greatest practical importance.

**The Short Long Bones.**—The scheme is very similar to that in the
tubular bones, but the presence of usually only a single epiphysis constitutes
an important difference. The nutrient vessel enters the shaft about its
centre, but there is a point of distinction in so far as it breaks up almost
immediately into a plexus: there are no long parallel nutritiae. At that
extremity of the bone which possesses an epiphysis the vascular arrange-
ments are exactly similar to those in the tubular bones. At the other
extremity the juxta-epiphyseal vessels are necessarily absent, and only those
analogous to the epiphyseal vessels exist.

**Flat Bones and Vertebrae.**—Each of the flat bones is supplied by
a nutrient vessel, which enters about the centre of the bone, and rapidly
subdivides; the periosteal vessels are of greater importance than in the
long bones. The vertebrae have a distinctive distribution—two large and
parallel vessels enter the body from behind, and reaching the centre of
the body, they are joined by a series of small vessels, running inwards
from the front. Corresponding to the juxta-epiphyseal vessels of the long
bones there are vessels entering at the attachment of the transverse process
PLATE II.—THE SCHEME OF THE ARTERIAL BLOOD SUPPLY OF BONES.

to the body. The vascular arrangements are similar in all the vertebrae, with the exception of the atlas: it, not possessing a body, derives its blood supply from two large lateral vessels.

**Ribs.**—Each rib is supplied by a nutrient vessel, which enters the bone from its outer surface, just beyond the tubercle, and runs forwards inside the bone as far as the costal cartilage, where it is joined by vessels from the perichondrium.

**The Pelvis.**—On account of the composite formation the vascular distribution in the pelvic bones is peculiar. The main nutrient vessel enters the ilium obliquely from behind through a large-sized foramen close to the great sacrosciatic notch; it breaks up into fine radial twigs which extend to the crest of the acetabulum. A second vessel enters at the sacro-iliac synchondrosis and distributes branches upwards. The periosteum is independently well supplied with blood.

**Microscopic Anatomy of Bone**

Lamellae or strands of connective tissue in a calcified ground substance constitute the framework of a bone. Between the lamellae are the interspaces which the marrow occupies, and scattered through the substance of the lamellae there are the branching bone corpuscles, each occupying its space or lacuna. The branching processes of the bone corpuscles extend into the surrounding bone, along the minute channels spoken of as canaliculi. Studded throughout the bone there are larger channels, the Haversian canals carrying the blood-vessels. They are most numerous in compact bone, as the vascular marrow in the more cancellous type precludes their necessity. In each canal there lies an artery and its accompanying vein, and the vessels are surrounded by a protective covering of loose connective tissue which may contain lymphatic vessels.

Most of the lamellae are arranged concentrically around the Haversian canals, constituting Haversian systems. Some are arranged parallel to the periosteum, the periosteal lamellae. Any spaces which exist between the Haversian and the periosteal lamellae are occupied by what are called the intermediate lamellae.

Piercing the periosteal lamellae in a vertical direction one finds vascular canals similar to the Haversian. They carry vessels from the periosteum to the interior of the bone, and they are called Volkmann's canals.

While the bone lamellae as a rule run parallel they sometimes cross and intermingle, and so constitute what are known as the "decussating fibres of Sharpey."

**The Periosteum.**—The periosteum is the fibrous vascular membrane which covers the exterior of a bone. It is arranged in two layers, an outer fibrous, in which the blood-vessels run, and an inner cellular and osteogenetic, endowed with active bone-forming properties.¹

¹ Sir William M'Ewen denies that the periosteum possesses bone-forming properties. See *The Growth of Bone*, Glasgow, 1912.
The function of the periosteum is a double one—it helps to maintain the nutrition of the bone by the blood and lymph vessels which it contains, and by virtue of its cellular layer it is the medium by which a bone increases in thickness. In the "resting stage," i.e. when no special demands upon the periosteum arise, the cellular layer is thin and imperfect; when special demands for activity are called for the layer becomes thick and active.

There is an important detail which must be mentioned in regard to the relationship which the periosteum bears to the epiphyseal cartilage. When the periosteum comes into contact with the edge of the epiphyseal cartilage, it splits into two layers—one, the outer, is continued onwards over the epiphysis, the other turns acutely inwards and is continuous with the deeper layers of the epiphyseal cartilage. This anatomical detail is explanatory of the fact that a subperiosteal abscess cannot easily infect the epiphysis or the neighbouring joint.

The Articular Cartilage. — The articular cartilage is a cap of hyaline cartilage covering that portion of a bone which enters into the formation of a joint. It extends over the extremity of the bone, and meets peripherally the periosteum covering the shaft. The cells of articular cartilage are more numerous than those of ordinary hyaline cartilage, the ground substance is correspondingly less. The cartilage cells are arranged on a uniform plan.

Peripherally the cells are small and flattened, arranged with their long axes parallel to the surface. Deeper the cells proliferate and become arranged in columns, springing radially from the head of the bone.

Where the periosteum joins the articular cartilage the fibres of the periosteum actually pass inwards between the cells, and separating them become uniform with the ground substance of the cartilage.

The Epiphyseal Cartilage. — It is by means of the epiphyseal cartilage that a bone increases in length. Situated near the articular cartilage it is an essential feature at each extremity of the long bones. Most of the short long bones possess only a single epiphyseal cartilage.

Macroscopically it appears as a thin plate of bluish cartilage separating epiphysis from diaphysis; microscopically it is cartilage of the hyaline variety.
PLATE III.—A VOLKMANN'S CANAL IN SECTION.
It contains an artery, a vein, two lymphatics, and a quantity of loose connective tissue.
Each plate of cartilage can be differentiated into two distinct zones. Immediately beneath the bone of the epiphysis there is a zone of clear cartilage, typically hyaline in appearance, but rather sparsely provided with cells; at a lower level there is a zone which is scarcely recognisable as cartilage; it forms nine-tenths of the total thickness of the plate, and its structure is essentially cellular.

The cells of this second zone are actively proliferating, and they are arranged in pod-like spaces in which the cells are packed together exactly like peas. Where the cartilage lies actually in contact with the diaphysis, the cells have escaped from their collective confinement, and they form irregular masses lying upon the diaphysis. These escaped cells are large, oval, or circular, each with a distinct cell membrane, a considerable amount of cytoplasm and a nucleus containing eosinophile granules.

The superficial layer of the epiphyseal cartilage plays no part in the ossification of the bone, it is from the deeper layer that this entirely proceeds. Calcareous material is deposited between the cells, and passing inwards, later invades the cell membrane.

The Epiphysis.—In structure the epiphysis is similar to the metaphysis, but the interstices of its substance contain only red marrow.

The Diaphysis.—The diaphysis or shaft of the bone is filled with yellow marrow, except the portion which immediately abuts upon the epiphyseal cartilage and which contains red marrow.

Bone Marrow.—One has no intention of entering into any depth of detail regarding the structure of the bone marrow, but sufficient must be said to make clear certain points in pathology.

Different types of marrow have been classified, depending upon the variety and number of cells present. If many of the blood-forming cells and their derivatives occur, the marrow is spoken of as red marrow. Absence of the cellular element and the proliferation, apparent or real, of the fatty element results in the production of yellow marrow.

There is a third variety, of which more will be said later, namely, the myxomatous or embryonic marrow. It results from a proliferation of the loose, fine connective tissue, which everywhere supports the cellular elements.

The actual marrow cells are classified into different divisions, according to the presence or absence of granules in the protoplasm and the character of these granules.

A. There are non-granular cells, and probably two varieties of such.
   (i.) Large non-granular basophilic cells.
   (ii.) Small non-basophilic cells.

B. There are granular cells, subdivided according to the type of granule which the cells contain.
   (i.) Neutrophile myelocytes, the forerunner of the polymorphonuclear leucocytes.
   (ii.) Eosinophile myelocytes.
   (iii.) Basophile myelocytes including mast cells.

C. There are precursors of red blood cells; these are characterised by
their nuclei, and they are subdivided according to size into normoblasts, megaloblasts, and microblasts.

D. Finally, there remain fat cells, connective tissue cells and different varieties of giant cells.

The Histology and Histogenesis of the Original Tubercle

When tuberculosis attacks a bone it develops primarily as an osteomyelitis, and the changes which lead to the development of the primary tubercle originate entirely within the marrow. The infection reaches the marrow by one of two possible routes. (1) It is carried directly inwards by the blood stream—the intravascular infection. (2) It extends into the marrow along the perivascular tissues, more especially in relation to the vessels which connect the interior of the end of a bone with the synovial membrane of the neighbouring joint—the perivascular infection. While the final development of the tubercle is similar in both these varieties, the preliminary histogenesis and histology varies.

1. The Intravascular Tubercle.—The tubercle originates as the result of an intravascular infection, caused probably by occlusion of the vessel lumen with an embolus charged with tubercle bacilli. At the point where the infection has occurred, upon the vessel wall, there appears a circumvascular area of tissue necrosis. It is an area of a diffuse ground-glass appearance, and it owes its origin to the toxic effects of the neighbouring arrested bacilli.

Around this central necrotic area there is a ring of mononuclear cells and more peripherally a granular change in the fat cells, which apparently results from a breaking up of the fat and the deposit of crystals of fatty acids. Such constitutes the earliest stage in the development of the intravascular tubercle.

Epithelioid cells next make their appearance; they probably originate from the mononuclear cells and the connective tissue cells of the part, and they can be recognised by their irregular shape, the excessive amount of faintly granular protoplasm and the whorl-like arrangement of the nuclear chromatin. These cells intermingle with the ring of mononuclear cells, they pass through the ring and invade the central necrotic area. The focus has now the appearance of a tuberculous follicle, viz. a cluster of epithelioid cells, and a surrounding zone of mononuclears.

2. The Perivascular Tubercle.—Disease of the neighbouring synovial membrane is the usual source from which the perivascular tubercle of bone develops. The lymphatics become invaded, and the development of the tubercle is slower and gradual. Changes occur in the vessel in relation to which the affected lymphatics run (vascular changes), and in the tissues around the vessel (perivascular changes).

Vascular Changes.—The lodgment of the infection in the perivascular
Plate IV.—The Histology of the Original Tubercle.

a. An early stage in the development of a tuberculous follicle in the marrow. A blood-vessel, occluded by a tuberculous embolus, has become the centre of a cellular infiltration. b. Vascular changes secondary to the development of a tuberculous follicle. The endothelial cells lining the blood-vessel are becoming detached, and they later become converted into epithelioid and giant cells. c. A further stage in the development of the marrow tubercle. The lodgment of the bacillus has produced a surrounding necrotic area, through the centre of which a blood-vessel runs. The infection probably originated in this vessel. d. The edge of a tuberculous follicle; a limiting band of fibrous tissue is beginning to be deposited.
PLATE V.—THE HISTOLOGY OF THE ORIGINAL TUBERCLE.

a, The developing tuberculous follicle. The central necrotic area is beginning to be invaded by lymphocytes.

b, A tuberculous follicle with giant cell formation in the marrow. One of the giant cells shows commencing calcification.

c, A fully developed follicle with a large central giant cell.

d, A tuberculous follicle developing in the perivascular tissues.

e, Multiple tuberculous follicles scattered through the marrow.
tissues at first gives rise to an accumulation of round cells about the periphery of the blood-vessel. These cells are almost without exception mononuclear, and they have been derived from the cells of the surrounding marrow.

With the accumulation of round cells changes begin to occur in the coats of the vessel. The vessel walls become altered, their tissues become loosened and structureless, and the cells composing them lose their nuclear staining. The lining endothelium undergoes a most distinctive change, the cells become swollen and rounded, and detaching themselves from the wall, pass

![Image](image.png)

**Fig. 3.—A developing perivascular tubercle.** The tubercle is actually surrounding the vessel.

into and later without the lumen of the vessel. These changes are the result of a toxemia emanating from the lodged bacilli, and they result in a clotting and ultimate arrest of the blood stream.

**Perivascular Changes.**—Around the altered vessel there is an area of tissue necrosis similar to that which occurs in the development of the intravascular tubercle, and at the periphery of the necrotic area one finds a limiting ring of round cells. Epithelioid cells make their appearance, and invading the part, convert it into the appearance one associates with a typical tuberculous follicle.

Thus by two very different routes one has arrived at a common point of development—the tuberculous follicle. It is important to distinguish the two very distinct methods of formation as they indicate quite different sources of infection.
3. Further Changes in the Original Follicle.—The simple follicle, constituted as such by a collection of epithelioid and mononuclear cells, tends to undergo a variety of changes which, while they may occur in tubercle anywhere, have certain peculiarities when they occur in relation to bone.

Giant Cell Formation.—Giant cells are formed early in development. From personal observation one is inclined to support Metchnikoff’s view that they owe their origin to a confluence of individual epithelioid cells. They are unique in their size and in the number of nuclei which they may possess. One has counted 117 nuclei in a single cell.

Reticulation of the Follicle.—This condition has been described by Schüffel in relation to tubercle occurring in glands. The cells in the epithelioid cluster lose their definiteness and become transformed into a branching and “fluffy”-like structure. The change is of frequent occurrence in bone, and it denotes more especially a degree of chronicity in the lesion. The origin of the condition is in all probability a metamorphosis of each individual epithelioid cell into a branched myxomatous structure, the interlacement of the cell processes giving the characteristic “fluffy” appearance.

Surrounding Fibrosis.—The epithelioid cells at the periphery of the follicle tend to undergo changes—possibly having the effect of limiting the disease—which are common to most forms of tubercle, but which occur in bone to an unusually well-marked extent. The polyhedral cells at the periphery become elongated, and taking up a uniform laminated arrangement around the edge of the follicle, they become converted into fibroblasts, and, later, into an actual capsule of fibrous tissue. The process is always accompanied by changes in the surrounding marrow (page 19), and the combination of both indicates the ever-present tendency towards cure which exists in osseous tubercle.

Caseation.—Caseation results in the interior of the follicle partly from a loss of blood supply and partly from the destructive effects of the tuberculous toxins. It is uncommon in small tubercles, but it occurs when the lesion attains to any considerable size.

Central Cystic Degeneration.—This is a frequent change and one not thoroughly understood. The central epithelioid cells gradually disappear, leaving a space containing fibrillar debris. The degeneration begins in the centre and gradually extends to the periphery. While the central cavity is enlarging, the peripheral cells become condensed into a fibrous membrane, devoid of all trace of lining epithelium. This degeneration is the explanation of the curious porous appearance which certain tubercles possess, e.g. tuberculous dactylitis.

Calcification.—Calcification rarely occurs in bone tuberculosis; one has occasionally noticed it as a deposit in the centre of the larger giant cells. From such an original deposit an entire nodule may become calcified.

1 Schüffel, Lymphdrüsen tuberkulose, Tubingen, 1871.
PLATE VI.—SECONDARY CHANGES IN THE TUBERCULOUS FOLLICLE.

a, Reticulation of the tuberculous follicle—note its "woolly" and open appearance.  
b, Cyst formation in the centre of a tuberculous follicle.  
c, Secondary caseation of the tuberculous follicle.  
d, Calcification of a tuberculous follicle.  The calcification is evident as a clear space in the centre of a giant cell.
PLATE VII.—MARROW CHANGES IN TUBERCULOUS OSTEOMYELITIS.

a. Healthy bone marrow. b. Yellow bone marrow. Secondary to the tuberculous disease the cellular elements tend to disappear and the marrow becomes of the yellow or fatty type. c. Early fibrous marrow. Young connective tissue begins to appear in the septa which lie between the fat cells, and with a low magnification the marrow acquires a mosaic-like appearance. d. Fibrous marrow. The spaces between the bone lamellae are occupied by fibrous tissue. e. Fully developed fibrous marrow. f. Fibrous marrow. Note the distinct peri-vascular arrangement of the fibrous tissue.
THE PATHOLOGY OF TUBERCULOSIS OF BONE

Associated Changes

The original tubercle appears in the marrow as a minute grey point. While it is enlarging and developing, changes are occurring in the tissues which collectively compose bone, and the structural alterations which result from these changes are of importance, as they account for many of the characteristic features of the disease.

The structures which become altered are: the bone marrow, the bone lamellae, the periosteum, and the blood-vessels.

1. Marrow Changes.—The changes in the marrow are twofold—an early or cellular, and a later or fibrous. The first is an actively antagonistic one, the second is more limiting in its intention.

Cellular Changes.—The greyness of the original follicle is always relieved by a setting of red, and such colouring is the evidence of the active changes in the marrow around.

Microscopically it is a neutrophile leucoblastic reaction, at first of immature cells, but later fully developed polymorpho-nuclear neutrophils. The cells are possessed of high phagocytic powers; they contain quantities of altered blood pigment, and their action must frequently lead to destruction of the attacking bacilli.

This, which one may term the acute reactionary stage, lasts for about 120 hours from the date of the original infection. The character of the cells then begins to change, the polymorphs diminish in number, and are replaced by two varieties of cell—a small lymphocyte and a type of immature lymphocyte or large mononuclear cell. The production of these cells is of course very suggestive of the development of tuberculosis. The connective tissue cells remain constant, the fat cells appear to be diminished, but the diminution is more apparent than real. These changes in their sequence are most intense in the neighbourhood of the diseased focus, and they extend in a diminishing degree throughout the surrounding tissues. The cellular reaction of the marrow continues as long as the disease is increasing in extent, as long, in fact, as active phagocytosis is necessary. When the growth of the disease becomes arrested the cellular reaction disappears, and the marrow passes into the series of changes which end in fibrosis.

Fibrous Changes.—The conversion of the marrow into fibrous tissue is a gradual process which extends over some considerable time. The change is inaugurated by a disappearance of the specialised cells (lymphocytes) with a corresponding increase in evidence of the fat cells, and the appearance among the latter of a growth of young connective tissue. This develops from two sources: (a) From the connective tissue corpuscles which lie scattered among the fat cells. (b) From connective tissue fibrils which exist in the perivascular tissues.

The formation of connective tissue between the fat cells of the marrow gives rise to a curious mosaic-like appearance. The fat cells diminish in size and tend to atrophy, and sometimes the fat becomes broken up into an amorphous collection of analytic products. When the connective tissue is
derived from a perivascular source the vessel acquires a thickened appearance, but there is no endovascular change. The further history of the connective tissue is one of increasing density, the fibrillae tend to lie closer together and to become more compact. The degree of density is greatest in the immediate neighbourhood of the diseased focus. Fibroed marrow is yellowish-white in colour and of a remarkably firm consistence. These marrow changes are the result of specific demands. The primary infection is that of an irritant, and as such it calls forth a simple leucoblastic reaction. With the development of the lesion the specific action of the tuberculous tissue becomes evident, and the result is the production of cells specially antagonistic to tubercle, namely, the lymphocytes. When the antagonistic attitude is no longer demanded, the marrow undergoes a sclerosing change in order to limit and encapsulate the focus.

2. Lamellar Changes.—When tuberculosis develops in a bone the surrounding lamellae undergo distinctive changes. These changes are of two possible varieties, rarefaction of the lamellae—osteoporosis, and thickening of the lamellae—osteosclerosis. In an individual lesion only one type of change may occur, but it is more usual to find both types occurring coincidentally.

Osteoporosis.—Rarefaction of the lamellae is brought about by true absorption of the bone, or by a type of metamorphosis. Osteoclasts are the medium when absorption is the end in view, they come to be alongside the lamellae, and as a result of their action excavations appear which are known as Howship’s lacunae. By continuation of the process large areas of bone are removed, and individual lamellae in process of removal acquire a typical worm-eaten appearance. This is the more rapid mode of rarefaction; it is best seen in those instances in which a considerable portion of bone must be quickly removed and replaced by a specialised fibro-cellular marrow.

The metaplastic is the second method of rarefaction, and of the two it is the more common. A lamella is built up of a dense connective tissue, impregnated with lime salts. In the process of metaplasia the lime salts disappear and the fibrous elements remain. At first the position of the original lamella is evidenced by the unusual density of the fibrous tissue, but it quickly becomes imperceptibly merged in the surrounding tissues.

While one has drawn an absolute distinction between these two methods of rarefaction, it must be remembered that both may and do occur synchronously in the same specimen.

Osteosclerosis.—Osteoblasts derived from the connective tissue cells are the media through which the lamellae increase in thickness. They arrange themselves along the surface of the latter, and deposit successive layers of dense new bone. This new bone possesses certain peculiarities which at once distinguish it from the old; it contains a greater number of bone corpuscles, it stains a lighter colour, and the junction line between the old bone and the new is sharp and distinct, with an edge which is often irregular. The process of osteosclerosis is indicative of the more chronic types of bone disease; its objective is a limiting one, but a more passive limitation than that of fibrous marrow for example.
PLATE VIII.—THE RAREFACTION OF BONE.

The lamella is being absorbed by osteoclasts.
PLATE IX.—THE LAMELLAR CHANGES SECONDARY TO TUBERCULOUS OSTEOMYELITIS.

a, Fibrous metaplasia of the lamella: the bone lamella has reverted into fibrous tissue. b, Rarefaction of the lamella: the lamella is being eaten out and absorbed by means of osteoclasts, the resulting spaces are called "Howship's Lacunae." c, Rarefaction of the lamella: only a small portion of the original lamella remains. d, Condensation and thickening of the lamella by the deposit of new bone. The new bone is deposited by osteoblasts which may be seen lying in chains along the surface of the lamella.
PLATE X.—THE STAGES IN THE FORMATION OF NEW SUBPERIOSTEAL BONE.

a. An early stage in the deposit. Note the overlying muscular fibres, the two layers of the periosteum, the slightly irregular appearance of the surface of the original shaft, and the commencing deposit of new bone. 
b. Second stage in the deposit. The new bone is growing outwards in the form of spicules. 
c. Third stage in the deposit. The bone is now being deposited in the form of arches, and the intervening spaces are occupied by vascular connective tissue.
PLATE XI.—THE FINAL PICTURE OF NEW SUPERIOSTEAL BONE.

There is a complete case enveloping the shaft of the original bone; the centre of the original bone shows a tuberculous osteomyelitis.
3. Periosteal Changes.—It is recognised clinically that a subperiosteal thickening is one of the earliest features of tuberculous disease of the underlying bone. Such a subperiosteal thickening is the result of a deposit of periosteal bone, and the activity of the periosteum depends on an increased vascularity secondary to the underlying disease. The deposited bone is one of two kinds, porous bone or dense bone, and in each variety the method of formation differs.

Method of Formation of Porous Bone.—In the deeper layers of the periosteum, in addition to numerous osteoblasts, there are always to be found a number of osteoclasts. The function of these is normally in abeyance, but by their activity they carry out a preliminary which is essential to the later stages of new periosteal bone formation. The osteoclasts eat out a series of lacunae along the shaft of the bone, until the usually smooth surface becomes rough and irregular. Their activity is short-lived, and the completion of the surface excavation is the signal for the cessation of their labours. As soon as the osteoclasts cease their activities, the osteoblasts, which meantime have been proliferating in the deeper parts of the periosteum, suddenly begin to functionate, and a thin layer of new bone becomes deposited upon the uneven surface of the irregular shaft.

The introductory excavation of the osteoclast is quite an intelligible proceeding. If the periosteal bone had been deposited upon a perfectly smooth and even shaft, it would have required only a slight degree of violence to dislodge its attachment, but the preliminary roughening of the surface is sufficient to prevent the possibility of this occurring.

After the first layer of bone is deposited a second tier is begun. At certain points conical projections of new bone appear. They extend outwards as small spines, and in the interspinous intervals there is a quantity of granulation tissue and one or more blood-vessels. The scheme of architecture undergoes further changes when the spines become joined at their extremities, and a series of arches is formed. Successive series of arches are in this way deposited until a varying thickness of porous bone has been laid down. It is a scheme of architecture in which nature combines a maximum of strength with a minimum of weight.

Method of Formation of Dense Bone.—Occasionally the new periosteal bone is compact in character. The preliminaries are similar to those in the deposit of porous bone, but in the later stages no arches are formed, the bone remaining compact throughout. This is the method of deposit which one finds occurring in the neighbourhood of joints, the reason being that the amount of its deposit is never excessive; the more profuse porous bone might easily interfere with the mobility of the joint.

4. Changes in the Blood-vessels.—One cannot fail to be struck by the frequent occurrence of endarteritis obliterans in bone tuberculosis. The disease affects the smaller vessels and occasionally the primary divisions of the nutrient vessel. In histological detail the changes closely resemble those which occur in syphilis, but the changes in the tunica adventitia illustrate a distinctive feature. In syphilis the external coat is infiltrated and
surrounded by a number of small lymphocyte cells, in the endarteritis of
tubercle no such cells are to be found, instead there is a development of
perivascular connective tissue. The condition arises from the circulation
through the vessels of a tuberculous toxine. The change has far-reaching
results, the narrowing of the vessel lumen gives rise to considerable disturb-
ance in nutrition, and many of the fibroid changes in the marrow are sequelæ
to it. Further, the disease of the vessel wall has an effect on the local
development of tubercle. Many of the cases of so-called primary tuber-
culous disease occurring in the metaphysis of the long bones, the short long
bones, and the short bones, owe their origin to an antecedent endarteritis of
the larger blood-vessels.

The Gross Pathological Varieties of Osseous
Tuberculosis

The previous chapter has been devoted to what one might term the
general pathological changes, changes which in some degree at least are
common to all forms of the tuberculous lesion. But each case of tubercu-
losis possesses some peculiarity in its general features which justifies its
classification into a special type of the disease. Therefore one may classify
four different varieties:

1. The encysted tuberculous lesion.
2. The infiltrating tuberculous lesion.
3. The atrophic tuberculous lesion.
4. The hypertrophic tuberculous lesion.

1. The Encysted Tuberculous Lesion. — When the disease focus,
after enlarging to a certain extent, becomes shut off and localised, it is termed
an encysted tubercle. The encysted tubercle is the commonest variety, it is also the most chronic, and its chronicity is evidenced in every step
of its formation.

Macroscopic Appearances. — The fully developed lesion varies consider-
ablely in size, a common gauge is from a pea to a walnut. For descriptive
purposes it may be considered in a series of zones. The centre is occupied
by an area of translucent jelly-like material, through which are scattered
a number of opaque grey points, rather resembling putty in appearance.
When the lesion is of some age the individual opaque spots amalgamate
and form a central caseous patch, which is surrounded by a thin shell of
the original jelly-like material. Passing to the periphery, there is a band of
pinkish-white colour running round the translucent zone and sharply defined
from it. The circumference of this zone merges imperceptibly in the
surrounding marrow, which at the line of junction is somewhat more
congested than usual. When the disease is of considerable age, the central
portion becomes converted into a collection of semi-fluid debris, giving
the part a cystic appearance.

Microscopic Appearances. — The disease begins as a follicle of the loose
reticular type. It enlarges until it can be appreciated by the naked eye as
PLATE XII.—The Vascular Changes secondary to Tuberculous Osteomyelitis.

a, Tuberculous endarteritis. b, The nutrient vessel of a bone affected with tuberculous endarteritis; the bone itself was the subject of tuberculous disease. c, A vessel entirely occluded as the result of tuberculous endarteritis.
PLATE XIII.

a, Coronal section through the head of the femur: the disease originated in the metaphysis on the under surface of the neck and has resulted in extensive sequestrum formation.  
b, Encysted tuberculous disease in the lower end of the humerus.
THE PATHOLOGY OF TUBERCULOSIS OF BONE

The pathologic lesion in the bone is characterized by the presence of tubercles which are surrounded by a dense fibrous capsule. The lesion begins as a deposit of reticulated tubercle in the center of red marrow. The bone lamellae are absorbed and undergo rarefaction and absorption by means of osteoclasts, the slow development of the follicle usually affording sufficient time for the absorption to become complete. If the absorption of the lamellae is not complete, the particles which are left, being isolated by the diseased tissue, undergo necrosis and become converted into small sequestra, commonly known by the term "bone sand." In the central clear deposit areas of caseation appear, and they may coalesce into a patch of considerable size. Around the tuberculous tissue there is a limiting band of connective tissue. It is the pink limiting band which has been noted in the macroscopic appearances, and it is developed from the connective tissue elements of the surrounding marrow. The changes in the surrounding marrow are not extensive; close to the disease the connective tissue cells proliferate, and the marrow acquires a loose fibromyxomatous character.

One would summarise the sequence of events as follows: A deposit of reticulated tubercle appears in the center of the marrow, and it increases in amount, the bone lamellae being absorbed, until it forms an appreciable gelatinous-looking patch. Caseation appears in the center of the patch, and the lesion is localised by the formation around its periphery of a pale pink band of loose connective tissue.

2. The Infiltrating Tuberculous Lesion.—Nelaton described an infiltrating type of bone tuberculosis in 1836, and it was probably the first variety to be distinctly classified. It essentially represents the acute form of the disease.

Macroscopic Appearances.—The naked-eye appearances are best appreciated in a lesion of some considerable size. As in the encysted disease, there is a natural division into a series of zones. The centre is occupied by a pale-yellow area, yielding and crumbling when touched: it is the rarefied bone framework, the interstices being filled with caseous debris. Nelaton described it accurately when he called it l'infiltration puriforme. Extending around the central patch there is a zone of grey semi-transparent tissue (l'infiltration grise), which merges almost imperceptibly into both the central and the peripheral tissues. The appearance is afforded by the infiltration between the lamellae of tuberculous granulation tissue which has not yet passed on to caseation. Around the grey zone the marrow is more congested than usual. It constitutes the third or red zone (l'infiltration liée de vin). At the line of junction of the grey and the red the latter is sometimes modified to form a paler pinkish band.

Microscopic Appearances.—In its earliest stages the infiltrating type of disease begins as a deposit in the marrow of a number of groups of epithelioid cells. These coalesce until an appreciable area is occupied by

a grey opaque pin point in a setting of red marrow. There is a groundwork of branching connective tissue cells, and the interspaces are filled with epithelioids and mononuclears; giant cells are usually present.

The impression afforded is one of a chronic and slowly developing tubercle. As the disease develops in the marrow, it comes to surround and enclose a number of bone lamellae, and these latter undergo rarefaction and absorption by means of osteoclasts, the slow development of the follicle usually affording sufficient time for the absorption to become complete. If the absorption of the lamellae should not be complete, the particles which are left, being isolated by the diseased tissue, undergo necrosis, and become converted into small sequestra, commonly known by the term "bone sand." In the central clear deposit areas of caseation appear, and they may coalesce into a patch of considerable size. Around the tuberculous tissue there is a limiting band of connective tissue. It is the pink limiting band which has been noted in the macroscopic appearances, and it is developed from the connective tissue elements of the surrounding marrow. The changes in the surrounding marrow are not extensive; close to the disease the connective tissue cells proliferate, and the marrow acquires a loose fibromyxomatous character.
the diseased tissue. The naked-eye appearance is that of a grey, semi-transparent tissue filling the interlamellar spaces. Its exact structure is difficult to elucidate. It is composed of densely packed masses of mononuclear and epithelioid cells. Intercellular connective tissue is at a minimum, and here and there there are branching connective tissue corpuscles. There is an early arrest of the vascular supply, and to this change one must attach considerable importance; it hastens the process of caseation, and in all probability it greatly depreciates any attempt at resistance in the surrounding tissues. Areas of caseation appear in the centre of this semi-transparent diseased tissue, at first isolated but later coalescing, and it is this caseous change which gives the characteristic yellow appearance to the central part of the lesion. As the disease develops, numbers of the bone lamellae become surrounded. When this occurs an effort is made to remove each individual lamella by means of osteoclasts, and in this the process of rarefaction consists. In an infiltrating disease all active changes are arrested long before rarefaction becomes complete, the blood flow ceases, perhaps the toxicity of the bacillus is great; at any rate the process of absorption is arrested, the lamella dies, and as such it constitutes a sequestrum. Scattered throughout the tuberculous tissue there may be numerous sequestra (séquestres parcellaires), each bearing evidence by its worm-eaten appearance of the degree of rarefaction which it has undergone.

If the infection has been specially rapid and acute, necrosis may occur before any degree of absorption has become possible, in which case a large lamellar area dies, and remains in contact with the surrounding bone until it becomes separated by granulation tissue. Such constitutes a composite sequestrum. In the surrounding marrow there is a leucocytic reaction around the periphery of the disease, and the type of cell which constitutes the reaction is mainly the polymorph, the representation of lymphocytes and mononuclears being sparse. There is, in fact, a cellular reaction resembling that which one finds in acute infections, and it has been suggested that a mixed infection is the dominating factor in the pathology of infiltrating tubercle. Occasionally the cellular reaction becomes modified, and there is an attempt at fibrous limitation of the disease; this is the explanation of the pink band which one occasionally finds at the periphery. The periosteum becomes early activated, and forms masses of new bone. The details of the method have already been described. The essential factor is a congestion of the overlying periosteum, secondary to the central disease; the deposit may be localised or it may extend widely over the shaft of the bone.

**Special Features of Infiltrating Tuberculosis of Bone:**

1. The original tubercle is a closely packed collection of epithelioid cells, and in appearance a tubercle of the acute type.

2. Early in the course of the disease the blood-vessels become occluded, not by a chronic process of endarteritis as one generally sees in tuberculous disease, but rather by a sudden clotting and destruction of the epithelium.

3. Caseation early appears in the diseased area and spreads rapidly.
PLATE XIV.—THE STAGES IN THE DEVELOPMENT OF AN ENCRYPTED TUBERCULOUS DISEASE OF THE BONE.

a, An early encysted tuberculosis of the bone: the follicle takes the form of a reticulated tubercle. b, The edge of an encysted tuberculous disease, showing the development of the limiting fibrous band. c, The fibrous structure of the limiting band; there is a deposit of new bone upon the outer surface of the band. d, A central encysted tuberculous disease.
PLATE XV.—INFILTRATING TUBERCULOUS DISEASE OF THE BONE.

a, The advancing edge of an infiltrating tuberculous disease: there is a comparative absence of reaction in the neighbouring marrow. b, Commencing infiltrating tuberculous disease: note the absence of a fibrous reaction in the marrow. c, Acute infiltrating tuberculosis of the bone; the lamellae in the lower part of the section enclosed in the disease have been converted into sequestra.
Infiltrating tuberculous osteomyelitis of the tibia. The central portion is occupied by caseous debris; around this there is a band of tuberculous granulation tissue infiltrating between the lamellae (l’infiltration grise); at the periphery there is the zone of congested marrow (l’infiltration lié de vin).
PLATE XVII.—INFILTRATING TUBERCULOUS DISEASE OF THE BONE.

a, Acute infiltrating tuberculosis spreading up the centre of the shaft of the humerus.  
b, Acute infiltrating tuberculosis affecting almost the entire interior of the scaphoid bone.
PLATE XVIII.—THE ATROPHIC TYPE OF TUBERCULOSIS OF BONE.

a, The upper end of the ulna affected with atrophic tuberculous disease: the upper end of the bone is markedly expanded.  b, A vertical section through the upper end of the ulna. The articular cartilage is intact, there is a marked rarefaction of the bone lamellae and the interlaminellar spaces are filled with tuberculous granulation tissue.  c, A transverse section through the upper end of the ulna. The section shows the rarefaction of the lamellae and the occupation of the spaces by tuberculous tissue.
PLATE XIX.—THE APPEARANCE OF THE MARROW IN ATROPHIC TUBERCULOSIS.

Note the rarefaction of the lamellae and the replacement of the marrow by tuberculous granulation tissue.
PLATE XX.—ATROPHIC TUBERCULOUS DISEASE OF BONE.

a. The appearance of the bone in transverse section. Note the extreme rarefaction of the bone and the case of new subperiosteal bone.  
b. Atrophic tuberculous disease of the bone in transverse section.
It results partly from the toxicity of the bacillus and partly from the interference with the blood supply.

(4) Sequestra of varying forms occur, and they are the result of necrosis appearing before rarefaction is complete.

(5) The attempt on the part of the marrow and the surrounding tissues to localise the disease is inefficient, and consists in an accumulation of cells rather than a fibrous reaction.

(6) The disease has a characteristic spreading and infiltrating character.

3. The Atrophic Tuberculous Lesion.—The distinctive feature of this variety of tubercle is a wasting and atrophy of the bone lamellae. In some respects it resembles the *caries cicca* first described by Volkmann \(^1\) in 1879, and later by Koenig \(^2\) in 1896; but on the other hand it has characteristics which associate it with the *caries carnosa* of Koenig and the *tuberculose charneu* of Mauclaire. \(^3\) It is more correct to consider *caries carnosa* and *caries cicca* as the same type of disease in different stages of its development, and confusion is avoided if both terms are combined in the single descriptive title of atrophic tubercle. The reason for this will be more obvious when the lesion has been fully described.

Macroscopic Appearances. —The situation of the disease is typical in so far as it attacks the metaphyseal end of a long bone. The affected bone is uniformly and diffusely enlarged. It is much lighter than healthy bone, and its surface yields to the application of a moderate degree of pressure with a curious crinkling sensation. The periosteum undergoes a moderate degree of activity, and a thin sheath of new periosteal bone is deposited. On cross section of the bone, after the outer shell is divided, the interior is found to be occupied with a soft granulation tissue in which atrophied lamellae are scattered. The granulation tissue is of a flesh colour, and throughout its substance there are numerous spaces, producing a spongy appearance. The changes may extend to the articular cartilage, but the latter is never invaded.

Microscopic Appearances. Changes in the Marrow.—The earlier changes appear in the marrow, and in their development they are slow and insidious. Gradually the connective tissue elements increase at the expense of the fatty tissue, and the marrow becomes transformed into a variety of granulation tissue. The granulation tissue is largely composed of connective tissue cells of a myxomatous type, and the vascularity of the part is considerable. There are numbers of mononuclear cells and osteoclasts, and there is a tendency for the tissue to become cystic. Scattered throughout the bone there are tuberculous follicles, but their numbers are few, and in structure they are almost without exception reticulated. As the disease progresses there is an ever-increasing tendency for the granulation tissue to become converted into fibrous tissue.

Changes in the Lamellae.—With the replacement of the marrow by

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granulation tissue the bone lamellae undergo a rapid absorption. It begins in the centre of the shaft, and it is the result of the activity of osteoclasts. The absorption extends to the compact bone of the shaft, the lacunae are increased in size, and the whole appearance is one of extreme porosity.

Changes in the Periosteum.—With the appearance of radical changes in the centre of the bone, the periosteum acquires a sudden activity; the result is the deposit of a sheath of new subperiosteal bone of the vascular cancellous type. The further history of the periosteal bone is thoroughly distinctive of this type of lesion. When a considerable amount has been formed, the foundation from which it springs becomes undermined; that portion which lies in contact with the shaft becomes absorbed, and between the new bone and the original shaft there is a ring of granulation tissue. The periosteum goes on forming new bone peripherally, but the deeper portion continues to be removed, and this is maintained until there is a considerable thickness of granulation tissue separating the new periosteal bone from the original shaft. The result is an increased but very unstable circumference.

The confusion in the nomenclature is explained by the changes which the lesion undergoes when it has reached a certain point of development; the soft vascular granulation tissue becomes converted into a dry contracting granulation tissue. The *caries carnosa* of Koenig and the *tuberculose charneu* of Mauclaire are descriptive of the lesion when it is at an early stage in its development, and the granulation tissue is young and vascular. The *caries sicca* of Volkmann and Koenig is the same lesion when the granulations have become fibrous tissue and the vascularity has diminished.

4. The Hypertrophic Tuberculous Lesion.1—As there is a type of bone tubercle in which an atrophy of the lamellae is the distinguishing feature, so there is a form in which a thickening of the lamellae is the predominating factor. Its occurrence is rare, and its situation is typical in so far as it attacks the metaphyseal end of a long bone.

Macroscopic Appearances.—There is a diffuse thickening of the bone, beginning where the diaphysis joins the epiphyseal cartilage, and extending towards the centre of the shaft. The periosteum is readily detached, and in the later stages there is a deposit of new subperiosteal bone. The weight of the part is considerably increased. When the bone is divided in transverse section its structure is found to be unusually dense and firm. From the healthy tissue a hyperostosis can gradually be traced, and the hyperostosis is the result of an endosteal formation. The thickening is not uniform throughout the whole diameter. In the centre there is an area from which the lamellae have been absorbed, their place being taken by a quantity of grey semi-diffusent material. Embedded in the centre of the soft tissue there is usually an elongated sclerosed sequestrum.

Microscopic Appearances. Changes in the Blood-vessels.—These are

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1 Since the description of this lesion was written the author has made observations which have led him to believe that the hypertrophic type is primarily a syphilitic infection, secondarily infected with tuberculous disease.
PLATE XXI.—HYPTERTROPHIC TUBERCULOSIS OF THE TIBIA.

The bone is thickened in its upper two-thirds as a result of the endosteal deposit of new bone.
PLATE XXII.—HYPERTROPHIC TUBERCULOSIS OF THE TIBIA.

a. The appearance of the tibia.  b. The appearance of the bone on transverse section.  Note the central sequestrum.  c. An early stage in the development of hypertrophic tuberculosis.  There is an effusion around one of the branches of the nutrient vessel.
given the premier consideration because they are undoubtedly the first changes to appear, and probably the vascular derangement is the essential etiological factor in the peculiarities possessed by this type of the disease. The changes appear in the larger divisions of the nutrient vessels soon after the latter break up into their primary divisions, and they take the form of a structureless effusion around the vessel, and an endarteritis in the substance of its wall. The perivascular effusion does not remain structureless, it becomes organised and converted into granulation tissue. The endarteritis in the wall progresses, and the vascular and perivascular sclerosis soon leads to an almost complete obliteration of the vessel lumen. It is a peri- and an endarteritis.

Changes in the Lamellae.—When the thickening of the central vessels has developed, the lamellae immediately surrounding the vessel undergo an absorption and a fibrous metaplasia. These changes depend upon nutritional disturbances, resulting from the thickened blood-vessel. Where the lamellae have become absorbed the resulting space is occupied by a fibromyxomatous tissue. Outside the central area of absorption the lamellae become thickened and the hyperostosis results from the deposit of bone by osteoblasts lining the lamellar surfaces. It is essentially an endosteal thickening, and the result is a remarkably firm dense bone.

Formation of Sequestrum.—When an area in the interior of the bone has been absorbed and replaced by granulation tissue a variety of sequestrum occurs about the centre of the bone. It is the type of sequestrum which Ollier called le séquestre dur. Its method of formation is as follows: A number of osteoblasts, assuming a sudden activity, deposit a quantity of closely arranged new bone in the centre of the area from which the lamellae have been absorbed. This original deposit is not permanent, when it has reached a certain size it becomes absorbed and redeposited as a firmer, denser bone. This process of absorption and remodelling is repeated until the deposit is densely sclerosed. Up to this point of development the term sequestrum is a misnomer, the tissue is not dead. Later it becomes a true sequestrum from the interference with its blood supply. These are the appearances which one finds on cutting through the centre of the diseased bone: an outer zone of hyperostosis, an elongated central sclerosed sequestrum, and an intermediate area of soft granulation tissue.

Changes in the Marrow.—Mention has been made of the formation of fibromyxomatous tissue in the centre of the bone. Generally the marrow undergoes a fibrous degeneration. True histological evidence of tubercle occurs in the shape of a number of follicles developing in the granulation tissue in the centre of the bone.

Changes in the Periosteum.—In the early stages of the disease the periosteum shows no reaction, and the thickening is entirely endosteal in its origin. In later stages the periosteum is activated, and deposits a thin layer of new bone around the sclerosed shaft.

The changes in the disease are essentially those of a chronic infection.

1 Ollier, Encyc. internat. de chirurg., 1885.
The primary endarteritis of the nutrient vessel is the original change, and it depends on the circulation within the vessel of a tuberculous toxine. The thickening of the vessel wall results in a focal nutritional disturbance, an absorption of the surrounding bone, and its replacement by granulation tissue. The irritation of the central changes leads to a hyperostosis and sclerosis of the surrounding lamellae. The actual cytological development of tubercle occurs late, and it is by no means the outstanding feature.

**Sequestrum Formation.**—In the progress of tuberculous disease sequestrum formation almost inevitably results. According to the type of sequestrum three different varieties may be classified—minute sequestra, (bone sand or sequestres parcelaires), rarefied sequestra, and sclerosed sequestra.

**Minute Sequestra.**—These are the commonest, and they are met with in the encysted and the infiltrating types of the disease. They appear as small irregular particles of bone scattered among the tuberculous tissue. The method of their formation is as follows: Secondary to the development of tubercle an active absorption of the lamellae begins, and is carried on by means of osteoclasts. The absorption has been almost completed and the lamellae have been disorganised into a collection of irregular particles when the progress of the disease leads to the arrest of the circulation; the broken up lamellae become converted into sequestra. In appearance they are of varying size and irregular shape, the edges are serrated, the lacunæ in which the bone corpuscles lie are enlarged, and the bone cells have disappeared. The staining reaction is peculiar. Healthy bone stains pink with eosin, but small sequestra take on the basic stain, either as purple lines or as a diffuse maroon colour.

**Rarefied Sequestra.**—The term “complete” would be more applicable to this variety. The condition is met with in acute infiltrating tubercle. The disease spreads with remarkable activity throughout the bone, and large areas of tissue are rapidly invaded. Attempts are made by rarefaction to remove the invaded lamellae, but long before absorption is complete, before the lamellae have reached the stage of minute sequestra, necrosis occurs, and the whole extent of invaded lamellar substance becomes a sequestrum. At first the connection of the sequestrum with the surrounding bone is maintained, later the irritation of the dead tissue gives rise to a reaction in the surrounding living bone, and a line of demarcation is formed. The line of demarcation is really a band of granulation tissue, which being possessed of considerable phagocytic powers, absorbs the lamellae which unite the living with the dead, and leaves the sequestrum free.

**Sclerosed Sequestra.**—This type of sequestrum was probably first described by Ollier in 1885. He gave it the name of le séquestre dur. It is the type which one finds in the hypertrophic variety of bone tubercle. The origin of the formation of the sequestrum is an irritative one, and it is intimately related to an endarteritis of one of the larger nutrient vessels. The nucleus of its formation is a portion of the original bone-tissue, and usually a portion of bone which either is already a sequestrum, or is in process
PLATE XXIII.—STAGES IN THE DEVELOPMENT OF HYPERTROPHIC TUBERCULOSIS.

a. The marrow reaction: there is a proliferation of the connective tissue framework. b. The bone on transverse section to show the marrow reaction. c. The sclerosed sequestrum which usually occupies the centre of a bone affected with hypertrophic tuberculosis. d. The bone on transverse section: the excessive formation of endosteal bone is well seen. e. The bone on transverse section. An endarteritis of the nutrient vessels is illustrated, also the sclerosed sequestrum surrounded by an area of bone absorption.
PLATE XXIV.—A FULLY-DEVELOPED HYPERTROPHIC TUBERCULOSIS OF THE TIBIA.

The shaft is thickened by a deposit of endosteal bone, around the periphery there is a deposit of new periosteal bone and the interior is occupied by an area of tuberculous osteomyelitis.
PLATE XXV.—SEQUESTRUM FORMATION.

a. A large composite sequestrum occupying the upper end of the tibia. b, Sequestres parcellaires or "bone sand" sequestra. c, The edge of a sclerosed sequestrum. d, The rarefied or complete sequestrum: the sequestrum occupies the lower part of the field.
PLATE XXVI.—EXTENSIVE SEQUESTRUM FORMATION IN THE INTERIOR OF THE FEMUR.
of being absorbed. Upon this original nucleus new bone begins to be deposited, and it can be recognised from the original tissue by its deeper purple colour when stained with haematoxylin. At first the new bone is deposited in an open porous arrangement, but it does not remain permanently so. When a certain amount has been deposited, the deposit is absorbed, and a fresh amount laid down. The second deposit is more condensed than the first. The process of destruction and reformation is repeated several times until it eventually results in a focus of dense solid bone. Up to this point of development the term sequestrum is a misnomer, the tissue is not dead, it may have formed upon a dead nucleus, but the greater part of it is active and living. Later it becomes a true sequestrum, partly from an interference with the circulation and partly from the progressive infiltration of the surrounding tubercle.

Possible Sequelae of Bone Tuberculosis.—From the original focus within the interior of the bone a number of possibilities may result.

1. The disease may remain localised to the interior of the bone, giving rise to no external evidence beyond some periosteal thickening. Such a sequel is best exemplified in the encysted variety of tubercle.

2. The disease may extend from the medulla to the periphery of the bone, and forms a subperiosteal cold abscess. Or extending still further the pus forces its way through the periosteum to become a cold abscess of the surrounding soft parts.

3. The whole extent of the shaft of the bone may become infected with tubercle—a diffuse tuberculous diaphysitis.

4. There may be an extension of the disease from the original metaphyseal focus, through the epiphyseal cartilage into the epiphysis, and from the epiphysis into the neighbouring joint, setting up tuberculous arthritis.

Method of Healing in Bone Tuberculosis.—Fibrous tissue is the medium which nature employs in her attempts to localise tuberculous disease. In bone tubercle there is a considerable tendency towards spontaneous cure, and it is by the formation of fibrous tissue that the conversion is carried out. Around a bone focus every available tissue is metamorphosed into fibrous tissue. The marrow loses its cellular character and becomes fibrous, the blood-vessels are thickened, and even the lamellæ undergo a metaplasia which ensures their conversion into fibrous tissue. Beyond this fibrous barrier the tuberculous disease does not penetrate, and as the surrounding fibrous tissue contracts the diseased focus becomes less and less in extent. Occasionally the central deposit becomes calcified. Around the barrier of fibrous tissue a further reserve is deposited in the shape of thickened bone; the lamellæ become hyperostosed and sclerosed. The contraction which occurs in the process of healing sometimes produces striking architectural alterations in the anatomy of the bone. Such is well evidenced in the exaggeration of the kyphosis which occurs in the healing of Pott’s disease.
The Location of the Lesion in Osseous Tuberculosis

When Lexer in 1897 investigated the blood supply of bones, he instituted the term metaphysis to mean that portion of the bone which lies immediately upon the diaphyseal side of the epiphyseal cartilage.

In the metaphysis he demonstrated an intricate and profuse blood supply, dependent on the anastomosis in that area of two and possibly three sets of blood-vessels—the nutrient or diaphyseal, the metaphyseal, and the epiphyseal. Lexer further believed in the primary embolic infection of tubercle, the infected embolus lodging in the area in which the anastomosis is most perfect, and there producing a tuberculous metaphysitis. For the short long bones and the short bones there are further explanations. In such, the nutrient vessels enter the bone about the centre, and breaking up almost immediately into a leash of small vessels, the infected embolus is arrested at the division of the vessel, and the result is a central tuberculous osteomyelitis.

But the situation of bone tubercle is governed by other factors than the simple distribution of the vessels, factors which are partly anatomical and partly pathological, and considering the subject from the viewpoint of situation occurrence, bone tuberculosis may be divided into two groups:

1. That which occurs in the portion of the bone lying in relation to a joint.
2. That which occurs in a portion of the bone not in any relation to a joint.

**Group 1.**—In the great majority of cases the portion of a bone which lies in relation to a joint is composed of an epiphysis, an epiphyseal cartilage, and the epiphyseal end of the diaphysis, i.e. the metaphysis.

Various observers have pointed out that in different bones different individual portions of the bone are primarily infected. For example, in the lower end of the femur the original infection is a tuberculous epiphysitis, while in the upper end of the femur it is a tuberculous metaphysitis. There has been much questioning regarding the factors which would appear to decide the situation of occurrence.

The primary infection is a blood-borne one, and it is carried by the arteries of the limbs to the circus vasculosus at the reflection of the synovial membrane of the joint. From the circus vasculosus there is a choice of two possible routes by which the infection may spread, it may extend to the synovial membrane and there produce synovial tubercle, or it may invade the bone and give rise to a tuberculous epiphysitis or metaphysitis.

The situation in the bone which becomes infected is governed by two factors. 1. The portion of bone which lies in relation to the synovial reflexion. 2. The presence of vessels passing from the synovial reflexion into the interior of the bone. The first factor is a purely anatomical one. In some instances the synovial reflexion lies in relation to the epiphysis, it never extends beyond the epiphyseal cartilage as far as the metaphysis, and instances of this are seen in the upper end of the humerus, and in a
modified degree at the lower end of the femur. In other cases the synovial reflexion passes beyond the epiphyseal cartilage and lies in relation to the metaphysis, e.g. the upper end of the femur and the lower end of the humerus. An infection of the circus vasculosus at the synovial reflexion extends to that portion of the bone which the reflexion immediately overlies, be it epiphysis or metaphysis. The second factor depends on the entry of blood-vessels—the metaphyseal vessels—from the circus vasculosus of the joint into the underlying bone. According to the position of the joint reflexion the vessels enter the epiphysis or the metaphysis, and they form the medium by which the infection extends to the bone.

One may summarise the situation by saying that when the synovial reflexion lies entirely in relation to the epiphysis of the bone the epiphysis is the site of the primary tuberculous infection; when the reflexion lies beyond the epiphysis, upon the end of the shaft, the metaphysis is the first part of the bone to become diseased.

Group 2.—In this group one includes those bones or portion of bones which do not lie in immediate relationship to a joint—the diaphysis of the long bones, the short long bones, and the short bones. The infection is a blood-borne one, and it is in its origin an osteomyelitis. But there is one factor which is responsible for localising the infection. In certain bones the nutrient vessel which supplies the interior becomes infected with a chronic tuberculous endarteritis, there is thickening of the wall and gradual obliteration of the lumen. Secondary to the obstruction, the interior of the bone becomes degenerated, the lamellae become atrophied, the red marrow disappears and is replaced by a fibromyxomatous tissue. A bone thus changed becomes, so to speak, predisposed to disease, and a tuberculous osteomyelitis almost invariably follows. The resistance of the marrow is destroyed and the lumen of the vessel is so narrowed that arrest of tuberculous material readily occurs. Certain bones are more susceptible than others, and the condition bears some resemblance to arteriosclerosis in so far as it usually affects the vessel at the point where bifurcation occurs. The bones which are most commonly infected are those upon the blood-vessels of which the greatest strain is thrown—the dorsal vertebrae of the spine, and the short bones of the hand and foot.

BIBLIOGRAPHY


TUBERCULOSIS OF THE BONES AND JOINTS


PLATE XXVII.—TUBERCULOUS DACTYLITIS.

There is a tuberculous endarteritis of the nutrient vessel, and as a result of the endarteritis the zone of bone supplied by the diseased vessel has undergone rarefaction; the zones supplied by the periosteal and the articular vessels are healthy.
PLATE XXVIII. — THE ANATOMY OF THE ARTICULAR AND EPiphyseAL REGIONS.

a. This illustration indicates the relationship of the various structures at the reflection of the synovial membrane: the articular cartilage, the epiphysis, the epiphyseal cartilage, the metaphysis, and the synovial reflection. b. The junction of metaphysis and epiphyseal cartilage. c. The edge of the articular surfaces showing the reduplication of synovial membrane between the ends of the bones. d. The structure of synovial membrane: lining cells and deeper connective tissue.
TUBERCULOUS DIAPHYSITIS

Spina Ventosa.—This need not be classified as a distinct pathological variety of tuberculous disease, because it is simply an infiltrating tuberculosi affecting the diaphysis of a long bone or of a short long bone. There are certain peculiar facts in its pathological etiology, and they are best illustrated in such a tuberculous diaphysis as a spina ventosa of the phalanges or metacarpals. An endarteritis of the nutrient vessel just before and after it enters the bone is the localising factor. The endarteritis leads to a fibromyxomatous degeneration of the marrow, which predisposes the part to infection by tubercle bacilli.

BIBLIOGRAPHY

THE PATHOLOGY OF TUBERCULOSIS OF JOINTS

Normal Anatomy of Joints

The structures which enter into the formation of joints vary with the type of articulation. In every instance there are the skeletal elements—bones or cartilages—and in addition there are uniting media, simple or intricate, according to the variety of joint.

In the economy of nature there are two varieties of joints: (a) the Synarthrodial, which permit of no movement between the approximated surfaces; (b) the Diarthrodial or movable joints.

In the synarthrodial type the opposing surfaces are united by means of fibrous tissue (suture) or by hyaline cartilage (synchondrosis), and in the progress of ossification the uniting medium tends to disappear.

A diarthrodial joint may be one of two possible varieties, the movement between the surfaces may be limited—the amphiarthrodial, or it may be free—the diarthrodial joint proper.

An amphiarthrosis is united by ligaments and by an interposed plate of fibrocartilage, in the centre of which there is a rudimentary synovial cavity. The joints belonging to this group occur in the mesial plane of the body, and it includes the symphysis pubis, the intervertebral joints, and the joint between the manubrium sterni and the gladiolus.

The diarthrodial is the most elaborate and the most complete form of articulation. It is characterised by the freedom of its movements and the presence of extensive lining by synovial membrane. The diarthrodial is the type of joint which is most liable to infection, and the following remarks are in relation to it.

Structures which enter into the Formation of a Joint.—The opposing surfaces of bone are held in apposition by means of ligaments, and every diarthrodial joint possesses a ligamentous envelope or capsule, variously arranged thickenings constituting special ligaments. Within the attachments of the capsule there are the opposing surfaces of the bones, each covered with hyaline cartilage. The capsule itself is lined with synovial membrane, which is continued on to the surface of the intracapsular portion of each articulating bone. The synovial membrane ceases at the edge of the articular cartilage, and its most apt description is that of a tube open at each end. Within the joint interarticular ligaments may extend between the opposing surfaces of the bones, and interarticular fibrocartilages or menisci may divide the joint cavity into distinct compartments. All around the joint, in localities between the synovial membrane and the surfaces which it covers, there is found a varying quantity of fat.
PLATE XXIX.—TUBERCULOUS DISEASE OF THE SYNOVIAL MEMBRANE.

a, The formation of the original tuberculous follicle at the reflection of the synovial membrane. The follicle is indistinct, it lies at the base of the synovial reflection in the lower right-hand corner of the section. b, Proliferation of the endothelium lining the synovial membrane secondary to the development of synovial tuberculous disease elsewhere in the joint.
Structure of Synovial Membrane.—Lining the interior of the synovial membrane there are a number of flattened endothelial cells; their distribution is irregular, in places they are absent, in others they may exist several layers thick. The distribution is most plentiful at the synovial reflection. Beneath the cellular lining there is a condensation of connective tissue, which really forms a basement membrane. Occasionally the connective tissue is prolonged into the joint in the form of pedunculated villi covered with endothelial cells. The synovial structure is completed by a quantity of loose connective tissue, largely interspersed with fat cells, and carrying a network of blood-vessels.

Blood Supply of a Joint.—The blood-vessels of the joint freely anastomose in the capsule, and in the deeper parts of the synovial membrane. The vessels are most profuse at both synovial reflections, where they form a vascular zone around the articular extremities of the opposing bones. To this special portion of the vascular supply the term *circus vasculosus* has been applied. From the *circus vasculosus* the metaphyseal and epiphyseal vessels pass into the underlying bone.

### The Pathology of Tuberculous Joints

The changes are best considered under three distinct headings:

A. The formation of the primary tubercle.

B. The changes in the component parts of the joint, synovial membrane, articular cartilage, underlying bone, blood-vessels, ligaments, and soft parts.

C. The gross pathological varieties of the disease.

#### A. The Formation of the Primary Tubercle

It is in the tissues of the synovial membrane that the original tubercle first makes its appearance, and more especially in the deeper parts of the synovial membrane where the blood-vessels run. The infection being blood-borne the lesion quite often appears in the wall of the vessel, and from this original deposit dissemination occurs. In appearance, the follicle is usually of the chronic variety, there is a well-marked reticulum, and the epithelioid cells are separated by intervals of varying size. Caseation is a change which rarely occurs. Giant cells are commonly present, and, as in bone disease, the giant cells are peculiar in so far as they often possess an enormous number of nuclei.

#### B. Changes in the Component Parts of the Joints

1. Synovial Membrane.—Synchronous with and subsequent to the development of the primary tubercle a whole series of changes may occur in the synovial membrane. Considering the changes in their sequence from the surface, one finds that the lining endothelium may be considerably increased in thickness, the thickening giving it a curious velvety sensation when handled. Scattered throughout the thickened endothelium there are distinctive cells, which in nuclear arrangement and amount of protoplasm resemble the simple epithelioid cell. Also there are giant cells
scattered about in isolated positions, and apparently developing quite independently of any secondary lesion; they are the result of a chronic irritative change. Important alterations occur in the connective tissues—the changes are sometimes spoken of as those of a gelatinous degeneration—the tissue fibres become swollen and pellucid, and the subjacent fat is increased in amount.

2. Changes in the Articular Cartilages.—The absence of blood-vessels renders cartilage practically immune to the development of original tubercle, but it does not prevent it from becoming involved secondary to disease of the synovial membrane.

The changes in the cartilage may be described under two headings: (a) The involvement of the cartilage from its superficial, i.e. from its joint, surface; (b) The involvement of the cartilage from its deep or osseous surface.

(a) Superficial Involvement. Perichondral Infiltration.—Koenig believed that the superficial involvement of the cartilage had its origin in a deposit upon the articular surface of a quantity of fibrin, and by organisation of the fibrin the underlying cartilage became softened and vascularised. This view is not correct. Schlabowski has shown that the changes begin where the diseased synovial membrane is reflected on to the bone. The diseased membrane becomes adherent to the cartilage, and when detached from it a pitted and irregular surface is left.

The granulating diseased synovia is a vascular tissue, and as it grows and extends it gives rise to certain changes in the underlying cartilage. The cartilage cells within their capsules begin to multiply and the capsules to enlarge correspondingly; only the superficial cells at first are affected, the deeper ones later. The proliferated cartilage cells are not healthy, they shrink and retract from the capsule wall, and ultimately degenerate entirely. The intercellular tissue becomes altered. Normally cartilage is a matrix in which there exists a quantity of fine connective tissue fibres, but in the healthy state these fibres are disguised and practically unrecognisable. When the cartilage becomes diseased the connective tissue fibres proliferate at the expense of the matrix, a change which is spoken of as "fibrillation of the cartilage." It consists in a conversion of the cartilage, at first into fibro-cartilage and later into fibrous tissue. At this stage the cartilage becomes infiltrated with tuberculous granulations, which force their way downwards among the tissue fibres. The appearance of a cartilage so affected is characteristic. Over its surface there is spreading a pannus of tuberculous granulation tissue, derived from the surrounding synovial membrane. The underlying cartilage appears congested, it has lost its characteristic glitter, and there are intervals of its surface which are pitted and replaced by patches of soft, vascular, velvety-looking tissue.

(b) Deep Involvement: Subchondral Infiltration.—Synovial tubercle begins and is most intense at the reflection of the membrane. From the

1 Koenig, loc. sup. cit.
PLATE XXX.—CHANGES IN THE CARTILAGE SECONDARY TO TUBERCULOUS DISEASE OF THE JOINT.

a, Perichondral ulceration secondary to disease of the synovial membrane. To the right of the illustration lies the tuberculous granulation tissue, to the left the cartilage. Note the irregular ulcerated surface of the latter.

b, "Fibrillation" of the cartilage. This appearance is found secondary to a spreading of tuberculous tissue over the surface of the cartilage.

c, Subchondral ulceration of the cartilage: a layer of tuberculous granulation tissue has spread inwards from the edge of the joint between the cartilage and the underlying bone.
reflection it may extend along the deep surface of the cartilage, between the cartilage and the underlying bone, and by doing so it constitutes a subchondral infiltration.

The infiltrating zone is a vascular granulation tissue, which does not possess an extreme degree of disease; in fact the cytological evidence of tubercle is at a minimum; its thickness is considerable, and it may undermine the whole extent of the articular cartilage. In its deeper parts the tissue tends to become fibrous, and by doing so it provides the bone with a protective covering or cap. Should the overlying cartilage be destroyed the bone is not left entirely exposed, but is protected by the fibrous shell. Sooner or later the result of the subchondral infiltration is a casting off of the overlying cartilage. It separates in flakes, or sometimes as the complete articular surface which comes to lie free within the joint cavity.

Watson Cheyne 1 has described a type of cartilage change secondary to tubercle, which differs from the two already mentioned. He thus describes it:

"The cartilage was intact except at the margin and at one spot towards the centre and anterior surface of the internal condyle of the femur, where there was a small depression on the surface... The depression on the cartilage is due to destruction of the cartilage at this point.

"There are further a number of flask-shaped spaces in the cartilage, which, under a high power, are found to be filled with young fibrous tissue. Some of these spaces communicate with the surface of the cartilage, either freely or by narrow channels, while the majority, and perhaps all, are connected with the superficial cancelli of the bone by similar channels. At various other points along the deeper parts of the cartilage we see flask-like projections communicating with the bone, and when these occur the most superficial cancelli show osteitis.

"I have not been able to find any tubercle in the bone. In this instance we have undoubtedly destruction of the cartilage commencing from the deeper parts in a manner totally different from the usual modes."

Changes in the Underlying Bone.—When the synovial membrane becomes diseased, changes appear in the portions of the bones which enter into the formation of the joint. According to the position of the attachment of the capsular ligament, there lies within the joint the epiphysis or the epiphysis and a portion of the metaphysis. Both of these in the healthy state contain red marrow.

Secondary to the synovial disease the first change to appear is an alteration of the red marrow into yellow marrow, due to a disappearance of the cellular elements. Insidiously the yellow marrow undergoes an extensive structural alteration, the loose connective tissue which normally exists in the spaces between the fat cells and around the blood-vessels proliferates, and by its proliferation converts the fatty marrow into a fibromyxomatous tissue. The macroscopic appearance of such a bone changes from a red to a yellow, and eventually to a grey gelatious colour.

Here one word of warning is necessary. The gelatinous appearance of the marrow is constantly being mistaken for a tuberculous infection of the bone, and without microscopic evidence it is sometimes extremely hard to distinguish between the two conditions. The marrow change lowers the resistance of the bone, and renders it more liable to a secondary infection. To what are the changes due? Their etiology can be traced to two sources—to a toxic process resulting from the development of tubercle in the synovia, and to an endarteritis of the epiphyseal and metaphyseal vessels, itself the sequel to a tuberculous toxemia.

Changes in the Blood-vessels.—Attention has been drawn to the importance of endarteritis in tuberculous disease of bones; it is just as frequently found in tuberculous disease of joints. The blood-vessels run in the sub-synovial tissues, and they are most plentiful around the synovial reflection.

The vessels undergo an early primary endarteritis and a later periarteritis; the perivascular changes form the starting-point of more extensive fibrosis in the surrounding tissues. So marked may be the tendency to vascular obliteration that even the largest periarticular vessels may suffer. Lannelongue has recorded that in hip-joint disease the lumen of the femoral artery is considerably narrowed.

The endarteritis extends from the synovial vessels along the metaphyseal and the epiphyseal vessels, and many of the changes in the articular ends of the bones are secondary to the vascular obliteration.

Changes in the Ligaments and Soft Parts.—In the neighbourhood of a synovial tubercle the surrounding soft parts undergo degenerative changes, and the most important of the soft parts are the ligaments which build up the joints. These ligaments are composed of dense fibrous tissue. Under the influence of disease they become swollen and gelatinous. This change depends upon an increased deposit of fat in the surrounding parts, and an accumulation in the interfibril spaces of a myxomatous material. From these alterations there results an abundant laminated tissue, having the same character as cicatricial tissue, and from the loss of form and boundary it is often impossible to say where individual ligaments begin and end. Sometimes in the ligamentous degeneration there is a deposit of osseous material in the shape of stalactites or plaques, more rarely in the shape of a ferrule of bone, which produces a complete osseous ankylosis (Henocque).

The changes spread beyond the ligaments; the muscles, tendon sheaths, and the overlying skin become pale, swollen, and oedematous, and these peculiarities have been the source of the term "white swelling." At a late period there may be actual involvement of the soft parts with tubercle; the disease spreads beyond the synovial tissues, burrowing along the lines of the blood-vessels.

In the neighbourhood of the periarticular changes there are gelatinous degenerations in the intermuscular tissues (Legg), and the muscles undergo considerable atrophy.

1 Lannelongue, Aběs froid et tuberculose osseeuse, Paris, 1881.
Plate XXXI.

a. Tuberculous disease of the hip joint. This specimen illustrates the appearance of the cartilage when it has undergone a sub-chondral ulceration. 
b. Tuberculous disease of the hip joint. The articular cartilage shows the typical appearance of a peri-chondral ulceration.
PLATE XXXII.—TUBERCULOUS DISEASE OF THE SYNOVIAL MEMBRANE.

a. Myxomatous degeneration in the subsynovial tissues: it is this which gives the characteristic appearance to the condition known as white swelling.  b. Tuberculous endarteritis of the vessels in the subsynovial tissues.  c. Bone changes secondary to the development of synovial tuberculosis. Note the rarefaction of the lamellae and the conversion of the marrow into a fibro-myxomatous tissue.
According to Poulet, there is an ascending degeneration in the surrounding nerves; the degeneration attacks the smaller filaments, and it has been blamed for much of the muscular atrophy which is so characteristic of joint tuberculosis.

C. The Gross Pathological Varieties of Joint Tuberculosis.—There have been a number of different classifications of joint tuberculosis; their multiplicity is sufficient evidence of the fact that a satisfactory division has not yet been proposed. The most typical changes of joint tuberculosis are evidenced in the synovial membrane, and a suitable classification can be made by taking the synovial changes as the basis of the division.

Upon this understanding one may divide joint disease into four distinct groups:

(a) Acute miliary tuberculous synovitis.
(b) Chronic tuberculous synovitis.
(c) Granulating or fungating tuberculous synovitis.
(d) Fibrous tuberculous synovitis.

(a) Acute Miliary Tuberculous Synovitis.—This is the most acute and fortunately the rarest variety of joint tuberculosis. It owes its origin to a vascular dissemination of the organism over the extent of the synovial membrane.

Clinically, it may be difficult to distinguish from simple acute synovitis. The interior of the joint contains a quantity of fluid, at first serous, later becoming purulent. The entire synovial membrane is congested, and the lining endothelium is desquamated. Scattered throughout the synovial tissue there are numbers of tiny tubercles, many of them microscopic, some as large as a millet seed. They are rapidly caseating, and each stands out as a yellow centre in a setting of red, a zone of reactionary congestion.

The articular cartilages are probably unaltered, but upon their surfaces there may be a deposit of fibrin and desquamated cells. If this cartilage deposit is long standing and becomes vascularised, the underlying cartilage will undergo a perichondral ulceration. The surrounding ligaments and soft parts are swollen and infiltrated with serum. The blood-vessels, intra-articular and periaricular, are dilated.

(b) Chronic Tuberculous Synovitis.—The interior of the joint contains an excess of fluid, usually clear. The synovial membrane is characteristically thickened, it has a pellucid gelatinous appearance, especially in its deeper parts, and everywhere there are tiny opacities which denote the development of individual tubercles. To the touch it is firm, and it has a sensation not unlike that of thick india-rubber. It appears paler and less vascular than the surrounding parts, and when it is stripped from the joint surface an unusual amount of fat is found to have accumulated beneath it. When the synovial membrane is examined microscopically, the tubercles are found to be of the chronic variety, open and reticulated in structure. Coincident with the development of the tubercles there are changes in the
component parts of the synovial tissue. The lining epithelium increases in thickness to many times its original depth. The connective tissue, which forms the groundwork upon which the lining cells rest, proliferates, and many of the fibres are arranged around the tuberculous follicles. The surrounding fibrous rings afterwards contract, and the central tuberculous follicle bulges upon the surface, affording what is perhaps the most typical appearance in this variety of tubercle, namely, the nodular appearance of the synovial membrane. The deeper connective tissues become changed, the alteration is idiomatically spoken of as a gelatinous degeneration, the tissue fibres are swollen, pellucid, and jelly-like. The blood-vessels are thickened and their lumina correspondingly narrowed. The articular cartilages become involved late in the disease by a perichondral infiltration. The subchondral infiltration does not occur in this variety. There are fibrotic and rarefactive degenerations in the underlying bones. The ligaments and soft parts undergo the fibro-myxomatous changes which are collectively spoken of as "white swelling."

(c) Fungating or Granulating Tuberculous Synovitis.—When the synovial membrane is converted into tuberculous granulation tissue the disease is best described by the term fungating or granulating tuberculous synovitis. The synovia becomes so thick that it may fill the entire joint cavity. It has a red proliferative appearance, and it is soft and spongy to touch. Scattered among the red tissue there are opaque or yellow points—tubercles—in some of which degenerative changes are occurring.

Microscopically, the disease begins in the deeper parts of the synovial membrane as a collection of tuberculous follicles. The tuberculous change rapidly spreads, extending from the deeper to the superficial parts of the membrane. The tubercles are clusters of epithelioid cells, there are numerous giant cells, and caseation readily occurs. Between the follicles and generally throughout the synovial membrane there is the formation of an amount of granulation tissue, which gives the characteristic appearance to the disease. The granulation tissue is simple and embryonic in structure. There is a loose reticulum of young connective-tissue fibrils, largely infiltrated with different varieties of round cells, and running through this granulation tissue there are considerable numbers of thin-walled blood-vessels. Throughout its substance there are scattered hemorrhagic areas, the results of rupture of the thin vascular walls. The articular cartilages may be largely obscured by the granulation tissue, but the free surface is rarely affected; there is, however, a typical subchondral infiltration. A zone of granulation tissue forms between the cartilage and the bone, extending inwards from the synovial reflection. The deep surface of the cartilage becomes invaded, and large scales of cartilage are thrown off into the interior of the joint. When the articular cartilage is destroyed the underlying bone is found to be covered with a protecting cap-like layer of fibrous tissue. The ligaments and soft parts are in a condition of white swelling, and it is no uncommon thing for the tuberculous granulation tissue directly to invade the soft parts along the line of the blood-vessels. The interior of the joint
PLATE XXXIII.—THE VARIETIES OF TUBERCULOUS DISEASE OF JOINTS.

a, The granulating type of synovial tuberculosis.  b, The miliary type of synovial tuberculosis.
PLATE XXXIV.—THE VARIETIES OF TUBERCULOUS DISEASE OF JOINTS,
a, Chronic tuberculous synovitis.  b, Fibrous tuberculous synovitis.
contains an excess of fluid, sometimes semi-purulent and often blood-stained.

(d) Fibrous Tuberculous Synovitis.—There is a type of synovial tubercle which is associated with a progressive formation of fibrous tissue. French observers have christened it synovite tubereuse, and Demoulin has associated its development with the caries sicca of bone tuberculosis. Its essential peculiarity is the conversion of the entire synovial tissue into dense fibrous tissue. The interior of the joint is of a light flesh colour; the synovial surface is rough and covered with tiny nodules—an appearance rather resembling fresh pigskin. Over the surface there are numbers of grey tuberculous follicles. There is an excess of fluid in the joint, and foreign bodies or rice bodies are often present. These are smooth, rounded bodies, sometimes flattened, sometimes spherical, covered with a mucous-like exudate, and occasionally attached by a pedicle of connective tissue.

Microscopical examination shows that the characteristic fibrosis begins around the original developing follicles, its function probably being a localising one. From the periphery of the follicle the fibrosis gradually extends into the surrounding tissue, and it progresses throughout the synovial membrane. The articular cartilage is not extensively affected; there is some fibrillation round its periphery. The blood-vessels are characteristically thickened. The rice bodies already mentioned are found microscopically to consist of nodules of fibrous tissue. Their method of formation is disputed. Reise and Koenig believe that they owe their origin to a deposit of fibrin upon the synovial membrane. Should the deposit become displaced it constitutes a rice body. Goldmann and Garie maintain that they are degenerative products of diseased synovial membrane, and that while they most usually occur in tuberculosis they may occur independently of it.

The Various Clinical Evidences and Sequelae of Joint Tuberculosis.

1. The disease in the joint may be chiefly evidenced by the accumulation within the joint cavity of a quantity of fluid—a tuberculous hydrops. It is analogous to the ascitic form of peritoneal tubercle, and it is characteristic of a chronic type of the disease.

2. The joint may become distended with tuberculous pus. This may be the sequel to a true synovial tubercle, but more frequently it is the result of a sudden invasion of the joint by a bone focus.

3. Tuberculous thickening of the synovial membrane may be the outstanding feature of the disease, the outline of the joint is enlarged according to the arrangement of the synovial membrane.

The hyperplasia extends beyond the synovial membrane, and the surrounding soft tissues share in the change. To this variety the term tumor albus or white swelling has been applied.

1 Demoulin, Archives gén. de méd., 1894.
2 Reise, Deutsche Zeitschr. für Chir. xlii. 1.
4. The extension of the disease from the joint into the surrounding soft parts leads to the development of periarticular cold abscesses, and these by bursting through the skin are the origin of sinuses.

5. The infection of the articular cartilages and their destruction permits of an exposure of the opposing osseous surfaces. The disease invades the cancellous tissue of the bone, and the joint becomes disorganised.

Method of Healing in Joint Tuberculosis.—The process of healing in a tuberculous joint will depend upon the extent of the original disease. If the disease has been purely synovial, the process of cure will consist in a development of fibrous tissue in the synovial membrane. There will probably be some degree of stiffness in the joint. When the disease has been more extensive and the articular cartilages have been destroyed, the formation of fibrous tissue is necessarily great. The opposing joint surfaces are bound together by it, the articular cartilages and the synovial tissues become converted into it, and the interlamellar spaces of the adjacent bones become occupied with it. Even the periarticular vessels share in the fibrosis. When a cure necessitates such extensive changes as these, there naturally results a fibrous ankylosis. Sometimes, just as in bone tubercle, the process of cure extends further, and the osseous tissue plays its part. The remains of the joint surfaces become united by new bone, and there is a fresh bone formation around the periphery of the joint.

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THE CLINICAL FEATURES OF BONE TUBERCULOSIS

It is necessary that one should insist on the paucity of symptoms in a pure type of bone tuberculosis; there is much confusion between the symptomatology of bone disease and joint disease. That the symptoms should be few in the case of the bone is what one would expect from the pathological features of the disease. From its deep situation its manifestations are hidden, and by reason of its slow progress the symptoms have little of the nature of the acute. But there are certain features which occur, and they are best considered in the order in which they appear in the progress of a case.

Local Features

Thickening.—Local thickening of the affected bone is usually the first feature to appear. Its recognition will largely depend on the situation of the diseased bone, whether it is superficial or deep. The increase in the circumference of the bone is the result of a periosteal reaction and the deposit of a quantity of new subperiosteal bone. Its origin is insidious, but its progress is steady, and it may advance until the shaft of the bone may have acquired twice its original circumference. At first the thickening is yielding and indentable, because it is virtually a granulation tissue, but as ossification proceeds it becomes as hard as healthy bone. The original position of the deposit is a fairly exact indication of the situation of the original disease, but in advanced cases it may surround the entire circumference of the bone. It is slightly tender when palpated, and in the early stages of the disease there is no increased local temperature or redness. Local thickening, such as has been described, is the most characteristic feature of bone tuberculosis.

Pain.—In bone disease pain is the result of pressure upon the nerve endings. Acute conditions in which the increase of tension is rapid and extreme have intense pain as the predominating symptom. In tuberculous disease, however, the pain is slight and frequently entirely absent. While the disease is confined to the interior of the bone the slow progress of the infiltration precludes any degree of tension, and it has been suggested that tuberculous disease exerts a degenerative, or at least an anesthetic influence upon nerve tissue. But in certain cases pain is certainly present, and the explanations of its occurrence are as follows: (1) The deeper layers of the periosteum are well supplied with nerves, and sometimes the nerve endings are of a highly specialised type. While the disease is still confined to the interior of the bone a simple serous effusion occurs beneath the peri-
osteum; the effusion exerts tension upon the nerve endings, and local pain is the result. It is therefore an early feature in the sequence of symptomatology. And it is only temporary, for with the formation of new periosteal bone the subperiosteal tension is relieved. (2) In the more rapid infiltrating types of tuberculous osteomyelitis it is quite possible that a considerable increase of intraosseous tension may occur, and, as in acute osteomyelitis, pain may be induced. (3) The pain met with may be not local, but referred. There is an irritation of nerve trunks, and the irritating factors vary, alterations in the architecture of the bone, the formation of masses of tuberculous granulation tissue, the pressure of a cold abscess. The pain is referred to the distribution of the affected nerve trunk, and the best illustration of it is found in Pott's disease, in which pain is often referred to the middle line in front.

**Muscular Wasting.**—It is difficult to estimate the extent to which muscular wasting is actually secondary to osseous tubercle. In joint disease it is uniformly quoted as a most outstanding feature, and it has been stated that it owes its occurrence to reflex irritation from the diseased joint. If such be its true explanation in joint tubercle, it very likely will explain its occurrence in bone disease. But the difficulty lies in deciding the question of to what extent atrophy is the result of want of use. The chances are that with the first appearance of symptoms and the diagnosis of tubercle, rest treatment is at once begun, and this must lead to a certain degree of disuse atrophy.

**Abscess Formation.**—As the disease progresses caseation and softening occur in the interior of the bone; when the periphery of the bone is invaded a subperiosteal cold abscess develops. Presently the periosteum gives way, and the abscess formation extends into the surrounding soft parts. Its further course will vary according to questions of gravity, position, and tissue arrangement.

The French appreciation of the pathology of a tuberculous abscess is a good one. They look upon the condition as one would a type of tumour formation, with central degeneration. Always at the periphery there is the infiltrating tuberculous granulation tissue; in the centre there is usually caseation and abscess formation. Considered in this light it is not difficult to understand how sometimes the abscess becomes pedunculated and sessile, and occasionally becomes entirely cut off from the focus which gave it origin. The further stage of untreated abscess formation is the opening on a free surface and the establishment of a sinus.

**General Features.**—Three factors are at work in producing the general features of osseous tubercle—they are the dissemination of the disease, the absorption of tuberculous toxins, and the occurrence of sinuses with the inevitable mixed infection. The dissemination of the disease is not common. Glands are the earliest tissues to become affected, and a spread to the meninges is often the terminal feature. The absorption of tuberculous toxins is of course continually proceeding, in small measure or in great. It produces such features as loss of weight, increasing debility,
disordered digestion, and occasional rises of temperature. But far more important than any of these is the part played by sinus formation and mixed infection. The infection of a cold abscess with organisms other than the tubercle bacillus is often tantamount to signing the patient's death warrant. When it has occurred, a cure is most difficult to obtain, and quickly in the train of the infection there come the complications of hectic fever, emaciation, sweating, diarrhoea, and the features of waxy disease.

THE CLINICAL FEATURES OF JOINT TUBERCULOSIS

In comparison with bone disease, tuberculosis of joints is accompanied by a much wider range of clinical features. There are several reasons why this should be the case. The majority of joints from their position are comparatively superficial, and those which are movable and diarthrodial joints are practically the only ones affected by the disease. The symptoms are exaggerated by the possibility of apposition and friction. Following the plan hitherto followed, the features are best considered in the order in which they clinically occur.

Local Features

Stiffness in Joint.—Free and untrammelled action of a joint is very largely guaranteed by the presence of synovial fluid, and any diminution in amount of this latter is demonstrated by varying degrees of stiffness. When the synovial membrane becomes infected with tuberculous disease one of the earliest sequelæ is a diminution in the amount of true synovial fluid. The amount is least in the morning, but as the day passes and the joint surfaces are stimulated by movements, the amount increases, though it never reaches a normal standard. One is therefore not surprised to find that the joint stiffness so characteristic of early joint tubercle has a distinct diurnal occurrence. It is most marked after the joint has been rested for some time, e.g. in the morning, and it disappears after movements have been indulged in. It is important to recognise the true etiology of this symptom, as it is often confused with the feature of muscular rigidity.

Alteration in Use of the Joint.—Each joint possesses a prescribed degree of movement, and any alteration in the degree is quickly evidenced. The evidence may take various forms. In the lower extremity it usually appears as a limp, in the upper extremity it may be as an error in the execution of some of the finer and more complicated movements. What is the explanation of this sign? It depends on an early degree of muscular irritability. It would appear as though the muscles were unwilling to trust the joint to its full range of movement. In the lower extremity the recognition of a limp may be comparatively easy, but in the upper extremity
the development of the feature may be so insidious that very considerable care may have to be taken before the condition is recognised.

Alteration in Position of the Joint.—In certain positions the opposing joint surfaces are more widely separated than in others, and it may be taken as a rule, to which there are few exceptions, that flexion is the position which most completely secures this. Therefore one finds that while the disease in the joint is as yet early, the limb tends to take up an altered position, and, as has been said, usually one of flexion.

When the disease is fully established there are more extensive alterations in position, and they depend upon one or other of two possible causes. The first of those is a very considerable increase in the amount of joint fluid, actually forcing the joint surfaces into an abnormal position. It has been shown experimentally that when the hip-joint has been filled with fluid under pressure the limb automatically takes up a position of abduction, flexion and external rotation. The second factor is one which is found comparatively late in the course of the disease, and it is a considerable alteration in the architecture of the bones which enter into the formation of the joint. According to the positions and the degree of bone destruction, a great variety of abnormal postures may be demonstrated.

Pain.—Pain is the feature which one generally associates with joint disease, and as a rule it is one of considerable prominence. Why should pain occur? The reasons differ according to the extent of the disease. In the early stages it is due to intra-articular tension and pressure. The tension is exerted upon the synovial membrane and the joint surface as a whole, or it is borne by the articular cartilage. In the first instance it is partly the result of a thickened synovial membrane and partly an increased amount of fluid within the joint. In the second instance it is the sequel to a subchondral infiltration of the disease, spreading between the articular cartilage and the underlying bone, and exerting pressure upon both these structures.

In the late stages of the disease pain is the result of a varying degree of disorganisation within the joint, a destruction of the articular cartilages, and an exposure of the osseous surfaces.

Not only is the pain variable in its cause, but it is also variable in degree. Sometimes it is agonising, and accompanied by general symptoms of considerable acuteness; at other times it may be slight, and even completely absent. It is increased by movements of the joint surfaces.

The site of the pain is also liable to change. Generally it is local in the affected joint. Occasionally it is referred to the distribution of a nerve trunk lying in relation to the diseased joint. The best example of referred pain is found in tuberculous disease of the hip-joint, when the pain is often referred to the front and the inner side of the knee, following the distribution of the anterior crural and the obturator nerves.

Night Cries.—They are usually considered as constituting a special variety of pain. They indicate an extension of the disease to the underlying bone, and their occurrence is evidence of ulceration of the articular
cartilages. During sleep the relaxed muscles permit the diseased surfaces to come into contact with each other; pain is at once induced, and the alarmed muscles contract. Their contraction is intended to fix the opposed surfaces, but before fixation is complete there is a momentary increase of pain. In some instances the pain is not sufficient to wake the patient, he is merely restless and may moan in his sleep. In other cases the pain is so severe as to wake the child with a start. Sometimes he wakens to find the pain gone, and cannot tell what disturbed him, sometimes it remains after consciousness is complete.

**Tenderness and Increased Temperature.**—When the diseased joint is palpated tenderness may be induced. The handling may increase the intra-articular tension, it may press upon some disorganised constituent of the joint, or it may irritate some periarticular structure (a bursa) which has shared in the joint inflammation. It is not a constant feature, and one should not be inclined to insist on its demonstration. If the joint is superficial, and the skin temperature be compared with that of the healthy joint, it is often found to be appreciably elevated. The raised temperature is the result of an increased vascularity secondary to the intra-articular changes.

**Muscular Rigidity.**—Nature provides the key to the treatment of tuberculous joint disease by her continual efforts to keep the diseased part at rest, and the medium which she employs is a muscular one. Intra-articular disease reflexly produces a rigidity of the muscles which normally move the joint. The degree of muscular spasm varies; it may be induced only by extreme degrees in the arc of possible movement; it may be so intense as to simulate ankylosis. The degree of rigidity is probably an indication of the amount and also of the position of the disease. The cause of the spasm is twofold. It is reflex from the intra-articular changes, and it is voluntary on the part of the patient to prevent friction of the diseased articular surfaces. Clinically it may be manifested on the slightest palpation, or it may require some degree of movement to demonstrate it. It is characterised by a most distinctive sudden contraction of the surrounding muscles.

**Swelling.**—In the more superficial joints swelling is a prominent feature. Its origin may be twofold; it may depend on a tuberculous thickening of the synovial membrane, or it may be the result of the distension of the joint cavity with fluid. When the synovial membrane is responsible for the enlargement, the thickening corresponds exactly to its anatomical distribution, and the thickening being most marked at the synovial reflexion, the swelling is noticed more especially at the periphery of the joint. To palpation a synovial thickening is characteristically doughy. When there is free fluid in the joint the swelling is a uniform distension of the joint capsule, and fluctuation can of course be elicited.

In estimating the degree of swelling in a tuberculous joint one must take into consideration the muscular wasting which exists around the joint. By comparison a swelling which is actually slight may appear very considerable.
The skin over a diseased joint often loses its natural hue, and acquires an anaemic and sodden appearance. The superficial veins may be distended. If the disease has spread from the joint into the neighbouring bone there may be some degree of osseous thickening.

**Muscular Wasting.**—Early atrophy of the muscles around the diseased joint is a constant sign. It is partly the result of disease and partly the result of a reflex impulse which originates within the joint. Accompanying the atrophy there is a diminution in the reaction to the faradic current, and the tendon reflexes around the joint are frequently diminished. The atrophy extends beyond the muscles, the bones become rarefied, and growth may be interfered with. In old-standing cases the degree of muscular wasting may give an exaggerated importance to the amount of joint thickening which is present.

**Alteration in Bony Outlines.**—As the joint disease progresses, there sooner or later ensues a destruction of the joint surfaces and of the underlying bones. Such a destruction may be responsible for an actual alteration in the outline of the joint, or it may induce simple shortening. In joints such as the hip, where the arrangement of the bones is irregular, the destruction may give rise to such deformities as abduction or adduction. There are cases in which the joint is infected secondary to a bone focus, and in such cases the destruction of bones is probably more extensive, and the alteration in the outline correspondingly prominent.

**Abscess Formation.**—The abscess formation which occurs may appear in three different regions: it may be purely intra-articular—a type which is sometimes designated empyema of the joint; it may be periarticular, being more exactly situated outside the capsule opposite the synovial reflexion; finally, it may be superficially in relation to any part of the joint. And as there are three positions of occurrence one finds that in each instance the etiology varies. The intra-articular abscess is the result of the conversion of a simple serous effusion—a hydrops of the joint—into a purulent fluid, or it owes its origin to the eruption of a bone focus into the joint.

The periarticular abscess is in the majority of instances located opposite the reflexion of the synovial membrane, and this peculiarity of situation offers the key to its exact etiology. From the synovial reflexion a number of blood-vessels extend outwards, piercing the capsular ligament, and spreading into the surrounding soft tissues. When the synovial membrane becomes diseased, offshoots of tuberculous tissue extend outwards along the line of the vessels, and give rise to periarticular abscesses. An intra-articular abscess may become periarticular by forcing its way through a weakened portion of the capsular ligament.

The etiology of the superficial abscess is quite distinctive. It only occurs when there is a considerable degree of white swelling in the surrounding tissue, and its development depends upon pus formation in the oedematous tissue. It has no traceable connection with the diseased joint. Bacteriological examination shows that these abscesses often contain a mixed infection.
The development of a cold abscess is always of serious import, because the chances of mixed infection of the joint are considerably increased.

**General Features.** — In addition to these local changes there are general changes. They are in every respect similar to those which have been described in bone tuberculosis, and there is no purpose to be gained by their repetition.

### THE DIAGNOSIS OF BONE TUBERCULOSIS

The system of diagnosis includes, or at least ought to include, two distinct psychological processes. The steps by which one comes to the decision that one is dealing with a certain recognised condition constitutes what one may term the actual diagnosis. The other process, the differential diagnosis, necessitates the recognition and the exclusion of conditions resembling the one under consideration.

**The Actual Diagnosis.**—How does one come to the decision that a definite bone lesion is tuberculous? The answers are gleaned from a variety of sources, and they are best considered in order of sequence.

**Milk History.**—In the examination of any condition suggestive of tuberculous disease, an interrogation regarding the milk supply is of the utmost importance. The assertion that the child has been breast-fed does not dispose of the possibility of infection by this source; for, except in very young children, cows' milk is almost certain to have been administered at some period. Two lines of further investigation must be followed. Has the milk which the child receives been boiled? Has there been any history of disease among the herd from which the milk was supplied? In bone tuberculosis bovine infection is a most fertile source, and no investigation is complete in which these questions have been omitted.

**Family History.**—Elsewhere the question of heredity in application to tuberculosis has been discussed. Of the importance of an inherited predisposition to infection no doubt can be entertained. But the occurrence of a tuberculous family history has a bearing even more important than that of inherited predisposition, for it may provide a fertile source of direct infection. A child residing in the house of a tuberculous father or mother may develop tubercle by direct infection from the parent. Some time ago the writer investigated a series of cases of bone tuberculosis from which the human bacillus had been isolated. In 71 per cent of these cases there was a history of the child having been in residence with a consumptive.

**Age.**—While tuberculosis of bones may occur at any age, its incidence is greatest during childhood, and more especially between the ages of five to twelve years. During the first year of life bone lesions are rare. After the first year they become increasingly common, and reach their acme about ten years.
Position of Lesion.—In disease of the long bones tubercle has a predilection for the ends of the bones, the metaphysis or the epiphysis. In this respect it resembles acute osteomyelitis, and differs from specific disease, except the epiphysitis of congenital syphilis. A certain proportion of cases develop in the centre of the shaft, the situation favoured by syphilis. Not only has the disease a partiality for certain situations in the bone, but some bones are more liable to the disease than others. The vertebrae are the most common to be affected, and the short bones of the hands and feet are frequently diseased.

Symptomatology.—If one were asked to mention the characteristic which distinguishes the clinical features of tuberculous bone disease, one would have no hesitation in giving first place to its insidiousness. Everything favours a gradual development. The bone is often deeply situated and protected by soft parts, its particularly dense structure is difficult of destruction and invasion, and there can be no doubt that the disease is more chronic in this situation than in many others. The general symptoms which are common to tubercle in any situation may be of extreme value in the diagnosis of a doubtful case.

Physical Signs.—Of the physical signs which may appear, thickening and abscess formation are certainly the most important. The thickening from the deposit of new subperiosteal bone is an early sign, the abscess formation is late. To the occurrence of pain one does not attach much importance; frequently it is entirely absent.

X-Ray Examination.—While one may come to a definite diagnosis of bone tubercle from a consideration of the several above-mentioned points, the reasoning is not complete until an X-ray photograph of the part has been taken. A good negative gives information on the following points. It tells one that the condition under examination is tuberculous, it delineates exactly the situation of the disease, and it affords information as to the exact type of the tuberculous disease, whether it is encysted, infiltrating, etc. Full details are given of the various X-ray features (page 58).

Tuberculin Tests.—No discussion upon general diagnosis is complete without making mention of certain well-known tuberculin tests. Space does not permit of more than a few remarks about the various methods.

Calmette's Ophthalmo-Tuberculin Reaction.1—All the tuberculin tests depend upon a heightened susceptibility on the part of the tuberculous to the poison of the tubercle bacillus. The increased susceptibility shows itself partly by a general disturbance, malaise, and fever, and partly by a local disturbance, the result of increased hyperemia of the tuberculous focus or the point of inoculation. The ophthalmic reaction consists in the instillation into the eye of a drop of tuberculin, either one-half per cent tuberculin prepared from the precipitate of Koch's old tuberculin by 95 per cent alcohol, or a standard solution prepared by dissolving old tuberculin in 0.3 per cent phenol. The reaction begins in six hours, and it is fully developed in twenty-four. It consists in a varying degree of simple conjunctivitis. The

inflammation lasts several days, occasionally weeks. The test must never be applied in cases of disease of the cornea or conjunctiva, as in such cases it is apt to lead to severe inflammation, ulceration, and even perforation of the cornea.

The Cutaneous Tuberculin Reaction (von Pirquet).—This consists in a skin vaccination with tuberculin. The reagent employed is composed of tuberculin 1 part, normal saline 3 parts, containing 25 per cent carbolic acid. Two small abrasions are made upon the cleansed upper arm. The abrasions must not be deep enough to draw blood. Into one a drop of the tuberculin solution is rubbed, the other is kept as a control. If tuberculous disease is present the infected abrasion shows within twenty-four hours a reactionary redness; this may pass on to actual papule formation.

Moro’s Test.—This is really a modification of the cutaneous von Pirquet test. It consists in rubbing into the skin a preparation of 5 per cent old tuberculin in lanoline. A reaction appears in the region into which the ointment has been rubbed.

The Focal Reaction Test.—The three tests already mentioned possess a great common fault; positive results are given by tuberculous disease in any part of the body, and the presence of a reaction does not necessarily mean that the lesion under examination is the tuberculous one. The local reaction test does not possess this disadvantage. It is a clinical test, and it consists in the injection into any part of the body of a small dose of tuberculin. If the lesion is a tuberculous one, it becomes congested and hyperaemic, and there are constitutional signs such as malaise, headache, and rise of temperature. The amount of tuberculin injected varies. A useful standard is 0.1 milligramme in children and 0.2 milligramme in adults. In Germany it is customary to begin with an injection in children of 0.1 milligramme. If no reaction results the injection is repeated with 2.5 milligrammes, and if there is still no reaction with 5 milligrammes. In using this method it must be remembered that susceptibility to tuberculin increases with each injection, so that even the healthy may react to large doses. With a focal reaction, however, the possibility of this error is diminished. In doubtful bone cases this is certainly the most reliable test. Take, for example, a swelling of the tibia. A study of history, symptoms, and physical signs leaves the diagnosis obscure. X-rays may not be available. The injection of 0.1 milligramme of tuberculin is followed in the twenty-four hours by increased pain in the doubtful part, swelling, oedema, tenderness, and redness of the overlying skin, if the condition is a tuberculous one.

The test is not without its disadvantages. The focal reaction has been blamed for causing a dissemination of the disease, and the use of the test is absolutely contra-indicated in conditions of fever.

The Diagnostic Use of the Tuberculo-Opsonic Determination.—A consideration of the facts embodied under this test is admirably given by

Rivière.\textsuperscript{1} One presupposes a knowledge of the details of the opsonic estimation and its principles. The application of the results is summed up by Rivière as follows:

1. The index for normal people is found to vary between 0.8 and 1.2 (Bulloch). When the index is persistently below this, if there is a localised infection which may be tuberculous, it probably is so. When the index remains normal it is not tubercle; when it is high, and especially when it fluctuates from time to time, there is active tuberculosis.

2. The effect of a small dose of tuberculin on the opsonic index is of diagnostic value. In the tuberculous it leads to a negative phase, followed by a positive phase. The negative phase is absent in non-tuberculous subjects.

3. When the local lesion contains fluid (abscess) the bacteriotropic power of the fluid is lowered towards the organism causing the lesion, \textit{i.e.} the opsonic index of the fluid is found to be lower than that of the patient's blood serum.

4. The "heated serum test" depends on the fact that the serum of the tuberculous and tuberculinised retains more of its opsonic power after heating to 60° C. for ten minutes than does normal serum. The tuberculosis determination has little use in clinical application.

\textbf{Differential Diagnosis.—} There are certain conditions which require to be differentiated from tuberculous disease, and confusion is more apt to occur before the stage of abscess formation.

\textit{Syphilis, Periostitis and Periosteal Nodes, and more especially Gummata and Sclerosing Osteitis.}—These are excluded by the history of syphilis, congenital or acquired, by the specific intensity of the pain during the night, by the affection occurring usually about the middle of the shaft, by the X-ray appearance, and by the result of the Wassermann reaction.

\textit{Chronic Staphylococcal Osteomyelitis.}—In this condition the onset has characters which betray the acuteness; its course is curiously liable to exacerbation and interval relapses, there are frequently considerable rises of temperature, there are often signs of local inflammation, oedema, and tenderness. An X-ray examination may be of value, but frequently the radiographic appearance closely resembles that shown in tuberculosis. The distinguishing points are, that in the subacute condition the deposit of new subperiosteal bone is scanty and incomplete, and sequestrum formation is more common.

\textit{Subperiosteal Lipoma.}—The mistake is made of confusing this with a subperiosteal cold abscess, and therefore assuming the presence of underlying tuberculous disease. The condition is recognised by the entire absence of bone thickening, the limitation and slowness of the disease, and the X-ray appearances of a healthy bone.

\textit{Periosteal Sarcoma.}—This condition is the most difficult to distinguish. It may usually, however, be recognised by the rapidity of its growth, the severity and the persistence of pain, and the entire absence of suppuration.

\textsuperscript{1} Rivière, \textit{Tuberculosis in Infancy and Childhood}, Kelynack, 1908, p. 283.
X-ray examination affords the most powerful diagnostic aid. In periosteal sarcoma there is the formation of new periosteal bone, but the line of junction between the new bone and the original shaft is irregular and eroded. In tuberculous disease the junction between old and new bone is sharply defined and clear cut. In exceptional cases an exploratory incision may be required to clear up the diagnosis.

Central Sarcoma.—Rarely this may be confused with central tuberculous disease. Its distinctions are the rapidity of its growth, the persistence of pain, the uniform character of the swelling, the presence of "egg-shell" crackling, and the distinctive X-ray appearance of a central growth expanding the outer shell of bone.

THE DIAGNOSIS OF JOINT TUBERCULOSIS

Actual Diagnosis.—Many of the remarks made in the section on the diagnosis of bone disease may be applied to joint disease. There is nothing further to be said upon the questions of age, family history, and milk history. In joints, as in bones, these facts are of immense importance.

Symptomatology and Physical Signs.—There are certain of the signs of joint disease which are important because they are unique, and therefore their value in diagnosis is correspondingly great. The three features to which one would apply the term unique are those of synovial thickening, muscular wasting, and night pains. The distinctiveness of each may be questioned, but closer examination will show how characteristic each may be. Synovial thickening may occur in other diseases, e.g. in syphilitic synovitis, but in tubercle there are two features which are pathognomonic, the uniform outline of the swelling delimiting the synovial membrane, and the doughy sensation on palpation. Muscular wasting occurs in the neighbourhood of any joint when the part is kept at rest, but the wasting in tuberculous disease is much more rapid and excessive than in any form of disease atrophy. Night pains owe their origin to destruction of the articular cartilage, and the cartilage may be destroyed in a variety of conditions; but the night cries of tubercle are characterised by their gradual onset and the relief afforded them by extension. The alterations in the use and position of the joint, while not unique, are exceedingly suggestive. The alteration in use is so gradual that the patient may be unconscious of it until his attention is directed towards it. Abscess formation is quite distinctive of the disease, but it would be well that a diagnosis be made before the disease had progressed so far. Muscular rigidity is important. It is essential to recognise that the fixation on account of the rigidity need not necessarily be complete, it may consist in a limitation of complete movement, but one attaches great weight to the fact that every movement of which the joint is capable is more or less affected.

General Tests.—These have been fully dealt with in the diagnosis of
bone disease. In application to joints the focal reaction following the inoculation of a small quantity of tuberculin is certainly the most reliable. A tuberculous joint becomes characteristically altered by increased pain, rigidity, and swelling.

**X-Ray Examination.**—Any doubt in diagnosis which a clinical study may leave is usually cleared up by X-ray examination. In the later stages of the disease the recognition of a tuberculous joint is an easy matter, the difficulty lies in the early stages. The appearances are hereafter described. The earliest is the indistinctness and blurring of the bone ends, an impression which is partly the result of the synovial thickening and partly of the increased vascularity of the membrane. When the cartilage edges become eaten out and their deep surface undermined, recognition is simplified. In the later stages of the disease no mistake can be made.

**Differential Diagnosis.**—There are a number of conditions which may increase the possibility of doubt and error; the following are the most important.

**Traumatic Synovitis.**—When a synovial effusion quickly follows on an injury such as a sprain, or on overuse or any form of internal derangement of the joint, it is a case of traumatic synovitis. In typical cases, seen soon after the injury, there is not much possibility of confusing the condition with tubercle, but if the case is seen some time after its onset there may be doubt. The synovial membrane may remain thickened after a traumatic synovitis, more especially if the traumatism has been recurrent. A distinction may be made by the history and the progressive nature of the tuberculous disease.

**Infective Synovitis and Arthritis.**—These diseases are characterised by more or less rapid and abundant effusion of fluid into the joint; in children they are pneumococcal, staphylococcal, or streptococcal in origin. In their early stages it may be impossible to distinguish them from tuberculous disease, but they quickly become recognisable by their sudden onset, the gravity of the general illness, and the tendency to pass on quickly to suppuration. Sometimes a study of age is helpful; these acute joint conditions are most commonly met with during the first year of life, a period when tubercle is comparatively rare.

**Epiphysitis and Osteitis in the Neighbourhood of the Joint.**—A neighbouring bone focus may produce a reflex joint effusion, and in this way a possibility of error may arise. The symptoms, however, are always in some degree acute, there is considerable swelling, and the temperature is continuously high. Early recognition of the condition is important on account of the ever-present tendency towards invasion of the joint.

**Periarticular Bursitis.**—Many joints are intimately related to overlying bursae, and lesions of the bursae may produce considerable similarity to tuberculous disease. This is well illustrated in the hip-joint, when disease of the bursa beneath the gluteus maximus, or that lying in relation to the psoas, may very closely simulate hip-joint disease. In bursitis, however, there is an absence of the characteristic signs of joint disease—the
synovial thickening, the muscular wasting, and the night cries. In the presence of further doubt an X-ray examination will clear up the point.

**Syphilitic Joint Disease.**—In application to children one need only consider the joint lesions of hereditary syphilis. The earliest are those associated with an epiphysitis in the ends of the bones. The condition occurs in infants, usually between the fourth and twelfth weeks of life, and the joint effusion is a simple serous one. The age of the child and other evidences of syphilis are sufficient to exclude the condition.

The gummatous synovitis of older children may give rise to great difficulty in diagnosis; it has, however, certain distinctive features, and they are its insidious development, the absence of constitutional disturbances, the bilateral character of the disease, the tendency for the knee-joints to be most commonly affected, the absence of pain, and the presence of free mobility.

**Rheumatoid Arthritis or Osteoarthritis.**—This has occasionally been confused with tuberculous disease. Its occurrence in children is rare, but when it is met with it may be recognised by the bony changes which are present and the polyarthritic character of the disease.

**Still's Disease of the Joints.**—The possibility of confusion is more probable in this disease than in rheumatoid arthritis. It resembles tubercle in so far as the synovial membrane is thickened and pulpy. The joints in the later stages become stiffened, simulating rigidity, and there is marked muscular wasting. It differs from tuberculous disease in being a polyarthritis, in being free from pain and true muscular rigidity, and in being associated with an enlargement of the spleen and the lymphatic glands.

**Infantile Paralysis.**—With the onset of anterior poliomyelitis there may be for a short time marked pain and tenderness, with immobility of the joint. The acute changes quickly subside, and the paralytic phenomena become obvious.

**Hysterical Joint Affections.**—In nervous children, during the period of life immediately before puberty, a condition of joint sensitiveness with lameness and pain is observed. If functional, these features may be recognised by the variability of their intensity and their inconsistency with one another.

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THE X-RAY APPEARANCES IN NEGATIVES OF TUBERCULOUS BONES

The Apparatus. — In taking a radiograph, the Röntgen or X-ray tube forms the most important part of the armamentarium. It is occasionally possible to get a good result from an inferior outfit if only there is a suitable tube, but the best outfit will be useless if an inferior tube is the only one available. The suitability of a tube depends upon the degree of vacuum within, and tubes may be classified into three groups—soft, hard, and medium.

Soft tubes possess a low degree of vacuum, and they give off rays of a low degree of penetration; hard tubes have a high degree of vacuum, and their rays have a correspondingly high penetrating power; medium tubes strike an average.

Substances are penetrated by X-rays in relation to (1) their atomic weight, (2) their thickness. The greater the atomic weight and the thickness the harder must be the ray in order to penetrate. It will therefore be understood why, in taking a radiograph of such a superficial part as the hand, one chooses a soft tube, and in deeply placed bones—femur and pelvis—a hard tube is to be preferred.

The Reading of the Radiograph. — The X-ray plate ¹ may be looked at from the glass or from the film side. If observations are made from the film side there is the advantage that the observer’s eye occupies the position of the X-ray tube, but it must be remembered that the positions are reversed, and the right hand of the observer corresponds to the left hand of the negative. In studying the negative from the glass side, the observer may imagine that he is looking at the part from behind, and the sides of observer and plate correspond. It is an advantage to examine the plate in an illuminating box. A diffuse light which can be varied in intensity is the best.

Normal X-Ray Appearance of Bone. — In a good X-ray considerable anatomical detail is shown. The periosteum is visible as a faint clear line, covering the surface of the bone. Beneath it there is the compact bone of the shaft; the arrangement of the lamellæ may be demonstrated, and occasionally Haversian systems.

In the centre of the bone the cancellous tissue appears as a porous network, the lamellæ appearing as irregular clear lines. Coursing through the interlamellæ spaces blood-vessels may sometimes be made out. In the

¹ In the following description the terms light and dark refer to the appearance of the negative. Dark areas in the plate signify that the tissue has been more permeable to X-rays than the surrounding parts, and vice versa.
PLATE XXXV.—THE X-RAY APPEARANCE OF EARLY TUBERCULOUS DISEASE OF THE BONE.

In the under surface of the neck of the femur there is a focus of encysted tuberculous disease. The centre of the focus shows an indefinite clear area which corresponds to a deposit of tuberculous granulation tissue. Around the central focus there is a dark band corresponding to an area of fibrous tissue, which as a soft tissue structure has offered little obstruction to the passage of the rays. Beyond this dark band there is a well-defined light band which corresponds to an area of condensed lamellae.
growing child the epiphyseal cartilages appear as clear bands of varying depths passing across the outline of the bone. It is important to observe that the distal surface of the cartilage, that is, the surface lying next the epiphysis, is smooth in outline, while the surface which looks towards the shaft, being the growing surface, is more irregular. Beyond the epiphyseal cartilage lies the epiphysis. According to the age of the child it may appear structureless, no ossification having yet developed, it may show a small developing centre of ossification, or it may have a structure similar to that of healthy cancellous bone.

It is most essential to have a definite knowledge of the normal X-ray anatomy in order to appreciate the finer discrepancies of the diseased condition.

Pathological Changes.—The changes will be described according to subdivisions of situation, whether they occur centrally or peripherally, within the cancellous tissue or beneath the periosteum. The description is concluded with a synopsis of the changes which one finds in the four types of bone tuberculosis—the encysted, the infiltrating, the atrophic, and the hypertrophic.

Central Changes.—One rarely has an opportunity of witnessing the X-ray appearance of an early central disease. The original marrow tuberculosis appears in the negative as a rounded light point. The cellular collection which constitutes the tubercle offers an increased resistance to the passage of the rays, with the result that the negative demonstrates its presence as a point of diminished density. At this early period no other change is visible. Now let us suppose that the disease is more extensive and has come to involve a greater extent of the bone. The principal changes are similar. A portion in the medulla of the bone appears, of diminished density, and stands out from the negative as a light area. But the changes do not stop there; there are characteristic appearances in the lamellae. Those which lie within the light area, that is to say, those which lie in the diseased tissue, have either been absorbed or are in process of absorption. The lamellae which are around the diseased area appear wasted and rarefied, a preliminary in the process of absorption. Sometimes lamellae which lie well beyond the diseased area appear thickened. Then there are radiographic alterations in the marrow between the lamellae. Normally marrow appears in the negative as a dark, structureless background, from which the clearer lamellae stand out. For some distance around a tuberculous focus one finds that the marrow loses its dark homogeneous character and becomes lighter with a faint striated appearance. The skiagraphic impressions are concomitant with a histological marrow fibrosis.

One would sum up the X-ray appearances of a well-defined central disease as follows: An area in the medulla of the bone appears of diminished density, it corresponds to the tuberculous granulation tissue. Within the light area the lamellae are absorbed, and around the periphery they are rarefied. There is an area well outside the diseased focus in which the lamellae appear thickened. Between the lamellae, around the periphery of
the central deposit, the carpet of marrow loses its dark uniform appearance; it becomes lighter, and its structure has a suggestion of striation. This, which may be taken as the typical appearance, is altered under two conditions, namely, cavity formation and sequestration. When cavity formation occurs there is a diminution in resistance to the passing rays, and the area is registered as a dense black shadow, it may be in the centre of the light tuberculous area. If a detached sequestrum is present, it, as an object, offers very considerable resistance to the rays. And in the skiagram it appears as an area somewhat lighter than that afforded by the diseased granulation tissue.

Peripheral Changes.—In the section on pathology attention has been drawn to the importance of new subperiosteal bone, and the deposit is well shown by an X-ray negative. If a series of negatives be examined at different stages of the disease, the earliest periosteal appearance is the development of what looks like a space between the periosteum and the underlying bone. In reality it is the picture afforded by the first stage of the deposit of new subperiosteal bone granulation tissue, which has not yet become ossified. At a later examination there is a typical deposit of new bone between the periosteum and the underlying shaft. If the new bone is deposited upon the shaft it is cancellous; if it is laid down in the neighbourhood of a joint its thickness is not so great, and its composition is comparatively denser. In examining an X-ray negative of new subperiosteal bone, one should never omit to examine the surface of the underlying compact bone. In tuberculous disease such ought to be smooth. This is important, because it is the distinguishing feature between the X-ray appearances of a periosteal thickening, due to underlying tubercle, and that due to periosteal sarcoma. In the latter the outline of the compact bone is eaten out and irregular.

The X-Ray Negative Appearances in Special Types of Bone Tuberculosis

Encysted Tubercle.—The situation is usually in or about the region of the metaphysis. In a fully developed focus the appearances are typical. Standing out from the centre of the bone there is a light area, from which all trace of lamellar structure has been removed. Within that light area, which corresponds to the actual tuberculous disease, there may be demonstrable the dark shadow of a cavity formation, or the lighter irregular appearance of a sequestrum. Around the periphery of the focus there is a dark, dense ring. It corresponds to the encapsulating fibrous tissue which has localised the disease, and it, as a soft tissue, offers little obstruction to the passage of the rays. Beyond this narrow dark band there is a broader and lighter zone, corresponding to an area of condensed lamellae. Sometimes the periosteum shows no reaction, but occasionally the picture is completed by the deposit of a varying amount of new periosteal bone.

Infiltrating Tubercle.—This is the most difficult type of tubercle
The new bone is secondary to tuberculous disease of the first metatarsal bone.
PLATE XXXVII.—The X-ray appearance of Tuberculous Disease of the Bone associated with Sequestrum Formation and a Cavity.
There is very considerable hyperostosis of the bone and a central sequestrum surrounded by an area of granulation tissue.
PLATE XXXIX.—The X-ray appearance of Atrophic Tuberculous Disease of the upper end of the ulna.

Note the thin "glassy" appearance of the bone.
in which to obtain a satisfactory radiograph. The best results are obtained by attention to a detail in the technique of development, and that detail consists in giving a long exposure, and subsequently retarding the development of what would otherwise be a dense negative. In appearance the cancellous tissue of the bone is occupied by an irregular light area corresponding to the diseased tissue. Within the clear area there may be darker spots of cavity formation, there certainly are lighter points which represent multiple minute sequestra. Occasionally the area may be occupied by a large composite sequestrum. The distinctive points in the interrogation of the plate lie at the periphery of the central disease. Here there is no limiting band to be seen and no condensation of lamellae. The periosteum always reacts, and there is the appearance of a quantity of new subperiosteal bone.

**Atrophic Tubercle.**—The X-ray appearances of this type are distinctive. The outline of the bone is enlarged, but it looks like an empty shell. The interior is clear, here and there are traces of lamellae, but they are wasted and thin. There is a deposit of new periosteal bone, but the deposit is meagre. All through the field there are dark areas of cavity formation, there is nothing suggestive of sequestra.

**Hypertrophic Tubercle.**—The diseased area is usually situated about the centre of the shaft. In examining a radiograph of the part, the first point to catch one's attention is an abnormality in the nutrient vessel. The vessel is apparent, which it ought not to be, and it is thickened. These changes are explicable by the endarteritis, which one knows to have occurred pathologically. Within the centre of the bone there is an oval dark area, and in the dark area the impression of a central sequestrum standing out in a light relief. All around the lamellae are hyperostosed and thickened. Finally, it is most important to observe that there is little formation of new periosteal bone, the thickening is mainly an endosteal one.

**The X-Ray Negative Appearances in Tuberculous Joints**

**The X-Ray Appearance of a Normal Joint.**—The characteristic of a healthy joint is its invisibility. The articular cartilages may be apparent as indefinite light lines, covering the opposing ends of the bones. The synovial membrane should certainly not be visible. The ligaments often may be traced on a good negative as faint light bands, and the surrounding tendons and muscles may often be similarly demonstrable. But of the true joint structure little or nothing should be visible.

**The X-Ray Appearance of a Tuberculous Joint.**—A comprehensive idea may be obtained if the changes are considered at three stages in the course of the disease—early, medium, and late.

**Early Joint Disease.**—Two joint structures show changes in even the earliest stages of joint disease, and these structures are the synovial membrane and the ends of the bones which lie within the synovial reflexion. The synovial membrane, invisible in a healthy joint, now becomes visible;
its distribution can be traced as a smoky indefinite band. It bulges outwards the overlying ligaments and muscles, and it projects into the interior of the joint. The other distinctive feature lies in the ends of the bones. They have lost their clear-cut cancellous structure, their outline is blurred, shadowy, and indistinct.

The explanations of these changes are obvious, the synovial membrane is thickened because it has become diseased. The ends of the bones are indistinct for two reasons, partly because the rays require to pass through thickened synovial membrane, and partly because they penetrate a membrane the vascularity of which has greatly increased.

Medium Joint Disease.—When one considers the changes in a joint in which the disease is more advanced, one finds, in addition to the above, other features making their appearance. The synovial membrane is thickened and the ends of the bones are blurred, but in addition the articular cartilage is most suggestively altered. It is altered in three situations—around its periphery, on its free surface, and on its deep surface. At the periphery there is an appearance as though pieces had been gouged out from the cartilage edges, it is a destruction of the extremity of the cartilage by the diseased tissue of the synovial membrane. On the free surface the cartilage has lost its smooth outline, and has become irregular—the result of a perichondral ulceration. On the deep surface the cartilage is irregular, and it looks as though it had been lifted off and separated from the underlying bone; this appearance is produced by the infiltration subchondrally of a quantity of diseased granulation tissue.

Late Joint Disease.—The X-ray appearances may vary within wide limits. All traces of the original joint outline become lost. A space between the ends of the bones is occupied by a white, blurred mass. The bone surfaces are eroded and irregular, and within the bone substance there are secondary tuberculous deposits, the radiographic appearance of which has been already described. If a quantity of fluid has collected within the joint it will be noticed that the articular surfaces are more widely separated than usual.

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The ends of the bones forming the joint have a characteristic "smoky" appearance; the outline of a thickened synovial membrane can be traced, and the wide separation of the ends of the bones indicate the presence of fluid.
PLATE XLI.—THE X-RAY APPEARANCE OF AN ADVANCED TUBERCULOSIS OF THE KNEE-JOINT.

The articular surface of the femur is eroded and destroyed, the outline of thickened synovial membrane can be traced; there is little or no fluid in the joint.


PROGNOSIS IN BONE AND JOINT TUBERCULOSIS

If the prognosis of bone and joint tuberculosis be considered from a scientific view-point, it will be found to depend upon two facts: (1) the general resistance which the body offers to a tuberculous toxæmia and bacillary dissemination; (2) the local resistance to the spread of the disease by the formation of a circumscribing fibrosis. Viewed from this standpoint, it would appear that the prognosis in bone disease, in comparison with many other forms of tubercle, is decidedly good. The disease is situated in a tissue which it is difficult to destroy and still more difficult to remove. Moreover, it is a tissue from which absorption is small because of the peculiarity of its blood supply and the meagreness of its lymphatics, and for the same reason the dissemination of bacilli is unlikely. Lastly, the disease is surrounded by marrow possessing cells of considerable phagocytic powers. Each of these points is favourable to an arrest of the disease, both local and general, and, from a pathological standpoint, one cannot help being struck by the frequency with which spontaneous cure occurs.

Arguing from the same basis, conditions are not so favourable in joint disease. The local powers of resistance are less, and the tendencies to dissemination of toxins and organisms are greater.

But to pass from theory to practical facts: any question of prognosis must be considered from two aspects—the prognosis regarding the life of the individual and the prognosis regarding the limb or the local part affected.

Life Prognosis.—As regards the life prognosis, it may be considered in application both to bones and joints, and at once it may be said that the prognosis is distinctly good. Children respond readily to treatment, and their powers of resistance and recuperation are considerable. A good life prognosis is therefore indicated in the great majority of cases. Under certain conditions the outlook is not so hopeful. There are certain features which, if present, increase the risk to life. These are:

(1) The Age of the Child.—If the disease occurs during the first two years of life, the life prognosis is grave.

(2) The Position of the Lesions.—Lesions in certain bones are much graver than those in others. The skull bones and the spine are the most unfavourable situations.

(3) The Multiplicity of the Lesions.—An extension of the disease to other parts indicates a want of general resistance, which forebodes ill in the ultimate prognosis.

(4) Abscess Formation.—This is serious in so far as it is so often the precursor of the next danger, namely, septic infection. Yet in itself it increases the gravity of the disease, because by its tendency to burrow it may open up to infection wide areas of soft tissue.
(5) Mixed Infection.—A superadded septic infection in tuberculous disease is the most serious complication which can occur. It follows abscess formation or imperfect surgical interference, and its danger lies in the apparent impetus which it gives to the tuberculous process.

Life is actually eventually threatened either by long-continued sinus formation with septic infection and waxy disease, or by the invasion of vital organs by the disease. In this respect the meninges most frequently suffer, the lungs are rarely invaded. Sometimes death occurs from a miliary dissemination.

Local Prognosis.—The prognosis in respect of the local part differs considerably, according to whether a bone or a joint is affected. In bone disease the local prognosis is good. The tissue is a resistant one, and there is a strong natural tendency towards cure. Further, as long as the disease is limited to the bone, the mobility of the part may not be seriously interfered with. In joints the conditions are not so favourable. The resistance is certainly less, and even the earliest disease interferes with the functions of the part. Sometimes in dealing with joints a cure cannot be obtained unaccompanied by some degree of ankylosis, and ankylosis in a joint necessitates a loss of its function in whole or in part. Therefore, everything considered, the local prognosis in joint tuberculosis is not so promising as it is in bone tuberculosis.

TREATMENT OF BONE TUBERCULOSIS

The treatment of bone tuberculosis embraces a wide variety of principles, treatment local and general, preventive and curative. It will be well to discuss the treatment under several distinct headings:

4. Treatment by tuberculin.

1. Preventive Treatment

It is an adage as old as time that prevention is better than cure, and surely nowhere can the application be more suitable than in this bearing. When one realises how distressing are the sequelae, no trouble is surely too great, no details too minute, that these may be prevented. First and foremost in the order of prevention there comes at the very threshold of life the question of milk. Bovine infection most undoubtedly plays its part in the origin of bone tuberculosis, and here is a cause crying for prevention. Sterilise the milk and the danger disappears. Milk may be guaranteed free from bovine infection, or it may have been sterilised, and yet in spite
of these precautions a most obvious preventible error occurs, and that is the contamination of milk or food of some kind with dust infected with tubercle bacilli. This applies more especially to the conditions under which the poor exist. The third order in the scheme of prevention would be the non-association of infants or children with consumptives. In a susceptible child infection may so easily occur. A careless consumptive spits upon the floor, the sputum dries and becomes converted into dust, and as such it is inhaled or ingested by the child. It seems unnecessary to enter a warning against the danger of an infant kissing a consumptive, and yet time and again it is a medium of infection. How simple are the principles of prevention, and yet how rarely are they recognised and observed.

2. General Treatment

(a) Hygienic Home Conditions.—The treatment of bone tuberculosis is such a long-drawn-out process that only in the minority of cases is the child detained in hospital until cure is complete. The treatment, therefore, has often to be carried out at home, where much may be done to improve the methods under which it is conducted. One has frequently had necessity to visit these cases in their homes, and one cannot avoid being struck by the absolute disregard so often displayed of the mere elements of hygiene. One must preach the doctrine of fresh air, a simple subject, but a most necessary one. If a balcony is available there the sufferer is placed, and there he is kept, fine weather and foul, night and day. The only inconvenience may be a passing catarrh; the benefits are too obvious to mention. If a balcony is not available, invention will meet the necessity. During the day he is carried to some open space, and at night his cot rests beneath an open window. Attention is drawn to the clothing. How often one sees the little sufferer actually groaning beneath the weight of garments and bed-clothes. One is apt to be branded as unkind if one substitutes a single garment and fewer blankets, but one earns the gratitude of the small being who wears them. You certainly have put him in a more favourable condition for his ultimate recovery. According to the type of disease from which the child suffers, he probably is fitted with a certain variety of splint, and frequently this necessitates a continuous recumbency. If it does, it is advisable that the patient should not be put in a large bed, as is so often the case, a bed shared perhaps by several members of the family. He should lie in an open crib, or even upon a home-made trestle.

These facts may appear trivial in their simplicity, but they are most essential to proper home treatment. There are others too numerous to mention, and they can only be recognised and dealt with in the light of actual experience.

(b) Hygienic Hospital Conditions.—In this country the average tuberculous child, when under active treatment, has to be content with a place in an urban children's general hospital. No doubt in every one of these institutions the hygienic conditions are as perfect as they can be made,
yet the principle of treating surgical tuberculosis in such for any length of time is fundamentally wrong.

During active or operative treatment residence in a general hospital is usually essential, but during the long-drawn-out period of after treatment it is distinctly inadvisable. There are obvious reasons for this: (1) It is impossible to keep the case in the wards of a general hospital until cure is complete. (2) No matter how perfect may be the hygiene of an urban hospital, it cannot for a moment compare with the conditions under which tuberculous children may exist in a country sanatorium. (3) The presence of a child often with discharging sinuses in a general hospital is a distinct source of danger and infection to those in contact with him.

The ideal which one lays down is not a very hard one. During the period of active treatment the child is kept in a general children's hospital. When that portion of the treatment which requires expert interference is completed the child is transferred to some country sanatorium, where it may be kept indefinitely, or at least until cure is completed. This ideal has been reached in several instances. England has its Lord Mayor Treloar Home at Alton and its hospital at Neuwall. France has its Berck-sur-mer and many others; Germany has at Rappenau an ideal institution. It is a matter for regret that as yet Scotland has not attained to a single institution of this kind.

In the building of these country sanatoria no elaborateness of construction is necessary. The actual building should be as simple as possible, the essential feature is the possession of abundant out-door space. At Berck, in front of the hospital, there is a wide plage, the sea-front of Brittany, and the space is thronged with recumbent patients, some on cadres, some on the ground, and some in voiturettes, being pulled along by donkeys. One has got to see cases treated under this regime to appreciate the excellence of the after results.

Surgical sanatoria require no elaborate buildings of stone and lime. There is a brick and concrete foundation, and the walls are built of wood and glass. The wards each hold an average of twelve to twenty children, and for preference they face south and west. An elevated situation and the most thorough drainage are necessary.

(c) Climatic Conditions.—Children, especially those resident in the larger towns, derive the most extraordinary benefit from change of air and scene, and it is in the early stages of tuberculosis that such changes are particularly to be advised. Now change of air and scene does not necessarily imply a change of climate. The latter is often the privilege of only the well-to-do, and it is from the poor that the bulk of our patients are drawn. But change one's surroundings, be it only the matter of a measured mile, and sometimes the benefit is enormous.

There are many classifications of climate. Sufficiently useful for one's purpose is that which classifies three varieties—sea-coast, inland, and mountainous. Each of these has got something to recommend it, and one will endeavour to give some points which will help towards a decision.
The sea-coast climate is one which is characterised by a low temperature, some degree of moisture, and the occurrence of winds. In the treatment of bone and joint tuberculosis it forms an ideal environment, and most especially for children. It is contra-indicated in certain conditions—when the disease is advanced, when there is considerable cachexia and wasting, and when the bone or joint disease is complicated by infection of the lungs.

Inland situations are on the whole dry and, when compared to the sea-coast, of a higher temperature. They are more suited for pulmonary infection than for the surgical tuberculosis of children.

Mountain climate has the characteristics of a rarefied atmosphere, a slight degree of humidity, and a low temperature. Of these the first is certainly the most important. In 1900 and 1901 some German physiologists (Zuntz, Loewy, Müller, and Caspari) carried out experiments upon dogs to demonstrate the changes produced by alteration in degree of rarefaction of the atmosphere. They showed that at the higher altitudes there are in the growing animal an increase in the amount of red blood corpuscles and haemoglobin, a stimulation of the active blood-making function of the marrow, and a relatively greater increase in growth. Now these changes necessitate an improvement in the blood and in the nutrition, and in the successful general treatment of tuberculosis no factors could be of more importance. Therefore, if from no other than a physiological reason, a mountain climate is ideal, the misfortune is that its enjoyment is only within the power of the few. Mountain climate possesses only one possible contra-indication, and that is an excessively irritable state of the nervous system.

Dr. A. Rollier of Leysin has urged the value of heliotherapy in surgical tuberculosis. The successful results which he claims are largely ascribed to the influences of the ultra-violet rays obtained at high altitudes.

(d) Diet. — In surgical tuberculosis, more especially when it is accompanied by a chronic febrile condition, there is a continuous loss of weight, and it is mainly to the diet that one looks in counteracting the progressive wasting. It may be taken as a general rule that in the ideal diet fats and carbohydrates, i.e. the more especially fattening forms of food, should be superabundantly represented, and combined with them there ought to be a considerable proportion of albuminates.

There are two difficulties which meet one at the very outset. The first of these is the occurrence of fever. If this is persistent and high, one may require to have recourse to fluid and easily absorbable foods, in much the same manner as in acute febrile diseases. The second difficulty is the ease with which the digestion is upset, and then ensues a want of appetite, and even a positive disgust for food. This can usually be prevented by the provision of well-cooked, appetising, and attractively served food. The diet of a child with tuberculous disease should contain a liberal allowance of fatty foods in the form of milk, cream, and butter. Raw meat is strongly recommended, and it is well digested by children. The milk ought to be sterilised or pasteurised, and some expedient may be followed to promote
its digestibility, the best is the addition to each glass of milk of two tablespoonfuls of hot water, in which about six grains of bicarbonate of soda and five grains of common salt are dissolved (Burney Yeo). Cream is well tolerated, and its value lies in the amount of fat which it contains; sometimes it may be diluted with hot water, and this procedure renders it more digestible.

The use of raw meat has been largely extolled. It may be reduced to a state of fine subdivision, it may be administered as a dry powder, or it may be given in the form of small, round pellets. Some children have an absolute antipathy to raw meat. The difficulty may be overcome by using meat-juice or underdone meat. Déboué’s forced feeding—*alimentation forcée*—was once popular in the dietetics of tuberculosis; it is now rarely used.

Eggs are always well borne by children, and they form an excellent diet. The general rule which would guide one would be a diet of food, regular and plentiful, containing a large proportion of fat.

(e) **Drugs.**—There are no specific drugs in the treatment of bone tuberculosis, any which appear to benefit act by improving the powers of assimilation and nutrition.

The preparations of cod-liver oil have a world-wide reputation; their benefit lies in the amount of fat which they contain. A common error in administration is the giving of the drug in far too large quantities, assimilation is much more perfect with small doses than with large. Malt and pepsin are often combined with cod-liver oil; their advantage lies in the stimulation which they offer to digestion.

Iron is frequently prescribed, and the most favourite forms in which it is given are the syrups of the iodide and of the phosphate of iron. One may with advantage combine these two preparations. In children the prescription of iron should be begun with one of the simpler preparations, one of the scale preparations for preference, or even dialysed iron, and the more complex preparations are introduced later. In children who are in any degree anaemic, the saccharated carbonate of iron is most beneficial, but it must be given in large doses, thirty grains t. i. d. Arsenic is recommended as a general tonic, Fowler’s solution being one of the most convenient forms.

Much has been written lately upon the effect which intestinal toxaemia has on the progress of tuberculosis, and undoubtedly its effect is a deleterious one, therefore one of the first principles ought to be careful regulation of the bowels. In children petroleum emulsion, 3 i., given at bedtime is an excellent laxative, or tinct. podophyllii m ii. t. i. d. If there is intestinal fermentation, salol or sodium sulpho-carbolate ought to be administered. Creasote-guaiacol or iodine given in pepsin is good. When a syphilitic taint is suspected a fraction of a drop of Donovan’s solution (liq. arsenii et hydrarg. iodidi) given after meals, alternating each week with Fowler’s solution (liq. arsenicalis), will be found beneficial. Succinimide of mercury has been recommended by Wright.\(^1\) It is given hypodermically in

doses of $\frac{1}{40}$ to $\frac{1}{60}$ of a grain daily for fifteen days, and the dose then gradually increased. Satisfactory results are obtained by the use of tonic doses of mercuric chloride.

3. Local Conservative Treatment

Fixation of the part.—No treatment has yielded such good results as that of simple fixation of the part. The necessity entailed is a fixation, not only of the local part, but also of the neighbouring joints, a detail which one frequently finds omitted.

Principles.—The principle upon which the treatment is based is a simple one—the nutrition and resistance of a tissue which is resting within limits are apparently superior to those of a tissue in constant use, and as a result of the improved resistance and nutrition the disease is opposed and frequently overcome. It has been asked why movement, with the increased blood supply which it entails, should not be rather antagonistic to the spread of tubercle than otherwise. The answer is that the arrest of tuberculous disease is not the result of an increased blood supply, but rather of a diminished one with subsequent fibrosis.

Methods.—There are numerous materials which at one time and another have been used for the purpose of fixation; those in most common use will be mentioned.

(1) Plaster of Paris.—Plaster of Paris is in many ways an ideal immobiliser. Its advantages are its cheapness, the adaptability of its application, and the complete fixation which it affords. Its disadvantages are few, possibly two are most obvious—the weight of the material and the muscular atrophy which the weight entails. In the application of plaster to a part, the operator must provide himself with three different materials: stocking-ette, plaster, and muslin. Some points of explanation about each are necessary. Stockingette is a light cotton material, made in a tubular form, and sold in rolls of varying sizes. It lies next the skin, and by its elasticity it naturally accommodates itself very closely to the part. It is a more satisfactory material than the boracic lint which is so commonly used.

Plaster or gypsum is a natural sulphate of lime prepared by heating at a temperature of 300° to 350° F. to drive off the water of crystallisation. There are two varieties of plaster—dental, and the grey or commercial. For use with bandages the dental plaster is the more satisfactory. Certain substances are recommended to be added to the plaster to improve it. There are those who advocate the addition of dextrin, on the ground that it lessens the tendency which the plaster has to crack. It has the disadvantage of considerably delaying the setting. Salt, alum, and sulphate of potash are used because they increase the rate at which the plaster sets. They all share the disadvantage of weakening the plaster. Probably the best addition to make is Portland cement; it is added to the plaster in the amount of one-twentieth part by volume. It increases the rate of setting and it materially strengthens the plaster.
PLATE XLII.—THE STAGES IN THE MAKING OF A PLASTER CASE.

a. The material which is used in the making of the plaster bandage: the edges are carefully frayed.
b. The technic of loading the bandage with plaster; one hand rolls the bandage while the other holds the part about to be rolled underneath a collection of dry plaster.
c. The correct manner of wringing a plaster bandage—it has been soaked in water.
d. The wrong method of wringing a bandage—by this method the centre of the bandage is extruded.
e. Stockingette adjusted to the limb.
f. The plaster bandages have been applied and the ends of the stockingette are turned over the case.
g. The completed plaster case: the free ends of the stockingette are incorporated in the case with a few turns of the plaster bandage.
The muslin is the crinoline type of starch muslin, sometimes called "tarlatan" or book muslin. Its mesh ought to be of such a size that there are seven or eight threads in each centimetre, and it is most important that it should have retained its starch. The muslin is used in the preparation of plaster bandages, and in the preparation of reinforcing plaster pads. Such bandages and pads may be made in one of two ways:—They may be prepared at the moment of use. A solution of the plaster is prepared, and the dry bandage is soaked and loosely rolled up in the plaster solution, to be immediately applied to the part. The alternative method consists in preparing the bandage or pads beforehand by rubbing the dry plaster into the muslin. The bandage lengths are cut, and the edges frayed. This is done to prevent cotton threads holding the bandage up as it is being put on. The lengths are loosely rolled into bandages. The end of the bandage is placed in a bowl full of dry plaster and pulled underneath the plaster. The bandage is re-rolled from this end, each portion being held under the plaster with the left hand, and pulled through and rolled with the right hand. The bandages are rolled loosely.

The technique of the application of a plaster case to the part is as follows: The part is carefully washed with a solution of alcohol and ether in equal parts. It is then dusted over with a light dusting powder, French chalk and talc in equal parts being useful. A single or a double layer of stockingette is now pulled over the part, and adjusted so that it lies free of all creases. The plaster bandage is then applied; if the bandages have been prepared beforehand they are placed endways in cold water and wrung out. In wringing out the bandage an important detail should be observed. It should not be wrung out with a closing fist, as this makes it bulge at one end, and it becomes irregular; it must be wrung out by compression of each end towards the centre. To secure a homogeneous setting, each bandage is wrung out drier than the preceding. The casing of bandage is put on uniformly and carefully, taking the greatest care to avoid creases. The case may be composed entirely of bandages, or it may be formed partly of pads—flat pieces of muslin—cut to fit the limb, wrung out of plaster, and applied anteriorly and posteriorly. The plaster should extend beyond the local part so as to embrace the joints at each end. After it has become firm, but not hard, it is moulded with the hands to the more prominent outlines of the part. While the plaster is setting it will be noticed that the casing becomes distinctly warm. This is due to the latent heat which is set free. When dry there is little change in the bulk of the splint, the plaster expands, the cloth shrinks, and there is an actual expansion of about 1 per cent. The stockingette should extend at each end for about one inch beyond the plaster, and a neat finish is given to the part if this free end is turned backwards over the plaster casing.

(2) Celluloid.—Celluloid is a material which has not been used sufficiently for bone fixation. It possesses many advantages—perfect fitting, lightness, and durability. Perhaps its only disadvantage is the time which is required to complete the splint. The method of its formation may be
described in a few words. Consider, for example, the making of a splint to be applied in tuberculous disease of the tibia. The limb from above the knee to the toes is covered with warm olive oil, and upon the part a thin casing of plaster bandages is applied, and carefully moulded to the bony outlines. When the casing is dry it is cut up one side, and carefully removed from the limb. From the mould a positive cast of the limb is taken. This is made by applying a single plaster bandage around the negative to keep it in position, blocking up one open end by standing the negative in a basin of sand, and then filling the cavity with a quantity of plaster of the consistence of cream. When the inner plaster is hard the negative is peeled off, and there is left a cast of the affected part. The actual size of the cast is now increased by covering its surface with an additional layer of plaster, about a sixteenth of an inch in thickness. When this is perfectly hard the cast is covered with a layer of stockingette. The stockingette must fit the cast very accurately, and to do so tapes are tied around the various inequalities and fastened with stitches. The celluloid solution is prepared by dissolving sheet celluloid in acetone, and adding to the solution 3 per cent of a solution of calcium chloride in water, to render the celluloid non-inflammable (Gauvain).

The fluid celluloid has the property of rapidly impregnating any loose tissue to which it is applied, and as the acetone evaporates a thin, firm coating of celluloid is deposited. The fluid is applied with a brush to the stockingette, covering the cast, and thoroughly worked in. Two or three coats are thus applied. When this original application has dried, the cast is covered with two pieces of unstiffened book muslin, applied one in front and one behind, slightly overlapping at the sides. A further coat of celluloid is applied. This is repeated until from ten to fifteen layers of muslin have been applied, each layer being allowed to dry before a further one is added. The celluloid is then cut up the middle and removed from the cast. Its edges are trimmed, and they may be bound with leather. Hooks for lacing are applied along each side of the cut surface. The inside is lined with some soft material, and the outside strengthened with narrow steel bands. It is a wise precaution to punch a number of holes in the circumference of the splint to favour evaporation from the skin. Made in this way a celluloid splint is excellent, and the results which it gives are well worth the trouble its manufacture may have cost.

(3) Wood.—Wood is not a suitable material. It is difficult to fit, and still more difficult to fasten so as to secure absolute fixation.

(4) Metal Splints.—Of the various metal splints which have been used aluminium is the best. It can easily be cut into desirable shapes, it is light, and it can be securely fastened to the part by bands of sticking-plaster. It makes an excellent splint in disease of the wrist and hand bones.

Many other materials have been used: poroplastic, silicate of potassium, isinglass, but each and all of them have serious drawbacks.

What is the length of time which a tuberculous bone requires to be kept at rest in order to effect a cure? It must be realised that the process of
healing in bone tuberculosis is a most gradual one. At least twelve months are required before a cure is properly established, and it is often wise to add an additional six months. In certain regions a still longer period is necessary. These are dealt with later.

Hyperæmic Treatment

Bier's Hyperæmic Method.—With August Bier there lies the credit of having introduced a new method in the local treatment of tuberculosis. The idea was based upon Rokitansky's observation that patients suffering from mitral lesions with pulmonary stasis rarely develop pulmonary tubercle. Underlying the method there are three possible processes upon which the apparent benefits depend.

Sources of Benefit.—(1) The circulation in the tissues is altered, the corpuscular elements become infused into the lymphatics of the hyperæmic limb, and there is a diffuse edema throughout the part. This edema spreads from the periphery to the centre; but when the stasis has been kept up for some time, the circulation changes in direction, and its course comes to be from the centre to the periphery. This circulatory disturbance is beneficial in two ways: the edema carries into the very centre of the tuberculous area antagonistic products such as leucocytes, lysins, and opsonins; the later reversal of the circulation provides for a rapid removal of the dead bacteria and their products. (2) Artificial hyperæmia is a great aid to absorption. This occurs chiefly after removal of the medium by which the hyperæmia is induced. By absorption a large amount of deleterious matter is rapidly removed. (3) Bier asserts that hyperæmia exerts a solvent action on organising tissues and exudation, and the solution is preparatory to absorption.

Methods of Employment.—There are four methods by which a part may be made hyperæmic:

(a) Active hyperæmia.
(b) Passive hyperæmia.
(c) Hyperæmia by cupping (mixed hyperæmia).
(d) Suction hyperæmia.

(a) Active Hyperæmia.—This is procured by the local application of dry heat. The part to be treated is put into a box or chamber, made of white wood soaked in a solution of silicate of sodium to prevent charring. The part is introduced into the chamber through a terminal opening, and the opening is rendered airtight by a felt cuff, which fits round the enclosed member. Into the chamber there opens a metal tube. The outer end of the tube ends in an inverted funnel, beneath which a gas-jet plays and supplies heat. Above the inner end of the tube, within the box, there is a flat, wooden flange; upon it the hot air entering the chamber strikes, and is equally distributed. The amount of heat is regulated by raising or lowering the burner, and the chamber carries a thermometer. Hyperæmia commences
at 30° C., perspiration appears at 60° C., and reaches its maximum at about 100° C. 114° C. is the limit of saturation. Each séance varies in time from thirty minutes to an hour; it may be repeated twice or three times each day. Active hyperæmia is an excellent analgesic; its outfit and conduction are expensive, however, and the ultimate results are probably not so successful as in passive hyperæmia.

(b) Passive Hyperæmia. — The most commonly used method of inducing passive hyperæmia is by the application of a Martin’s elastic bandage. The bandage is of thin rubber about two inches wide, and it is applied to the limb some distance above the site of the disease. The bandage ought to be applied at such a pressure that while the thin-walled, deep, and superficial veins are compressed, the thicker arteries are not obstructed. One or two layers of gauze are applied to the limb and upon these the bandage is fastened. To the end of the rubber a piece of tape is stitched in order to facilitate the tying. The bandage need not be more than eighteen to twenty-four inches long. Some practice is required to gauge the degree of tightness to which the bandage should be applied. The skin should be of a bluish tint, with distended superficial veins. Prolonged pressure with the finger should show the presence of oedema. The pulse should remain full and strong, there should be no subjective coldness in the part, and no pain.

Wilson¹ has demonstrated a mechanical method of regulating the pressure. The pressure bag of a Riva-Rocci sphygmomanometer is applied to the limb and adjusted in position. The blood-pressure is taken, and allowed to fall 5 or 10 mm. below systolic pressure. The tube from the arm-pad is securely clamped, and it is disconnected from the apparatus. The arm-pad is kept in position, and it induces a perfect passive hyperæmia. The bandage should be applied for from one to two hours each day, and the treatment will probably extend over nine months. It is not advisable to apply the bandage for longer than two hours a day, as a more extended application appears to hasten the formation of cold abscesses. Passive hyperæmia is excellently adapted in lesions of the arm up to the level of the elbow. In the lower extremity the proper degree of hyperæmia is difficult to induce. Ritchie Thomson² has described a method which he has found useful in dealing with the lower limb. An elastic bandage is applied above the knee, sufficiently tightly to render the limb bloodless. The bandage is kept in

position for five minutes and then removed. Its removal is the signal for a very active hyperaemia of the limb. While the active hyperaemia is in progress the elastic bandage is reapplied, just sufficiently tightly to induce a passive hyperaemia.

The results of treatment by passive hyperaemia are good in the upper limb—more especially in the terminal portions, carpus, metacarpus, and phalanges. In the lower extremity the results are not so good, probably on account of the difficulty in inducing the hyperaemia. The disadvantage of the treatment is the tendency which it undoubtedly has to hasten abscess formation; this, however, can be largely avoided by minimising the length of application.

(c) Hyperaemia by Means of Dry Cupping (Mixed Hyperaemia).—In localised tuberculous lesions hyperaemia is sometimes induced by a modification of the ordinary dry cup. The method was devised by Klapp, Professor Bier's assistant. Glass cups of varying shapes and sizes are used, to fit the different parts of the body, and to the cups rubber bulbs are attached in order to exhaust the air. A negative pressure of 200 to 400 millimetres of mercury may be obtained. The area to be treated is washed with benzine, and then covered with a thin layer of vaseline and lanoline. This aids the adhesion of the cup, and if any sinuses are present it diminishes the tendency to skin infection and ulceration. The cup is left in place for five minutes and removed for three; it is reapplied for five more minutes in a slightly different place to avoid skin irritation. The application should extend over forty-five minutes, at first daily, then every second or third day. Klapp uses these cups for simple osseous tuberculosis, for infected abscesses and sinuses, and for uninfected cold abscesses. These last are opened by a small incision and "cupped." The explanation of the benefit which the treatment produces is partly the result of a hyperaemia, and partly of an actual suction action.

(d) Suction Hyperaemia.—When hyperaemia is to be induced in an entire limb, glass chambers of varying shapes and sizes are employed. These are provided at their open extremity with a loose rubber cuff. When the part has been placed within the chamber the rubber cuff is fastened to the limb with a few turns of an Esmarch bandage, to render the apparatus air-tight. The air in the chamber is partially withdrawn by an exhaust pump, and a partial vacuum maintained for about five minutes; the air is then readmitted. After two minutes the procedure is repeated, and so on, until the treatment has extended over half an hour. The application is made at first every day, and later every second or third day.

Conclusion.—In the upper limbs hyperaemic treatment of tuberculosis frequently gives good results, in the lower limbs the benefits are not so marked, and in the neighbourhood of the shoulders and hip its use is impracticable. The results obtained in children are better than those met with in adults. As a method of treatment it must be combined with mechanical immobilisation. Its undoubted drawback is the tendency to hasten cold abscess formation.
Counter-irritation

In these days when radical treatment is so common, one feels one ought to apologise for including counter-irritation in one’s scheme of treatment; there are, however, certain cases which undoubtedly benefit from its use. The class of case which one finds reacts most beneficially is bone disease, uncomplicated by abscess or sinus formation, and accompanied by considerable pain. The pain is the result of increased pressure within the unyielding bone, and counter-irritation improves the symptoms by withdrawing blood from the deeper parts to the periphery, and thus relieving the congestion.

Methods of Application.—An excellent method of employing counter-irritation is by the use of the cautery. Sometimes the simple actual cautery is applied to the overlying skin at such a degree of heat as to produce a slight superficial eschar. More recently another method has been introduced. The thermo-cautery, provided with a fine platinum point two millimetres in thickness, is used, and with it at a white heat a number of points of cauterisation are made into the soft tissue overlying the bone. The bone itself is sometimes penetrated. As many as fifty to sixty points of cauterisation may be made. The points of entry of the cautery are very small, and the whole operation is conducted with the most rigorous antiseptic precaution. There are other varieties of counter-irritants which are sometimes employed, viz. cantharides blisters, tincture of iodine, etc. None produces the improvement which follows the use of the actual cautery.

X-Rays

It is held that X-rays produce improvement in tuberculous lesions. This is certainly true when the lesion is a superficial one, the affected bone must not lie at a greater depth than 4 mm.¹ In applying the rays the surrounding soft parts ought to be protected, and it is advisable to filter the rays through an aluminium plate 1 millimetre thick.² No more than three successive applications should be made to the one part. This method of treatment has the disadvantage that if the disease lies in the neighbourhood of the epiphyseal cartilage, the growth of the cartilage cells may be inhibited by the action of the rays.

Treatment of Cold Abscesses

Abscess formation is the most frequent complication in bone disease. Its pathology has already been fully dealt with, but to facilitate the discussion of the treatment of the condition, it will be well to recall that a cold abscess extends by an actual tuberculous change taking place at its periphery, and gradually extending throughout the tissues. It is not a true extension of pus, but a gradual extension of tuberculous granulation.

¹ Iselin, Münch. med. Wochenschr., Dec. 3 and 10, 1912.
² Quervain, La Semaine méd., Jan. 1, 1913, p. 347.
tissue, and the conversion of the granulation tissue into pus. When the complication arises, its treatment must be considered, and there are a number of different methods which may be employed. They may be classified as follows:

1. Conservative measures.
2. Simple aspiration.
3. Aspiration with the injection of medicaments.
4. Simple incision without drainage.
5. Simple incision with drainage.

1. **Conservative Treatment.**—There is no doubt that an untreated cold abscess may be entirely absorbed or may be converted into an innocent collection of calcareous debris. For this reason there exists the method of leaving tuberculous abscesses severely alone. This purely expectant treatment must not be blindly adhered to in every instance. There are certain conditions which are suitable for it, and these are the maintenance of good health on the part of the patient, a diminution in the size of the abscess, and an abscess which is deeply situated. Spinal abscesses are the type which most completely fulfil these desiderata. If treatment is persevered in under suitable conditions, the abscess may become shut off from its origin, and the localised collection of pus undergoes contraction and absorption. It may disappear entirely, more often it becomes converted into a small fibrous nodule with a caseous or calcareous centre. Tubby gives the following as indications for the conservative treatment:—

1. When the abscess is single, and not tracking in two or more directions.
2. When the recumbent position is immediately followed by cessation from pain and improvement in the general health.
3. The expectant plan should be persevered with if after a short trial the abscess ceases to enlarge.
4. A large collection of pus is no hindrance to the trial of this method, provided that the appetite is good and the temperature is normal.

2. **Simple Aspiration.**—Too often the tendency is for a tuberculous abscess to increase steadily in size; active interference then becomes necessary, and of the more active measures, simple aspiration is the first which should be tried. A Potain’s aspirator is used for the removal of the fluid, and the most scrupulous asepsis must be observed. When inserting the aspirating needle it is unwise to enter it directly into the most superficial part of the abscess; the puncture is apt to be followed by a tuberculous sinus. The needle should be inserted through healthy tissues, being entered at some distance from the abscess. When the fluid is being withdrawn, trouble may arise by blocking up of the cannula by caseous debris. To obviate this, a needle with a large bore should be used, the needle being provided with a stilette in case it should be necessary to clear the lumen. The fluid is withdrawn under a negative pressure, and the cavity emptied as completely as possible. The needle puncture is sealed with collodion, and it is wise to diminish the potential cavity of the abscess by applying firm

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pressure with a pad and bandage. A single aspiration is almost certainly followed by a reaccumulation of fluid. Several successive aspirations may bring about a cure.

The benefit which follows aspiration is the result of a diminished or negative pressure within the abscess cavity. The surrounding blood and lymph vessels become distended, and a quantity of serous fluid is poured out. In the fluid which collects there are a number of bodies antagonistic to the bacillus and its products: precipitins, lysins, and opsonins. It is from the action of these that a benefit accrues. The collapse of the abscess wall brings the parts in contact with the altered fluid.

(3) Aspiration with the Injection of Medicaments.—The idea underlying this treatment is that after removal of the pus, if a medicated fluid is intro-

![Fig. 5. — The technique of abscess aspiration. The two upper drawings illustrate the danger of sinus formation following the direct introduction of the needle. The lower drawings illustrate the beneficial valve-like arrangement of the tissues when the puncture is an oblique one.](image)

duced into the cavity, the fluid will act upon the surrounding disease and produce a cure. The technique is very similar to that employed in aspiration. After removal of the pus the cannula is disconnected from the aspirating bottle. At the side of the cannula there is an opening into which a large syringe fits; by this lateral opening the medicated fluid is injected along the cannula into the cavity. A great variety of materials have been used for injection. A 10 per cent solution of iodoform in glycerin is one in most common use. Its advantages are the simplicity of its composition and manufacture, its slow absorption, and therefore slight toxicity, and, finally, the property which it possesses of uniform dissemination over the cavity. Kirmisson \(^1\) recommends a solution of iodoform in ether. According to the age of the patient and the size of the cavity, four standard amounts of solution may be injected: 5, 10, 15, or 20 grammes of the solution, representing respectively 50 centigrammes, 1 gramme, 1 gramme 50 centigrammes, and 2

grammes of iodoform. After the abscess is thoroughly evacuated the cavity is washed out with sterile boracic lotion, and the ether and iodoform injected. Soon after injection the ether passes into a state of vapour and distends the abscess. It is therefore advisable to keep the trocar, with closed stop-cock, in position until this occurs, and then to open the stop-cock. The ether vapour thus escapes, and the iodoform is disposed upon the walls of the cavity.

Ménard recommends the use of a thymol-camphor injection, prepared in a strength of thymol 1 part and camphor 2 parts. The amount injected varies from 5 to 40 grammes. He had previously used a preparation of naphthol and camphor, but after two cases of acute poisoning he gave up this method. It would appear that the thymol-camphor solution has a solvent effect on the caseous material within the abscess, and thus subsequent evacuation is rendered more complete. It induces an irritation of the abscess wall and later a curative fibrosis. Ménard recommends that the process should be repeated in from eight to twenty days.

Calot makes use of two solutions, and the indications for each differ. The first is an oily solution of creasote and iodoform (olive oil, 70 grammes; ether, 30 grammes; creasote, 5 grammes; guaiacol, 1 grammé; iodoform, 10 grammes). The second is a solution of naphthol and camphor in glycerin (naphthol-camphor, 2 grammes; glycerin, 12 grammes). The first solution is the one most generally used; the second is employed when the abscess cavity contains a quantity of thick caseous matter. Calot considers that there is a further important indication for the use of the naphthol-camphor solution, namely, abscesses which are not yet localised, but which are really masses of tuberculous granulation tissue, with some caseation in the centre. In such cases the solution increases, so to speak, the maturity of the abscess by liquefying the granulation tissue of the abscess wall. Successive aspirations, therefore, yield increasing quantities of fluid.

Other materials have from time to time been used. Good results have been obtained by a 10 per cent solution of zinc chloride, also with a solution consisting of—

Tincture of iodine . . . . . 1 part.
Iodide of potash . . . . . 1 part.
Water to . . . . . . . . 100 parts.

Calvé and Gauvain have published excellent results from the use of a solution containing—

Iodoform . . . . . . . . 5 grammes.
Ether . . . . . . . . 10 "
Guaiacol . . . . . . . . 2 "
Creasote . . . . . . . . 2 "
Sterile olive oil . . . . . . 100 cc.

The Explanation of the Improvement which follows the Injection of Medicaments.—It is supposed that the injection of a medicated fluid produces an

1 Ménard, Étude pratique sur le mal de Pott, Paris, 1900, p. 304 et seq.
2 Calot, Orthopédie indispensable, p. 176 et seq.
3 Calvé and Gauvain, Lancet, March 5, 1910.
inflammatory reaction, with the exudation of blood cells and lymph. There is an active diapedesis of the white cells, and a fibrinous exudate forms around the cavity. By a proliferation of the fixed connective tissue cells a barrier of limiting fibrous tissue is deposited. Thymol has a specific action in actually liquefying caseous material.

Coyon and Fiessinger \(^1\) offer a clinical explanation. In the pus of an ordinary abscess they have shown that there exists a proteolytic ferment, analogous to the trypsinic ferment of the pancreas, which has the power to digest coagulated albumens, and to transform them into peptones and amido acids. This ferment is liberated by the destruction of polymorph leucocytes. It does not exist in a simple tuberculous abscess, because there are no polymorphs. The injection of a medicated fluid induces the accumulation of leucocytes and the production of the ferment.

\(1\) Simple Incision without Drainage.—By this is meant the opening of the abscess, the evacuation of its contents, and the closing of the wound to secure primary union. It is a method which is indicated in deeply situated abscesses, and it is absolutely contra-indicated in cases in which the skin has become stretched and undermined from the accumulation of subcutaneous pus. Primary healing is essential to the success of the method.

After opening the abscess, opinion varies as to the treatment which ought to be meted out to the abscess wall. In Barker’s method the abscess wall is thoroughly scraped with a flushing curette, the debris being washed away by a stream of hot boracic lotion or saline. There are some who condemn such drastic means, on the grounds that the curette destroys a beneficial wall of connective tissue which forms outside the abscess and limits it. They believe and practise that it is sufficient to scrape the interior of the cavity lightly with a pledget of gauze, afterwards washing away the debris with hot lotion. Before the wound is closed, an antiseptic application should be made to the wall. An excellent preparation is that used by Stiles. It is a paste made up with 2 parts of subnitrate of bismuth and 1 part of iodoform, stored in a solution of 1 in 1000 corrosive sublimate. The bismuth is included to lessen the absorption and toxicity of the iodoform. Phelps has advocated that the interior of the abscess should be touched with pure carbolic acid, and the cavity washed out with absolute alcohol. A good application is the tinctura iodinei (Ph., Edinburgh). Its strength is 1 part of iodine in 16 parts of 90 per cent alcohol, and it differs from the ordinary tincture in being without potassium iodide.

The wound is carefully closed. If possible deeper structures, muscles and fasciae, are brought together over the cavity. The skin edges are united preferably with "Michael’s" clips; they secure a broad, healing surface, and there is no penetration of the skin by a suture, which often acts as a seton. A careful and copious dressing must be applied, and it is important to exert considerable pressure over the abscess cavity by means of a specially arranged pad and bandage.

This is an operation in which one's technique cannot be too careful. If there is any doubt about asepsis it is wiser to adopt antiseptic methods throughout. After operation the abscess cavity practically becomes a hæmatoma, and one knows the persistency of an infected hæmatoma. But even more important is the complication of a mixed infection in a hitherto pure tuberculous lesion. The primary disease spreads rapidly, cachexia and waxy changes develop, and the ultimate result is too frequently fatal. For these reasons the operation entails a very considerable responsibility.

Occasionally a complete removal of the abscess cavity by dissection has been recommended, the operator cutting through healthy tissues. The conditions under which such an operation would become possible are excessively rare. Too often size, position, and migration render the thing an impossibility.

(5) Simple Incision with Drainage.—Primary drainage should never be attempted in a tuberculous abscess. A drained wound is infinitely more liable to infection than one which is completely closed, and a drainage tube is often the originator of an infected sinus. In a pure tuberculous abscess drainage is never necessary; it may become so, however, when a mixed infection makes its appearance.

Treatment of Sinuses

This troublesome complication is usually the result of the secondary infection of a tuberculous abscess. It is possible, however, for a sinus to exist which is purely and entirely a tuberculous one. The track, leading from the abscess to the surface of skin or mucous membrane, is frequently of great length, not because the abscess lies specially deep, but because the sinus is usually branching and tortuous. The wall of the sinus is lined by numerous tuberculous follicles, many of them caseating. Around the tuberculous granulation tissue there is a deposit of fibrous tissue, which keeps the circumference of the sinus within limits.

In itself a sinus gives rise to no symptoms beyond its discharge, but indirectly it is responsible for a continuation of the secondary infection, the development of temperature and cachexia, and eventually for amyloid degeneration and death. No pains therefore should be spared to prevent the formation and to cure the condition when it does occur.

The prevention of sinuses has already been dealt with. It consists in the treatment of cold abscesses by aspiration or incision without drainage, and the most scrupulous care to prevent secondary infection. When a sinus has been established its cure may be excessively difficult. It is rarely possible to excise it on account of the extent and tortuosity of its course, and the difficulty in securing primary union of the wound. One therefore has to fall back upon more conservative measures. These resolve themselves into two groups: the injection of the sinus with medicaments, and Bier's hyperæmic method.
**Injection of Medicaments.**—Dr. Beck of Chicago found that after injecting sinuses with bismuth paste for the purpose of radiography, many of them healed. He acted upon the hint, and was successful in obtaining some cures. At first Beck used a preparation containing:

- Bismuth subnitrate: 6 parts.
- White wax: 1 part.
- Soft paraffin: 1 part.

This mixture he later discarded because he found it difficult to maintain a temperature suitable for its injection. He substituted instead a mixture of:

- Bismuth subnitrate: 1 part.
- Vaseline: 2 parts.

The ingredients are thoroughly mixed, and the mixture is heated in a water bath. The injection is made at a temperature of about 40° C. A glass syringe with a conical vulcanite nozzle is used. The syringe is sterilised by boiling, and afterwards washed out with absolute alcohol to prevent any water gaining access to the mixture. The skin around the sinus is sterilised with alcohol or 2 per cent iodine in spirit, no water being used. The injection is made slowly, and the amount varies according to the length of the sinus and the age of the child; an average amount is rather less than 10 cc. As soon as the injection is made the syringe is withdrawn from the orifice of the sinus, and the opening closed by quickly applying a tampon of sterilised gauze; this is fastened in place by a rubber bandage or a piece of sticking-plaster. The injection is repeated, only if a quantity of the original injection escapes and the amount injected is approximately equal to that evacuated.

Ridlon and Blanchard published in 1908 the result of an extensive trial of bismuth paste injections. They employed the bismuth vaseline mixture for diagnostic purposes, and the bismuth, white wax, and paraffin mixture for treatment. When the first mentioned formula was used for diagnosis it was evacuated within twenty-four hours, and the second mentioned was then injected until the sinus was full. The details of injection were similar to those already mentioned.

It is doubtful to what exactly the beneficial effect of the injection is due. By some it is supposed that the bismuth has a stimulating effect upon the formation of healthy granulation tissue, by others the improvement is said to be entirely due to the mechanical effect of the injection.

There are certain conditions which contra-indicate the use of bismuth injection. They are summarised thus by Ridlon and Blanchard: (1) The presence of a sequestrum; (2) Coincident waxy changes in the internal organa; (3) When there are large distal pus sacs which become filled after repeated injections with residuary bismuth; (4) In sinuses of tuberculous bone disease which have existed for less than two or three months; (5) In

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3 Ibid., 1909, vol. vii. No. 1, p. 34 et seq.
old tuberculous sinuses with extensive skin destruction and large areas of skin undermined.

The most urgent danger is the occurrence of bismuth poisoning. It takes the shape of ulcerative stomatitis, black lines at the gum-edge of the teeth, diarrhoea, cyanosis, desquamative nephritis, and loss of weight. If the injections are producing benefit the secretion from the sinuses changes its character, it becomes seropurulent and serous, and organisms diminish in number and ultimately disappear.

In a paper entitled "Some Experimental Work on Materials for Plugging Sinuses and Bone Cavities," 1 Prescott le Breton has derived benefit from certain preparations. The first is composed of:

- Cacao butter: 7 parts.
- White wax: 1 part.
- Iodine flakes.

It is a useful preparation, but in children it may produce very considerable irritation.

The second preparation which he recommends is:

- Borax: 2 parts.
- Wax: 1 part.
- Lanolin: 24 parts.

This, while not so rapidly efficacious as the first mentioned, is much less productive of irritation.

Calot 2 uses solutions very similar to those which he employs in the treatment of cold abscesses, iodoform, creasote oil, and naphthol-camphor glycerin. The composition of the first is as follows:

- Phenol camphor
- Naphthol camphor
- Guaiacol
- Iodoform
- Lanoline or Spermaceti

The first preparation is twice as active as the second, and it is used in the smaller tracts. Conversely the second composition is employed in the larger and more tortuous sinuses.

Hyperemic Treatment of Sinuses.—The details of this treatment are best quoted from Bier's 3 original monograph upon the subject:

3 Bier, Text-book of Hyperæmia, Translation 1901, p. 263.
my treatment for tubercular affections with cupping glasses, which I practised about ten years ago. . . . The cupping glass is at first applied three-quarters of an hour daily to all forms of open and fistulous tuberculosis, which have not been treated heretofore. The rule laid down for acute inflammation, that the cupping glasses should be removed for three minutes after it has been applied for five minutes, holds good here also. The patients are given daily treatment until the indolent, pale, tuberculous granulations become red and hard, and until the immediate vicinity of the sinus becomes hard. It is then time to increase the intervals between the treatments, at first every second, later every third, and finally every eighth day. . . . In the vicinity of tuberculosis with sinuses which have been treated with the cupping glass, one often sees ulcers, which must be regarded as inoculated tuberculosis. To avoid this, Klapp suggests the following method. After removal of the dressing, and previous to suction, the vicinity is cleansed with benzine, and a large surrounding area is covered with fat (lanoline, vaseline, ëë). After suction the first fat is removed with benzine and fresh applied.

Wright's Treatment.—In treating tuberculous sinuses Wright endeavours to bring the body lymph into contact with the diseased tissues of the sinus. This fluid contains active bacteriotropic powers, and if it is allowed to bathe the tissues excellent results may follow. A free circulation of lymph is largely prevented by fibrinous deposits in the tissues around. Wright introduces into the sinus a solution of 0.5 per cent sodium citrate and 5 per cent sodium chloride. A double purpose is fulfilled, the sodium citrate prevents coagulation within and around the sinus, while the sodium chloride induces osmosis and a free flow of lymph. The method of treatment is founded upon an excellent theoretical basis, and in practice it is well worth a trial.

Special Forms of Treatment

Trypsin Treatment of Bone Tuberculosis.—This treatment is based upon the idea that the injection of a proteolytic ferment will induce the resolution of a tuberculous lesion. The method consists in the injection subcutaneously of a sterile 60 per cent solution of trypsin in glycerin. The dose varies from 1 to 2 cc., diluted with one to ten parts of physiological salt solution, and injections are made at intervals of two to seven days. The solution is injected preferably in the region of the tuberculous focus. The injection is followed by smarting pain, occasionally a rise in temperature, and local signs of inflammatory reaction. The symptoms disappear in from twenty-four to forty-eight hours; the swelling continues for about five days. It is said that under the influence of the ferment injection a vigorous reaction takes place in the tuberculous focus, and ensuing hyperaemia, cellular infiltration, and proliferation lead to a transformation of the substance and structure of the pathological tissue, and to necrosis of the fungoid masses, without impairing in any way the vitality of the healthy parts.

Bätzner 1 quotes four cases of advanced tuberculosis of the ankle joint which yielded admirably to the treatment. Several of these were compli-

1 Bätzner, Practitioner, 1913, xc. p. 213.
cated by superficial ulceration and sinuses, leading down to bare bone. The cases were cured respectively in 1 year 9 months; 1 year 2 months; 2 years; and 1 year 8 months. He notes that among the general effects of treatment there is improvement in general physical and mental condition, and unusual improvement in appetite. He advises the treatment in all surgical tuberculosis, especially those cases complicated by sinuses and abscesses.

_Treatment of Bone Tubercle with Mesbé._—Hermann and Spangenberg introduced this substance into the field of therapeutic medicine. Bietzen-gieger has recounted his experiences with it in the treatment of bone tuberculosis. Seven cases of fistulous bone disease were treated. The mesbé was applied pure, or as a 50 per cent ointment. Two of the cases healed after ten weeks' treatment, and apparently the cure was a permanent one. In one case a local reaction resulted from the application, and there was a slight rise of temperature. In most of the cases there was an increased discharge from the fistula. The remedy is thought to possess a specific action upon tuberculous processes on account of its containing anti-tuberculous bodies.

_Treatment of Bone Tubercle with Allyl Sulphide._—Doctor Minchin of Dublin published in the British Medical Journal of August 24, 1912, the results which he had had from the use of an ointment containing the active principle of garlic—allyl sulphide. Its use has been tried with benefit in cases of superficial bone tubercle, such as tuberculous dactylitis of the hand and foot. There is remarkable improvement when it is employed in cases in which the bone lesion is associated with tuberculous ulceration of the overlying skin. The ointment is applied directly to the affected part, and the dressing is changed twice daily.

4. Tuberculin Treatment

Tuberculin is a product of the tubercle bacillus, containing either the soluble products of the bacillus, the insoluble fragments of the bacillus, or a combination of both. The first may be spoken of as an extract, the second and third come under the heading of vaccines. Tuberculin is used in diagnosis, and its application in this relation has already been examined. It is also used in treatment, and it is this question which will now be discussed.

_Varieties of Tuberculins._—These may be divided into two groups: extract tuberculins and vaccine tuberculins.

**Extracts.**

<table>
<thead>
<tr>
<th>Name</th>
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<tr>
<td>Koch's old tuberculin</td>
<td>(Syn. T.A.)</td>
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<tr>
<td>Beraneck's tuberculin</td>
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<td>Denys' tuberculin</td>
<td>(Sp. B.F.)</td>
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<tr>
<td>Bovine tuberculin</td>
<td>(Syn. P.T.O.)</td>
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1 Münch, med. Wochenschr., 1913, ix. 128.
2 W. C. Minchin, Treatment of Tuberculosis and Lupus with Allyl Sulphide, Baillière, Tindall & Co.
Vaccines.
Koch's new tuberculin (Syn. T.R.).
Tubercle bacilli emulsion (B.E.).
Tulase (Von Behring).
Bovine tuberculin (P.T.R.).
Vacuum tuberculin.

Mode of Preparation.
(1) Extract Tuberculin.—The human tubercle bacillus is grown upon a medium of nutrient broth, containing 5 per cent glycerin. Into this medium a certain amount of toxic products from the bacilli find their way. When a fair amount of growth has been obtained, broth medium and organism are sterilised by steam for thirty minutes, evaporated to one-tenth of their volume by a temperature which never exceeds 70° C., and finally filtered. 0-5 per cent of phenol is added to the resulting fluid, and the preparation allowed to stand for some weeks, when it is again filtered. It is now a dark-brown fluid, syrup like in consistence, and perfectly miscible with water. It contains a large proportion of glycerin (about 50 per cent), 10 per cent of albumoses, the toxic products of the tubercle bacilli, and substances obtained from the bacilli in the processes of sterilising and filtering.

(2) Vaccine Tuberculin.—This is prepared in two different ways, as illustrated by Koch's new tuberculin on the one hand, and Koch's bacillary emulsion on the other. Koch's new tuberculin is prepared by grinding up dried cultures of virulent bacilli in an agate mortar. When the organisms have been disintegrated, distilled water is added, and the mixture centrifuged. There results a clear supernatant fluid and a white deposit. The fluid is decanted off, and the deposit, which is really composed of the insoluble portions of the bacilli, is retained. With the deposit the process of dilution and grinding is repeated, until an opalescent fluid is obtained. To that fluid 20 per cent glycerin is added to prevent decomposition.

Koch's bacillary emulsion has a more simple method of preparation. Dried powdered cultures are mixed with a solution of equal parts of glycerin and water, in such a proportion that half a gramme of powdered bacilli is suspended in 100 cc. of the glycerin solution. By prolonged shaking a fine emulsion is produced.

These three methods may be taken as the standards upon which the manufacture of all tuberculins is based.

The Result of Inoculation into the Body. — In the healthy individual there is absolutely no result from the introduction of even an enormous amount of tuberculin (1000 cmm.). In the person already infected by tuberculosis, the inoculation of a minute dose produces a very considerable disturbance. This disturbance is spoken of as the tuberculin reaction. The tuberculin reaction embraces three different changes: (1) A local reaction, some degree of swelling and redness at the point of introduction of the tuberculin. (2) A focal reaction, due to changes occurring in the neighbourhood of the tuberculous foci, increased circulation of blood, and serous exudation. (3) A general reaction, due to the circulation of toxic
TREATMENT OF BONE TUBERCULOSIS

products derived from the introduced tuberculin, and characterised by fever, malaise, body pains, and headache.

The most satisfactory scientific explanation of these changes is supplied by Wolff-Eisner’s theory. He supposes that there is circulating in the tissues of the tuberculous a specific anti-body. On the introduction of tuberculin this anti-body attacks the tuberculin molecule, and liberates from it certain toxic products. The circulating toxins produce the local reaction, and, if sufficient in quantity, a general reaction, and finally the focal reaction. This peculiar property of the tuberculous tissue to act upon tuberculin is spoken of as “tubercular sensitiveness.”

In addition to “sensitiveness” there exists another factor, which must be understood before one can pass to speak of the clinical bearings, and that is the question of “tolerance.” When a small amount of tuberculin is injected into a tuberculous subject, the “tuberculin reaction” appears. If a few weeks later a second amount is injected the process is faithfully repeated, but if the second injection is made very soon after the first (three or four days) its efficiency in producing a reaction may be almost completely annulled. This phenomenon depends upon a degree of “tolerance” induced by the first injection. No proper explanation has been given of the occurrence of tolerance, but it may depend upon the formation of an anti-body, which either partly or wholly counteracts the degree of sensitiveness present.

Methods of Administration of Tuberculin.—At the present time two methods of administration are practised: (1) The clinical method; (2) The scientific method.

(1) The Clinical Method.—The aim of this method is to attain a well-marked focal reaction without inducing any general disturbance, and at the same time to produce a tolerance to tuberculous poisons. “The local hyperaemia supplies to the local lesions an abundance of whatever antibodies the patient’s blood may possess. The increased tolerance raises the well-being of the patient by removing to some extent the symptoms which interfere with his progress” (Rivière 1).

The amount injected varies with different preparations, but the ideal is to use the highest possible dose without inducing a reaction, and to inject gradually increasing amounts at short intervals in order to produce a rising tolerance. The dosage varies with the preparation used. With old tuberculin, in infants the initial dose is usually \( \frac{1}{100} \) milligramme; in older children, \( \frac{1}{40} \) or \( \frac{2}{10} \) milligramme; with new tuberculin, children under one year old may be begun with \( \frac{1}{25000} \) milligramme, older children with \( \frac{1}{10000} \) or \( \frac{1}{5000} \) milligramme. The bacillary emulsion is given to infants in a dose of \( \frac{1}{10000} \) milligramme, older children getting \( \frac{1}{2500} \) or \( \frac{1}{2000} \) milligramme. Injections ought to be given twice weekly in steadily increasing doses, the amount of increase being gauged by the degree of reaction induced.

(2) The Scientific Method.—This method was originally introduced by Wright, and it is the one most commonly practised in this country. Wright

1 Rivière, Tuberculosis in Infancy and Childhood (Kelynach), p. 290.
pointed out that the tubercle bacillus is one of a class of organisms which is resisted by the body through the medium of opsonins. These opsonins so alter the tubercle bacillus that it becomes readily destroyed by phagocytes. The degree of phagocytosis which occurs is expressed as "the opsonic index," and among healthy people the quantity of opsonin remains relatively constant between 0.8 and 1.2. If the opsonic index in a tuberculous subject falls below 0.8, there is very probably a localised lesion, and the index is lowest at the tuberculous focus. If the index fluctuates widely, now high and now low, it points to a more extensive disease, lying in more open relation to the blood stream.

"The object of the scientific method of tuberculin administration is to keep the opsonic power of the patient for the longest possible time at the highest possible figure" (Rivière).\(^1\) To fulfil this object tuberculin is administered in minute doses, with a sufficient interval between the injections, and avoiding any increase of dosage.

In regard to dosage, Rivière recommends \(\frac{1}{4000}\) to \(\frac{1}{400}\) milligramme for children less than one year old. At five years \(\frac{1}{2000}\) milligramme. For children of twelve years and upwards, \(\frac{1}{1500}\) milligramme. The interval between doses ought to be judged very largely upon the opsonic index, but on an average an interval of two weeks is usually most suitable.

**Choice of Method.**—Now the question arises which of these two methods is the one to adopt? Bone and joint tubercle comes under the class of localised lesions. There is no great degree of auto-inoculation, and in the neighbourhood of the focus the opsonic index is low. These indications are sufficient to justify one in adopting the scientific method of administration. Are there any circumstances under which one would adopt the clinical method? If the tuberculous lesion is extensive, and from its relationship to the blood stream a considerable degree of auto-inoculation is occurring, one employs the clinical method, because by it the steady increase of dosage produces a tolerance sufficient to counteract in part at least the tuberculous auto-inoculation.

**Choice of Tuberculin.**—In regard to the type of tuberculin which should be used, success may be attained with any variety if its characteristics and dosage are thoroughly understood. Rivière and Morland\(^2\) recommend that one of the vaccine tuberculins (endoplasm) be used. Its rate of absorption is slower, and therefore a mild and prolonged focal reaction is produced, with the minimal amount of general disturbance.

**Human and Bovine Tuberculins.**—A certain proportion of bone and joint tuberculosis undoubtedly owes its origin to infection with the bovine bacillus. This fact, in application to surgical tuberculosis generally, has inaugurated the idea that these lesions should be treated with a specific tuberculin, human or bovine. If the plan is to be adopted, there must necessarily be either an examination and separation of the organism in each individual case, or an acceptance of the belief that surgical tuberculosis is due

\(^1\) Rivière, *op. cit.* p. 294.

to the bovine bacillus, while pulmonary tuberculosis is human in its origin (Nathan Raw).\(^1\) Workers who believe in the specific use of human and bovine tubercle are divided into two schools: (1) There are those who believe in the use of autonomous vaccines, and treat a lesion due to a bovine bacillus with a bovine tuberculin, and \textit{vice versa}. (2) There are those, such as Spengler\(^2\) and Nathan Raw, who use a human tuberculin for conditions due to the bovine bacillus, and \textit{vice versa}. Good results have been obtained by representatives of both schools, and the probability is that human and bovine bacilli are so closely related that the respective tuberculins produce very similar results.

There is one point which clinically has been shown to be of advantage, and it is this: If a continuous course of one type of tuberculin (human or bovine) does not produce improvement, benefit often results from suddenly altering the course and using the other variety.

**Mixed Infections.**—Before tuberculin treatment is adopted, a large proportion of bone and joint disease undergoes a mixed infection, usually through the medium of cold abscesses and sinuses. The most common organisms to produce this secondary infection are certainly the staphylococci and streptococci (Petroff\(^3\)). When the clinical method of tuberculin administration is used, mixed infection is looked upon as a distinct contra-indication, but it is no precluder of the scientific method. If a mixed infection exists, it is essential that the secondary organism should be recognised and isolated, and a vaccine prepared from it. In the treatment the secondary vaccine may be added to the tuberculin, and the combined injection used throughout. It is more satisfactory at first to treat the lesions with a pure tuberculin. Improvement will proceed to a certain point, and the condition will then come to a standstill. This is the most appropriate time at which to introduce the secondary vaccine, and its introduction often succeeds in curing the disease.

**Autogenous Tuberculins.**—Some authors have attached considerable importance to the use of an autogenous vaccine, \textit{i.e.} a tuberculin prepared from the actual bacillus which is causing the disease. Krause\(^4\) has carried out a number of investigations upon the method, and he is satisfied that the results obtained compare favourably with those obtained by the stock preparations. The method entails an enormous amount of labour, and it is doubtful whether the results are sufficiently good to justify its use.

Another method of autogenous treatment is that in which a tuberculin is prepared from the actual diseased tissue (Fraser and MacGowan\(^5\)). A portion of the tissue is ground up in a mortar and made into an emulsion with saline. The supernatant fluid is pipetted away, and sterilised and standardised like a vaccine. The standardisation is carried out by the weight of the original tissue used in the preparation.

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1 Nathan Raw, 	extit{Tuberculose} (Berlin).
2 Spengler, 	extit{Tuberkulinbehandlung in Hochgebirge} (Davos, 1904).
4 Krause, 	extit{Zeitschr. für Tuberkulose}, 1909, xiv. a. 73.
5 Fraser and MacGowan, 	extit{Lancet}, June 1912.
The treatment is begun by an injection of 10 cms., and repeated at intervals of ten days. Succeeding amounts are increased upon each occasion by 5 cmm., unless there is a severe reaction, in which case the amount injected is somewhat diminished.

Results of Treatment.—There has now been sufficient time and opportunity to judge of the results which follow tuberculin treatment in bone and joint tuberculosis. Opinions upon the subject can be gathered by quotations from a series of articles published during the past six years. They will be considered in sequence of date. In 1906 Gray \(^1\) published a paper upon the vaccine treatment of surgical tuberculosis. Speaking in relation to tuberculous bones and joints, he says:

Here again the prospect is a hopeful one, but ultimate complete success in restoring full healthy function will be obtained, only by making a correct diagnosis in early stages, and adding T.R. injections to those well proved and approved lines of treatment usually carried out. . . . A very different feature from the point of view of rapid results is presented usually by cases when abscess formation with subsequent development of sinuses and compound infection has occurred. In none have I obtained satisfactory results with T.R. alone, unless after operation, and in the majority, although great improvement has occurred, yet it has been slow and subject to occasional retrogression.

In 1908 Nathan Raw \(^2\) recorded his experiences of the treatment.

Twenty-seven cases of tuberculous joints, mostly of a chronic or subacute variety, have been treated, 15 disease of the knee, 8 of the hip, 4 of other joints. The cases where the best results were obtained were those in which there was some suppuration or sinus directly leading down to tuberculous disease. . . . In the great majority of cases the suppuration first ceased, and then the sinus closed. . . . In cases of pulpy disease of the joints there was in many instances marked diminution in the size of the joints, with absence of inflammation and more movement. . . . I have not yet seen any case where fixed and ankylosed joints have been benefited.

The next in the series are the results of Maynard Smith,\(^3\) published in 1909. Information was gathered from 34 cases. In 16 cases treatment by splinting, rest, and operation was first tried, and because there was no improvement tuberculin treatment was introduced. In 10 out of the 16 cases complete cure resulted, with absolute restoration of joint function. Three cases were treated with tuberculin from the beginning, two were completely cured. Of the remaining 15 cases, 6 were cured, 5 improved, while 2 showed no improvement.

Painter \(^4\) published in 1910 a long paper upon "Vaccine Therapy in the Management of Arthritis." His conclusion is as follows:

As regards tuberculous joint infection, there does not seem as yet to be any

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well-established ground for a belief that vaccination after infection could play a curative rôle. Practically there is very little evidence that it ever does.

Finally, one records the most recent opinion; it is that of Förster. He reports the tuberculin treatment in 21 cases of tuberculous bones and joints in children. Of the 21 cases recorded, 3 were not benefited, while marked improvement was shown in all the others. The routine treatment of surgical tuberculosis—rest, fresh air, and food—was used in all the cases.

**Conclusions.**—In judging of the ultimate value of the treatment, it is difficult to appreciate the exact amount of benefit which is due to the tuberculin. Much of the improvement which one sees is the result of the rest and the other conservative measures adopted, and of course one never has an opportunity of judging a case treated purely by injection. In early cases it may be unnecessary to employ tuberculin, but on the other hand it may advantageously be combined with the usual conservative measures. In later cases, when suppuration and sinus formation have occurred, tuberculin has perhaps its widest sphere of usefulness, especially when there is combined with it a vaccine of the organism or organisms producing the secondary infection.

**Marmorek’s Serum.**—Marmorek’s serum is prepared by injecting horses for seven or eight months with filtered young cultures of tubercle bacilli, grown on a fluid medium consisting of calf serum and glycerinated liver bouillon. The calf serum is rendered leucotoxic by previously treating the calf with injections of guinea-pig’s blood. The effect of the leucotoxic property is that bacilli grown in the blood set free tuberculo-toxin. By injecting the filtered cultures into horses, it is claimed that a special antitoxin is obtained, which is able to confer immunity of a passive character on animals. The serum is given by subcutaneous injection, or by the rectum after a cleansing enema.

Hoffa has used the serum in a number of cases of bone and joint tuberculosis. He concludes that it exerts a specific reaction, and he believes that it is likely to become a valuable means of combating surgical tuberculosis.

Van Huellen reports Sonnenburg’s experiences with 37 cases. The results on the whole were good. Joint disease showed the least improvement.

Results have been published by Schenker, Hohmeier, and Glaessner, and the general conclusion arrived at is that the use of the serum produces distinct improvement in the tuberculous lesion.

**Spengler’s I.K. Serum.**—This is a preparation of tuberculosis-immune blood made by extracting the red blood cells of immunised sheep and rabbits.

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2 Marmorek, Von Sydow Hygeia, 1906.
3 Hoffa, Berlin, klin. Wochenschr., 1906, No. 44.
4 Van Huellen, Centralbl. für Chir., 1907, No. 3.
5 Schenker, Münch. med. Wochenschr., 1907, No. 3.
6 Hohmeier, Münch. med. Wochenschr., April 14, 1908.
7 Glaessner, Deutsche med. Wochenschr., 1909, No. 17, p. 753.
It is described as chemically pure, free from albumen and haemoglobin, and containing one million lytic and antitoxic units in each cubic centimetre. Dilutions are prepared, varying in strength from 1 in 10 to 1 in 10,000,000, of the original I.E., and in all there are seven of these dilutions. In children a suitable initial dose is 0·1 cc. of the fifth dilution i.e. 1 in 100,000. The injections are repeated at intervals of a week, the amount of each injection being increased by 0·1 cc. Experiences of the treatment have been published by Porter and Quinn, and by H. O. Eversole. The results obtained have been satisfactory.

Mehnarto's Serum.—Dr. Mehnarto of Heidelberg has introduced a serum to which he has given the name of contra-toxine. The idea underlying contra-toxine is to use the serum of a warm-blooded animal naturally immune to tuberculosis, and to sensitise or correct the serum by the addition of other sera, which will prevent the hsemolytic and anaphylactic tendencies of the original serum without impairing its bactericidal qualities.

With regard to dosage a child is given, 2 cc. At the end of a week a second injection of 4 cc. is given, and the injections are repeated twice a week, until the physical condition shows a complete cessation of activity. The treatment is still sub judice. So far the results obtained have been promising.

5. Operative Treatment of Bone Tuberculosis

At this stage only the leading points can be dealt with, full details are given in the sections on individual bones and joints. The question under consideration entails two problems: What are the indications for operative treatment? and, when operative measures have been decided upon, In what do they consist?

Indications for Operative Treatment.—Every one is agreed that a full and complete trial ought to be given to conservative means before there is any question of operation. The majority are convinced, on the other hand, that it is unwise to delay operative measures until there is much bone destruction, secondary infection, and sinus formation. There exists, therefore, between what one may term certainties, a wide area of dubiety. It is here that the difficulty arises, and it is well that one should consider the points which help one in deciding the line of treatment to adopt.

Age.—It is important to keep in view the fact that one is dealing entirely with children, and one's remarks are necessarily influenced by this fact. As a class, children offer considerable resistance to the development of tubercle, and in application to bone tuberculosis this is especially true. When one comes to examine the age-period more individually, one finds that this resistance is at its lowest during the first year of life, thereafter it increases steadily during the age-period of childhood. The practical bearing

1 J. L. Porter and L. C. Quinn, Chicago Med. Rec., 1912, xxxiv. 84-91:
of these points upon the question at issue is as follows: If operation procedure is recommended, it must of necessity be complete and thorough. In a child of less than two years old this may necessitate a most extensive operation, and one associated with considerable shock. Further, if the disease be not thoroughly removed, the small resistance of infancy greatly increases the risk of recurrence, a risk which may be counterbalanced in older children. One may put it in this way. Looking at the matter purely from the point of view of age, one is disinclined to urge operation during the first two years of life. At a later period, in a case perhaps exactly similar from a clinical aspect, one would recommend operative interference.

**Family History.**—This is a point which ought to be carefully considered. The question of heredity has been already discussed, and while one may neglect such a possibility as a true congenital tuberculosis, there is undoubtedly an inherited predisposition to tuberculosis. If tuberculous disease appears in a child whose family history is bad, and the disease is at all amenable to operative treatment, then undoubtedly such treatment ought to be adopted. If the disease is treated early, complete removal may spell a complete cure. If there is delay, one finds scanty tendency towards natural cure, but rather a metastasis and progression of the disease. Therefore, other things being equal, a tuberculous family history influences one in urging operative treatment where otherwise there might be doubt.

**Social Position.**—The conservative treatment of tubercle may necessitate a prolonged and exacting recumbency. In the children of the well-to-do such a course is perfectly feasible, but among the poorer classes it may constitute an impossibility. The time will come, and one hopes it is not very far distant, when this statement will be in error, at present one must face the fact of its veracity. As operative measures therefore shorten the duration of treatment, there are cases in which, purely from the consideration of the wretched social conditions, one recommends an operation. The child is admitted to hospital, the disease is entirely removed, a period is spent in a convalescent home, and the treatment is terminated. There may have been a sacrifice from the aesthetic point of view, but that is much more than counterbalanced by the brevity of treatment.

**The Position of the Lesion and the Bone Affected.**—There are certain bones which, from their anatomical position do not permit of operative measures, these are comparatively few. Upon the other hand there are bones which from the point of view of their locality indicate operation. For example, in dealing with fingers and toes, one would advise operation in the toes but conservative measures for the hands. Where a limb is supported by two bones, and one is diseased, operation may be recommended, whereas had there been only a single bone, such a procedure would have been considered contra-indicated. But even more important than the gross position is the exact localisation of the focus in the affected bone. If the disease lies in the immediate neighbourhood of a joint, and has not yet invaded that joint, there is a very distinct advantage in removing the infected tissue before the joint becomes involved.
The Multiplicity of the Lesion.—It is difficult to appreciate whether this should be taken as an indication for operation or the reverse. It is probably wisest to consider the matter in the light of the case history. If the affected bone has been the original source of the infection, and if from it by dissemination there have appeared a number of minor secondary foci, it is wise to attempt the removal of the original disease. It is possible that the secondary foci may themselves resolve spontaneously or under suitable treatment. But if, on the other hand, the bone focus is itself secondary to an earlier infection, or if the dissemination which it has induced is well developed and advanced, operation is certainly inadvisable.

The Clinical Features.—The first consideration is the opportunity which has already been given for the disease becoming cured by non-operative measures. If at the end of six to nine months of conservative treatment the disease is not improving, but is becoming rather more extensive and established, it is well to interfere, and few mistakes are commoner than that of delaying too long. The second clinical feature to which importance must be attached is the question of cold abscess formation. It does not of necessity indicate operation, but in a doubtful case its occurrence influences one in that direction. Lastly, there are the signs which are so often terminal, such as cachexia and waxy disease. They are the signals that nature's resistance is at an end, and if life is to be saved, drastic measures require to be employed.

X-Ray Appearances.—Apart from what has been said in regard to the situation of the disease, and it of course is best demonstrated by radiography, there is the important point of sequestrum formation. A sequestrum, if it is of any size, is not readily absorbed, it leads sooner or later to cold abscess and sinus formation. One may take it that sequestrum formation is a definite indication for operation. These are the points which influence the observer, but they have special bearings in individual situations, and under the head of these situations they will be discussed.

Varieties of Operative Measures. Preliminaries to Operation—Opsonic Index.—There are several points which require special mention. The first is the question of opsonic index, and its application in relation to positive and negative phases. By estimating the opsonic index there may be chosen, as far as science can tell, the most suitable period at which to conduct the operative measure, the most advantageous time being after the commencement of the positive phase.

Local Preparation.—The second preliminary deals with the local preparation of the part. It is essential that this should be extensive, even more thorough than might at first appear necessary; it is often impossible to foretell to what extent the operation may extend. Further, in the preparation it is unwise to use strong antiseptics. The skin overlying a cold abscess is usually of very doubtful vitality, and the application of 1 in 20 carbolic, for example, may produce sloughing. Three per cent iodine in rectified spirit is the most suitable application to use.

Tourniquet.—Lastly, there is the question of using an Esmarch's
bandage as a prelude to operation. Its supporters have argued that its use prevents a troublesome oozing. This may certainly be true, but there is the disadvantage, that if the oozing does not occur at the time, it makes its appearance later, and often necessitates a most undesirable drainage. It is well to avoid the application of the elastic bandage.

Types of Operation

(1) **Gouging and Scraping.**—This consists in freely exposing the affected bone, and removing from it with gouge and sharp spoon the diseased focus. In exposing the bone it is usual to choose a suitable intermuscular plane in order to avoid damaging the tissues. Of necessity the incisions will vary in different localities. The periosteum is separated to expose healthy bone, above and below the disease. The medulla is opened with gouge and hammer, or with a small trephine. With a sharp spoon the diseased material is thoroughly curetted from the interior of the bone, until there is a cavity lined by healthy cancellous tissue.

As it is almost impossible to avoid infecting the wall with tuberculous material, it is well to disinfect the walls with some preparation of iodoform or pure carbolic. The cavity that is left may be treated in various ways. The following are the most important.

(a) It may be stuffed with iodoform gauze, and the space encouraged to close partly by the formation of fibrous tissue, and partly by the development of new bone, the packing being continued until there is complete obliteration.

(b) **Mosetig Moorhof's Plug.**¹—All blood clot is removed from the cavity by packing with gauze wrung out of hydrogen peroxide. The walls of the cavity are thoroughly dried with a hot-air douche, of which the dentist’s pattern, upon a larger scale, is one of the best. The material used to fill the cavity is next prepared. It is composed of iodoform 60 parts, spermaceti 40 parts, oil of sesame 40 parts. The total ingredients are heated slowly to a temperature of 100° C., and after being thoroughly mixed, are allowed to cool. Immediately before use the mixture is heated in a water-bath to 60° C. to render it fluid, and then poured carefully into the dry bone cavity. In filling the cavity it is exceedingly important to prevent the entry of any air bubbles, and further to fill the space as completely as possible. When the mass solidifies the soft parts are replaced.

(c) **Neuber's Iodoform Starch.**—This is used in the same fashion as Mosetig-Moorhof's wax, and Neuber considers the method most suitable in the removal of superficial tuberculous foci. Ten grammes of wheat-starch are mixed with the smallest possible quantity of water, and to the mixture one adds 200 grammes of boiling 2 per cent watery carbolic solution. After partial cooling, 10 grammes of powdered iodoform are added. The preparation should be kept in the dark, and it is used in exactly the same fashion as Mosetig-Moorhof's wax.

¹ Mosetig-Moorhof, Zeitschr. für Chirurg., April 18, 1903.
(d) Schede's Aseptic Blood Clot.—If the bone cavity is not packed or filled in any way, sufficient bleeding occurs to fill it with a quantity of blood clot. The periosteous and soft parts are sutured over the cavity, the skin wound is closed, except to permit of drainage by a single strand of catgut or rubber tissue. The part is abundantly dressed and put up in a vertical position. This prevents any inconvenient bleeding, and the excess of blood is carried by the drain into the dressings. The organising blood clot acts as a scaffolding, upon which fresh tissue quickly develops, and even a cavity of considerable size will close in about six weeks. It is absolutely essential to observe the most rigid asepsis; infection is disastrous to the success of the method.

(e) Senn's Decalcified Bone Chips.—The chips are prepared from the compact fresh bone of the ox. The bone is cut into long narrow strips, and decalcified by immersion in a 10 per cent watery solution of hydrochloric acid. The fluid is changed frequently, and the decalcification is complete in about two weeks. To remove all traces of the acid, the bone is washed in running water for twenty-four hours, soaked in 1 in 1000 mercuric chloride for forty-eight hours, and stored in a saturated solution of iodoform in ether. Before use the chips are soaked in alcohol to remove the iodoform and ether and then carefully dried. The cavity is filled completely with the bone chips, and the interspaces are occupied by blood clot. It is claimed that the bones strengthen the frame-work of blood clot into which the healthy granulation tissue penetrates. Instead of decalcified bone, chips of fresh bone have been used.

(f) Murphy's Glycero-gelatin-formalin Plug.—100 cc. of white gelatin are boiled in 150 cc. of glycerin and 500 cc. of water. To the mixture 1 to 2 per cent of commercial formalin is added.

(g) Beck's Paste (page 82). This may be used in a manner similar to iodoform wax or Neuber's starch.

When the cavity has been treated by one of the above methods, the soft parts are brought together over it. It is usually impossible to obtain a periosteal covering, but muscles and fasciae are available.

After-treatment.—There are certain important features in the after-treatment which require to be recognised. It is important to maintain rigid asepsis, and for this reason it is well to avoid frequent and unnecessary dressing. While the wound is healing the part must be immobilised upon some form of light splint, readily adaptable to the limb. Aluminium answers the purpose in the majority of instances. When the wound is healed the part is encased in a light splint of plaster of Paris, and this is kept in position for from three months to six. If the wound is not completely healed a plaster case may still be applied if a window is cut out to permit of dressing. The prolonged fixation in after-treatment is very essential, even though it would appear that all trace of the disease had been removed.

(2) The Resection Operation.—Mr. Stiles first brought this procedure

into active use, and for many years he has used it to the exclusion of other methods. By the aid of skiagraphy the disease is localised within the bone, and conditions are most favourable when a limited area is involved. Not that diffuseness is a contra-indication, for the whole diaphysis may be removed. It is well that the disease should lie within the limits of the bone and not have involved the surrounding soft tissues. The bone is exposed by a suitable incision, and the periosteum separated from it well above and below the disease. The bone is divided at one side of and at some distance from the disease. The division is best carried out with a Gigli saw, or in small bones with a bone forceps. When the bone has been divided, a strong sharp hook is introduced into the medullary cavity, and by the leverage of the hook the diseased bone is strongly pulled upwards, and further separated from its periosteal bed. The further limit of the disease having been reached, the bone is again divided, and the diseased portion removed. If the upper extent of the disease lies in relation to the epiphyseal cartilage, the bone should not be divided, but wrenched away from its attachment to the epiphysis. When this is done it will be found that the epiphyseal cartilage remains attached to the epiphysis. Much of the success of the operation is based upon this anatomical fact; were it otherwise the operation would often be contra-indicated on account of the shortening which it would entail. “As long as the epiphyseal cartilage is not actually involved in the disease, the operation does not give rise to any subsequent shortening.” ¹ Subsequent to the removal of the bone there is little bleeding; occasionally the main nutrient vessel requires to be tied. There is left a flaccid tube of periosteum, and this is closed with a series of interrupted catgut sutures. Special care is taken to cover over the divided ends of the bones. The periosteal tube fills with blood clot, and this, by organising, forms a scaffolding upon which new bone is enabled to regenerate. The regeneration occurs partly from the separated periosteum and partly from the divided ends of the bones. Any overlying muscles and fasciae are united with catgut sutures, and the skin edges are brought together with silkworm gut sutures or Michel’s clips.

After-treatment.—The part must be kept at rest in good position for some weeks after the operation. It is sometimes found, more especially when a single bone has been removed, that the pull of the overlying muscles tends to crumple up the lax periosteum, and thus gives rise to considerable shortening. This complication may be avoided by applying extension to the limb of sufficient degree to overcome the muscular pull. When the wound is firmly healed, the part is encased in a light splint of plaster of Paris, and this is renewed at intervals of three months until new bone formation is completed. Regeneration is usually complete at the end of nine months. Even when reformation of bone may appear complete, it is unwise to permit full weight-bearing upon the part; some form of protection splint should be applied and worn for about three more months.

¹ Stiles, loc. sup. cit. vol. ii. p. 7.
TUBERCULOSIS OF THE BONES AND JOINTS

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TUBERCULIN TREATMENT


TREATMENT OF BONE TUBERCULOSIS 99


TREATMENT OF BONE CAVITIES


TREATMENT OF JOINT TUBERCULOSIS

It is unnecessary to deal with preventive, general, or tuberculin treatment. These have been already discussed in application to bone tuberculosis, and their conduction is exactly similar in joint disease. Conservative and operative treatment, upon the other hand, have more special applications, and they require to be considered.

Conservative Treatment

A number of methods are included under the "Conservative treatment." The following will be dealt with:

- Fixation
- Counter-irritation
- Hyperæmia
- Extension
- Injection

Fixation Treatment.—This will be discussed under three headings:
(1) The stage of absolute fixation of the joint; (2) The stage of partial fixation, in which slight movement is permitted, but no weight-bearing; (3) The final stage, in which moderate weight-bearing is allowed, but the extremes of movement are curtailed.

(1) Absolute Fixation.—As in bone tuberculosis, absolute fixation of the part must be put in the forefront of conservative treatment. The materials which may be suitably used are less numerous than in the treatment of osseous disease, because there are only certain substances which are sufficiently and completely adaptable. Of the available material a premier position must be given to plaster of Paris, applied by the method already described. A casing of sufficient thickness is used, and while still soft it is moulded with the hand to the outlines of the enveloped joint. Celluloid makes an excellent fixation splint, but it necessitates the taking of a cast and a prolonged preparatory process. A well-fitting celluloid splint provides absolute fixation, with the minimum of weight and the greatest possible degree of comfort. Splints of wood and metal are not suitable. They are not readily adaptable to the joint outline unless they have been thoroughly padded, and when padded they often lose a considerable degree of their fixing power.

In applying the fixation splint, two principles must be kept in view. The first is that it is not sufficient to fix merely the joint affected. It is essential that the joints immediately above and below should also be rendered rigid. This may necessitate considerable increase in the size of the splint. The second essential is in regard to the position of the limbs, when the splint is in position.

The cure of a tuberculous joint sometimes necessitates ankylosis of the joint, and it is all-important that the ankylosis should occur in a position most useful to the patient. Therefore, when a fixation splint is necessary,
it ought to be applied with the joint in such a position that if ankylosis occurs the sacrifice of limb function is reduced to a minimum. This point is dealt with fully in application to the individual joints.

Joints treated in this way are in a condition of absolute fixation, and depending on the position, size, and weight-bearing necessities of the joint, the treatment will extend over a period varying from six months to several years. At the termination of this period the second stage of fixation treatment is entered upon.

(2) Partial Fixation. — The fixation is no longer absolute, a slight degree of movement is possible, but all idea of weight-bearing is rigidly avoided. To secure this effect, numerous splints have been devised for individual joints, and this is the principle upon which the well-known Thomas's hip and knee splints are based. The duration of the second stage of treatment varies according to the joint affected. A suitable average period is one of six months.

(3) Final Stage. — Lastly, one enters on the final stage in fixation treatment. Movement is now permitted, but within limits. The extreme movements of the joint are avoided; weight-bearing is begun, at first in a slight degree, and then gradually increasing. Very often this last stage is neglected, but if it is adopted the joint is fitted with a light retentive apparatus, usually of leather, which prevents the more extensive of the joint movements.

Treatment by Extension. — A diseased joint may be in such a condition that it cannot be immediately placed in a position of absolute fixation, and a preliminary period of treatment by extension becomes necessary. There are two conditions which give rise to the necessity: the presence of pain in the joint with muscular spasm, and deformity of the joint due to irregular muscular contraction.

Extension is applied to the limb by elastic tension or by weight. The latter method is preferable, as its amount can be easily varied at will. The
actual application is made in different ways. Some form of adhesive strapping is applied to the limb, it may be in the form of single lateral strips, or in the more complicated form originated by Taylor. In the Edinburgh Children's Hospital a modification of Taylor's method is used. Its application is simple, and may be understood by reference to Fig. 6, C.

Before applying the strapping the limb should be shaved, and any bony prominence over which the extension may play ought to be protected by small pads of lint. To the lower end of the adhesive strapping, tapes are stitched, and to the tapes, weights are attached through the medium of an ordinary wooden stirrup. The weight-cord runs over a pulley, the position of which can be altered at will. Fig. 99 illustrates a useful form of pulley-holder, which can be attached to most varieties of cots. The amount of weight varies with three factors: the age of the child, the degree of muscular development, and the pathological condition which necessitates the use of the weight. During the first three years of life it is often stated that a pound is added for each year. Above three years the proportion cannot be increased so rapidly. The muscular strength varies enormously, and it must be carefully considered in judging the degree of weight required. The type of lesion is a most important consideration. If extension is applied on account of pain in the joint, the pain resulting from muscular contraction and tissue destruction, a comparatively small amount of weight is sufficient to relieve the symptoms. But if the extension is being used to correct a joint deformity, a much greater weight becomes necessary.

It is important to apply the extension in the actual axis which the limb occupies. If this is a deformed axis it does not matter, because by extending, first in the deformed position and gradually bringing the axis towards the normal one, the deformity is overcome.

A warning must be given in regard to the danger of using too much weight. Joint pain which is not relieved by extension often means an excessive degree of weight, and when this is reduced the relief may be immediate. Excessive weight application also tends to stretch ligaments and weaken joints, and even to produce some separation of epiphysis. Counter extension may be necessary, the weights being applied in opposite directions. The weight of the body may be used instead of a second application of weights, as, for example, in the extension used in lower spine Pott's disease, in which weights are applied to the lower limbs, and the foot of the bed raised. In certain cases, second extension must not be applied as a true counter or opposite extension, but as an oblique or right-angled extension; for example, in tuberculous disease of the hip-joint, simple extension in the long axis of the femur may not relieve the symptoms, because the lower part of the head is pressing against the rim of the acetabulum. There is immediate relief when a second extension is carried out at right angles to the first in the axis of the neck of the femur.

Counter-irritation of Joint.—Many authors have drawn attention to the marked benefit which appears in joint symptoms after the application to the joint of some form of counter-irritation. There is almost universal
agreement that the best way in which to apply the counter-irritation is by means of the actual cautery. Heated to a black heat, a broad cautery is applied momentarily to the skin over the affected joint. Blisters form, and are suitably dressed. Other counter-irritants, and more especially tincture of iodine, have been recommended. It is rarely that the reaction they produce is sufficient to give rise to any symptomatic improvement.

**Injection of the Joint Cavity and its Surroundings.**—Medicated injections are among the accessories of local treatment. They are introduced into the interior of the joint or into the thickened tuberculous tissue around. When the injection is made into the interior of the joint, the solution is distributed as completely as possible over the synovial surface. The fluid contents are withdrawn, and the medicament introduced through a single puncture. The technique is exactly similar to that described in the account of the treatment of a cold abscess. When the injection is made into the periarticular tissues, small amounts are introduced through a number of separate punctures.

**Solutions.**—A favourite solution to employ is a sterile emulsion of 10 per cent iodoform in glycerin. It produces a benefit in cases in which the synovial membrane only is affected; it is useless when the bone is diseased. A disadvantage is the intense reaction which, more especially in children, sometimes follows its employment. There is a local reaction in the joint—pain and swelling. But the general reaction is of more import; it consists in symptoms of fever, headache, malaise, rash, and unfortunately sometimes the graver symptoms of sickness, delirium, and hematuria.

Iodoform in ether, 5 or 10 per cent, is used less commonly than the glycerin emulsion. It possesses the disadvantages common to all iodoform preparations, and in addition the special disadvantage of the volatility of its ether, which sometimes distends the joint to a dangerous degree.

Calot recommends the use of naphthol-camphor and creasote-iodoform solutions. He distinguishes two varieties of tuberculous joints from the point of view of injection treatment: (a) tuberculous joints with effusion, and (b) dry tuberculous joints. The former he treats exactly upon the line of a cold abscess. Creasote and iodoform emulsion is injected at intervals of six or eight days, over a period extending in all to two months. In the dry form of tuberculous joint he offers a choice of two modes of cure:

1. By producing a simple sclerosis without effusion. This he secures by injecting once a week for eight or nine weeks a quantity of the iodoform-creasote emulsion. The amount injected varies from 2 to 12 grammes, according to the age of the child and the capacity of the joint.

2. In the second method the object is to produce an effusion into the joint, and this is secured by using the naphthol-camphor solution (1 gramme naphthol-camphor to 5 grammes of glycerin). The amount injected varies from 6 to 30 drops, and the treatment is continued each day until an effusion appears into the joint. When an effusion appears the joint is treated as in class 1.

**Hyperæmic Treatment.**—A tuberculous joint was the first disease to
which Bier applied his hyperæmic treatment. He recommends only the passive method of treatment, as he considers that symptoms tend to become aggravated by the use of an active hyperæmia. At first Bier applied hyperæmia for a prolonged period on each application, but he found that this induced the formation of large cold abscesses and quantities of fungating granulation tissue. To avoid these complications he altered his régime. The treatment was begun by applying the bandage for a period of eight or ten hours a day, gradually reducing the time, until at the end of a few weeks only one hour's application was made each day. The change produced a decided improvement, but cold abscesses continued to form, though perhaps with less persistency. Bier now makes use of the method employed by Tilmann in the Greifswald Surgical Polyclinic: a method in which he applies the congestion treatment only one hour daily. For this period it is permissible to allow the hyperæmia strongly to affect the limb, but the bandage must not be applied tightly enough to cause pain or paraesthesia in the treated extremity. If the joint lesion is an especially intractable one, an hour daily is too short a period; two or even three hours may be necessary.

**Cold Abscesses and Sinuses.**—When cold abscesses and sinuses develop, they are treated by the methods already described.

**Summary of Treatment.**—In concluding this outline of the conservative treatment of tuberculous joints, it will be well to mention the sequence one follows in employing the different methods of treatment. When the joint first comes under treatment, if there is much pain or any degree of deformity, weight extension is applied until the pain disappears or the deformity is corrected. The joint is then placed at absolute rest, in the most suitable position—the most suitable should ankylosis occur. While it is kept at rest the auxiliary treatment of hyperæmia or medicated injection may be used. If plaster of Paris is employed to secure the complete fixation, and it is intended to employ joint injection in addition, suitable windows will require to be cut out of the plaster over the joint to allow the injections to be made. When the hyperæmic treatment is to be used in conjunction with fixation, plaster is not so suitable, as the swelling of the part may be too intense.

The fixation material, plaster or whatever it may be, is changed at intervals of three months, and on the occasion of each successive change it is advisable to have the part X-rayed in order to record the progress which is being made. At each interval it is important carefully to examine the joint for the formation of a cold abscess. This applies more especially to such deeply situated joints as the hip, in which a cursory examination may easily overlook a small collection of pus. The period of complete fixation will extend upon an average over twelve months. A further period of time is spent in some form of ambulatory apparatus, and then the joint is allowed to perform limited movements, unless of course the cure has been accompanied by ankylosis.
Operative Treatment

Indications for Operation.—The indications for operative treatment are very similar to those discussed in regard to bone tuberculosis. Nothing can be added in regard to the questions of age and family history. The social condition of the patient is even a more important guide than it is in bone tuberculosis.

A tuberculous joint interferes with movement and locomotion more completely than a tuberculous bone ever can, and when the disease appears in the joint the whole limb is crippled. You give the patient a choice of a period of conservative treatment, extending over many months, with perhaps a movable joint at the end of that time; or an operation, a period of post-operative treatment, and a stiff joint. Among the classes from which hospital patients are drawn the tendency is to choose the latter alternative.

The joint affected is of premier consideration. In the knee-joint the results of operation are so good that one has little hesitancy in recommending it; but in such a position as the wrist-joint one prefers to persevere with conservative measures.

Lastly, there are indications in regard to the clinical features. One should take into consideration the duration of conservative treatment which has been already attempted, the development of cold abscesses and sinuses, and the appearance of bone foci as demonstrated by X-rays. There are special indications for individual joints, and these will be dealt with separately.

Types of Operation

The operative measures to be considered are:

- Arthrotomy and Curetting
- Arthrectomy
- Amputation
- Excision

Arthrotomy and Curetting.—There are cases in which there can be demonstrated a small localised area of disease in the synovial membrane or in the underlying bone. By removing this single focus, it may be possible to completely arrest the disease, and at the same time obviate the necessity for any prolonged after-treatment. The joint is opened by a suitable incision, and the diseased tissue cut out or curetted away. The cavity is touched with absolute alcohol, containing 10 parts of carbolic acid, and the wound is closed without drainage. The operation should be followed by traction upon the limb, and the after-treatment should include a period of absolute fixation.

Synovectomy, Arthrectomy, and Excision.—These three procedures may be considered together.

Synovectomy.—Theoretically, synovectomy is a removal of the synovial membrane, without interfering in any way with the underlying cartilage or bone. The joint is freely opened, and the diseased membrane clipped away with a pair of scissors curved on the flat. Naturally the indications calling for such an operation are exceedingly limited, and as an
operation it carries with it the risk of recurrence, because in a complicated joint it may be impossible entirely to remove synovial membrane and synovial membrane only.

**Arthrectomy.**—Arthrectomy may be looked upon as a further stage of synovectomy, but instead of restricting one's attention to the membrane, a layer of the underlying cartilage is removed. The bone is not exposed, and thus there is not the same tendency to ankylosis. As an operation, a pure arthrectomy is frequently indicated, and the results obtained are often excellent. It possesses the advantage of not necessarily being followed by ankylosis.

**Excision.**—Excision is the dernier ressort of the local removal treatment. The entire joint-bearing surface is removed, all the intricacies of the synovial arrangement are followed out, and the underlying bone surfaces are exposed. As an operation it is indicated in cases too extensive to permit of arthrectomy, in which there is disease of the subarticular bone. When the procedure is thoroughly carried out, recurrence of the disease is rare. It has one distinct disadvantage, and one which may be a possible disadvantage. The first is the shortening which necessarily results in the limb, most marked when the epiphyseal cartilage is destroyed. The second possible disadvantage is the osseous ankylosis which is so likely to result. In many joints this latter is looked upon as an advantage rather than a disadvantage, e.g. the knee-joint.

**Amputation.**—The question of amputation of the diseased limb remains for consideration. It is indicated when there is steady progression of the disease, mixed infection with sinus formation, and a general health decline from waxy disease and cachexia. The mutilation which results is the chief objection to the operation. It is most important not to delay amputation too long, and in the actual technique of the operation one must avoid the danger of encroaching upon the diseased area, and so running the risk of tuberculous infection of the flaps. The operation is described under the head of each individual joint.

**Correction of Deformity.**—As the result of neglect or improper treatment, tuberculous joints may become fixed in deformed positions. The deformity is at first the result of a muscular contraction, and usually the greater power of the flexors decides that the deformity is one of flexion. In the later stages adhesion between the joint surfaces renders the alteration in position more permanent in character. The deformity may be corrected by conservative or by operative means.

**Conservative Treatment.**—The conservative measures adopted may be gradual or immediate.

(a) Gradual.—Speaking generally, it may be said that gradual correction is obtained by some form of extension. The variety may vary within wide limits. It may be accomplished by head or by foot extension, by horizontal extension in the hip and knee, first in the line of the deformity, then gradually towards normal, by fastening the bent limb to a straight frame, as in the spine, or by a series of plaster of Paris fixations in improved positions.
It is unnecessary to give more exact details at this point, as they are discussed under the individual joints.

(b) Immediate.—Under a general anaesthetic, a cautious and experienced surgeon can secure great improvement in the position of a deformed joint by gradually straightening the part and fixing it in the corrected position. Myotomy of shortened muscles may be necessary before complete correction can be obtained.

Operative Treatment.—Different operative procedures are adopted in different joints. A complete division of shortened soft parts may be sufficient. Frequently it becomes necessary to divide the bone by a transverse or a cuneiform osteotomy.

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PART II.—SPECIAL
TUBERCULOUS DISEASE OF THE SPINE

The vertebrae are, of all the bones, the most liable to tuberculous infection, and as the spinal column is the axis upon which the whole osseous arrangement depends, the importance of a spinal infection cannot be overestimated. It is calculated that one-fifth of all cases of bone disease have their seat in the spine; it is slightly more common in boys than in girls.

Etiology

The condition is essentially due to infection of the vertebrae with tubercle bacilli. The method by which the infection gains admission, and the changes which the organism produces, are discussed under pathology, but there are certain features bearing upon the etiology which must now be considered.

Age.—The disease is most common in children, and probably its most frequent incidence is found during the first five years of life. Lannelongue\(^1\) has given statistics gained from a study of 180 cases occurring in children under sixteen years old. In 7 per cent of the cases the disease first appeared when the child was less than two years old. Between two years and five years no less than 50 per cent of the cases occurred. In the period from five years to ten, 32 per cent of the cases could be placed. The remaining 10 per cent occurred over ten years of age. It is generally acknowledged, and all statistics support the fact, that five years of age is the most common period at which the disease appears.

Sex.—Sex does not appear to be a factor of any importance. The disease is slightly more common in boys than in girls, but according to Wullstein\(^2\) the proportion is wonderfully equal: 53·29 per cent males and 46·71 females.

Injury.—It is quite certain that in the history of a number of cases one finds some account of an injury, in particular a fall from some small height. From what one knows of the pathology, it is possible that accident does play its part in originating the disease, but too often the history of injury is more imaginary than real. It is a slight injury rather more than a severe one which predisposes to the disease.

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1 Lannelongue, *Tuberculous Vertebrae*, p. 137.

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Heredity.—Tuberculosis is so common and so widespread that it is never very difficult to trace its ravages. In Pott's disease, as in tuberculosis elsewhere, there is usually a tuberculous family history. Gibney found that 76 per cent of cases showed a family history of tubercle—in 38 per cent on the mother's side, in 35 per cent on the father's side, in 31 per cent on both sides. Statistics published by Waterman and Jaeger differ considerably from these. According to them only 10 per cent of the children were born of tuberculous parents.

There are other subsidiary facts in the predisposing etiology. One frequently finds the disease coming on after an attack of one of the exanthemata; the predisposition is due to a lowering of the body vitality. Then there is the fact of tuberculosis elsewhere. Vertebral tuberculosis is rarely a primary manifestation. Autopsy usually reveals a primary focus in some other part, most commonly in the bronchial or mesenteric glands.

In regard to the association of other bone and joint lesions with Pott's disease, one is thoroughly in agreement with Tubby when he says: "At the Evelina Hospital for children we have often observed the sequence of events: tuberculous dactylitis, glands, coxitis, or other varieties of arthritis, persisting for some months or a year, and then the onset of spinal caries. Very rarely is the reverse order of events met with."

Pathology

The Localisation of the Disease.—The majority of authorities are agreed that the lower dorsal portion of the spine is the part most frequently affected. This rule of location is, however, not universally accepted. Thorndike holds that the proportion of occurrence is that of one cervical for three dorsal and five lumbar cases; but he adds that in New York, out of 1000 cases 6.6 per cent were cervical, 70.9 per cent dorsal, and 22.5 per cent lumbar.

As regards the individual vertebrae affected, the most common are those from the eighth dorsal to the first lumbar, vertebrae which require to stand greater superincumbent weight than any others in the spinal column.

General Structure of Vertebrae.—The anterior portion of each vertebra is formed by the large rounded body, filled with cancellous tissue, and bounded above and below by the discs of the intervertebral cartilages. From the postero-lateral aspects of the bodies there project backwards the two pedicles, which with the two transverse processes, the articular processes, the two laminae, and the spinous process, complete the vertebrae, and enclose the spinal canal.

With the exception of the atlas and axis vertebrae, all the vertebrae of the column may be said to be articulated upon the same scheme. Three

1 Quoted by Bradford and Lovett, Orth. Surg., p. 11.
3 Deformities, including Diseases of the Bones and Joints, 1912, vol. ii. p. 57.
4 Thorndike, Orthopedic Surgery, 1907, p. 208.
separate joints exist between opposing bodies, a central amphiarthrodial joint, and two lateral diarthrodial joints. The amphiarthrodial joint occupies the greater part of the space between the vertebral bodies, where the two bone surfaces are brought into contact by a layer of fibrocartilage. Between the opposing articular processes there are joints of the diarthrodial variety. The ligaments which bind the bodies together are the anterior common ligament in front of the vertebral bodies, the posterior common ligament which lies on the posterior aspect of the vertebral bodies, and the various interspinous and intertransverse ligaments, with the ligamenta subflava between the adjacent laminae.

It is unnecessary to describe the distinct and numerous articulations between the axis, atlas, and occipital bones. All the joints are of the diarthrodial variety.

**Blood Supply of Vertebrae.**—The largest amount of the blood supply is distributed to the interior of the body of the vertebra. The vessel is derived from the posterior spinal artery, and it enters the body by one or two distinct foramina upon the centre of the posterior surface. Narrow zones of bone at the attachment of each intervertebral cartilage upon the upper and lower surfaces of the body derive special blood supplies from what are termed the epiphyseal arteries, derived from the posterior spinal artery. An area of bone in the front of the body obtains its blood from branches of the intercostal arteries. Each vertebral body therefore has four distinct sources of blood supply. At the base of each transverse process a separate vessel on each side penetrates the front of the process at its junction with the pedicle. It owes its origin to the intercostal vessels.

The scheme of blood supply is distinct in the atlas vertebra. It possesses no proper body, and therefore the large central artery is absent. Its place is taken by two lateral vessels, which enter one from each side and run forwards and backwards within the bone.

**Pathology.**—The infection is carried by the blood stream into the bone, and, according to the distribution of the vessel, different areas are infected by the disease. (1) It may occur in the centre of the vertebral body, and this constitutes by far the greatest proportion of the cases. It may be spoken of as the central variety. (2) The infection may begin at the epiphysis of the body, beside the attachment of the intervertebral disc. From the epiphysis it extends into the body of the vertebra or into the substance of the disc: the epiphyseal variety. (3) The anterior or peripheral variety occurs in the anterior portion of the vertebral body, supplied with blood through the intercostal vessels, and lying immediately beneath the anterior common ligament of the vertebra. This type of the disease is practically limited to adults. (4) Lastly, there are extremely rare forms of the disease, which attack one or other of what one may term the vertebral appendages, and most commonly the transverse processes. In each of these four varieties the exact pathology is very similar, but it is best observed as it occurs in the central form.

**Changes in Individual Vertebra.**—It is probable that a vertebra
is predisposed to tuberculous disease by a preliminary change in the main nutrient vessel. This change is of the nature of a tuberculous endarteritis obliterans; it is the result of a tuberculous toxaemia, and it affects these vessels which supply vertebrae most liable to trauma and strain; hence the common localisation of the disease to the lower dorsal spine. The thickening of the vessel wall interferes with the nutrition of the bone and its marrow, and the marrow becomes altered from a resistant red marrow to one of a pale, myxomatous and less resistant type. It is in such an altered tissue that the original tubercle makes its appearance. If there has been a predisposing trauma, it acts by producing a small ecchymosis in the weak and friable tissue, and the extravasation of blood is responsible for an arrest of the tubercle bacilli. The formation of a tuberculous follicle is the first stage in the actual pathology. It is situated in the centre of the marrow. It is composed of the usual arrangement of epithelioid cells, lymphocytes, and giant cells, and to the naked eye it appears as a tiny grey point, standing out from the surrounding marrow. The tubercle enlarges, others appear around it, and as they eventually coalesce, a considerable focus of disease is formed. Caseation appears in the centre, and the original grey colour of the diseased area is now altered and replaced by a variety of colour, a yellow interior, a grey periphery, and a thin limiting zone of congested marrow.

As the disease spreads throughout the cancellous spaces it comes into contact with the bone lamellae. These are rarefied, and if possible entirely absorbed before they become surrounded by the diseased tissue. Should the lamellae become isolated before they are completely absorbed, they form minute sequestra. Attention has been drawn to the preliminary changes which the marrow undergoes. When the disease is well established the myxomatous marrow in the immediate neighbourhood of the disease shows a tendency towards the development of fibrous tissue and the limitation of the tuberculous tissue. It is an interesting fact, and one which has never been explained, that in tuberculosis of the vertebrae the periosteum rarely forms any degree of new bone. It is difficult to understand when one remembers how typical is the formation of new subperiosteal bone in other situations.

The entire architecture of the bone is now altered; the interior of the body has lost all stability, and the weight and pressure are entirely borne by the thin compact bone of the periphery. It is like a box with walls of unstable cardboard. Upon each vertebra a considerable amount of pressure is normally exerted, and such pressure, most marked in the anterior part of the column, is borne by the thick bodies and the strong intervertebral discs. If the strength of the body of one or more vertebrae is undermined by a central rarefying disease, the continuation of pressure produces a crumpling up and a collapse of the body. The body having collapsed, and the posterior part of the spine, pedicles, laminae, and transverse processes remaining healthy and in situ, the result is the development of an angulation or kyphosis.

1 Fraser, Edin. M. J., 1912, N.S. ix. 436-441.
PLATE XLIII.—THE PATHOLOGICAL VARIETIES OF POTT'S DISEASE (after Wallstein).

a, The central variety of Pott's disease.  b, The epiphyseal variety of Pott's disease.

c, The anterior or peripheral variety of Pott's disease.
The vertical pressure which is exerted upon the diseased vertebra is the result of the superincumbent weight and of the contraction of the irritated muscles which lie along each side of the spine. The natural tendency which the disintegrated vertebra has to produce a kyphosis, places the anterior muscles at a mechanical advantage over the posterior. The gradual increase in power of the anterior muscles accentuates the kyphosis, and the posterior muscles by becoming stretched act at a greater and greater disadvantage. With the collapse of the body the disease is more widely disseminated, it may be extended among the surrounding soft parts to form the origin of a cold abscess.

When sequestra occur they are of the minute variety, intimately mixed with the caseating and purulent debris. Sequestra of larger size may occur, but they are broken up and destroyed when the body of the vertebra collapses.

The amount and the character of the kyphosis depend upon two factors: the number of vertebrae affected, and the situation in which the disease has occurred. Disease in a single vertebra produces a sharp kyphosis, with probably little general deformity. Co-existent disease of several vertebrae gives rise to a rounded gibbosity, with considerable general deformity. The alterations in different regions of the spine have been demonstrated by Menard.1 In the cervical region destruction of the vertebral bodies does not produce much kyphosis, because inflexion is largely prevented by interposition of the roots of the pedicles where they come off from the sides of the vertebrae. The cervical region, on account of the space which normally

1 Étude pratique sur le mal de Pott, Paris, Masson & Cie., 1900.
exists between the posterior arches, permits of a considerable degree of hyperextension, and when inflexion occurs it is corrected by hyperextension. The result is a slight kyphosis and some degree of shortening in the spinal column.

In the dorsal region of the spine, destruction of a single body produces a distinct kyphosis, and the deformity is more marked as other vertebrae are affected. This striking difference depends upon the anatomical fact that in the dorsal spine the pedicles do not come off from the side of the body, but from the posterior surface, therefore they cannot by interlocking prevent a spinal inflexion. The deformity cannot be neutralised by hyperextension as in the cervical region, because the laminæ and the spine are normally so close together that very little extension is possible.

When the lumbar spine is diseased, the results resemble those found in the cervical spine. On account of the thick intervertebral discs and the large interlaminar and interspinous spaces, there is considerable power of hyperextension. Collapse of the lumbar body is counterbalanced by a corresponding degree of hyperextension, and the result is a slight kyphosis and some amount of shortening. Sometimes, although the diseased vertebra has collapsed, the body above does not come into contact with the body below. Until there is actual contact, a supposed cure is more apparent than real.

In addition to the changes in the bodies of the vertebrae, there are changes in the arches. The posterior arch of the diseased body is partly dislocated backwards, giving origin to the early spinal prominence. The posterior segment is wasted and atrophied, and sometimes it is firmly ankylosed to segments above and below by the quantity of new bone thrown out from its surface and attachments.

**Changes in Vertebral Column as a Whole.—**

The essential deformity of Pott’s disease is a kyphosis, but there are compensatory changes above and below. These compensations are in the shape of curves, to maintain the figure in a correct attitude.

In cervical disease the axis of the skull becomes altered, and there is a compensatory curve in the dorsal spine. When the disease attacks the dorsal spine, its most favourite situation, there are compensatory lordotic curves in the cervical and lumbar regions. If the angulation is in the lower part of the lumbar region, any kyphosis which may occur is largely compensated for by hyperextension of the hip-joints.

**Lateral Deviation of the Spine.**—Occasionally one finds that in addition to a kyphotic deformity there is also a lateral one, and the complication sometimes leads to the erroneous diagnosis of simple scoliosis. A
lateral deviation occurs in Pott's disease for two reasons. The first is that when in the collapse of the spine, owing to the destruction of a vertebra, the upper segment does not fall true upon the lower one, a sharp and almost angular scoliosis results. The second possible cause is the irregular course of the disease. If only one-half of the vertebral body is destroyed, and the disease spreads to the vertebral half immediately below, a lateral deviation will result. It is usually uniform, and, apart from the muscular rigidity, it closely resembles at first sight a simple scoliosis.

**Changes in the Spinal Cord and its Membranes.**—From the close proximity of the spinal cord to the disease, it is but natural to expect that when a kyphosis occurs, pressure will be exerted upon the cord, pressure of such a degree as to give rise to symptoms. In reality such a sequel is the exception rather than the rule. The power of accommodation is so great that even a very extensive deformity will produce no nervous tissue change.

In a certain proportion of cases pressure upon the cord does occur, producing what has been called "compression paraplegia," and the changes which produce it may originate (1) in the bones of the spinal column; (2) in the spinal membranes; (3) in the spinal cord itself.

1. **Bone Causes.**—It is very exceptional to find that the bending of the spinal column is of such a nature as to compress the spinal cord. It angles, but rarely compresses. A partial dislocation is a more common source of bone pressure. When the diseased vertebra collapses, the upper segment is displaced somewhat backwards, and its posterior edge comes into contact with the enclosed nerve tissue. Cases have been recorded in which a sequestrum has gradually been extruded from the diseased area, and has exerted pressure upon the nerve tissue. The commonest manner in which the diseased bone causes compression is an actual extension of the disease, either as tuberculous granulation tissue or as a cold abscess. The disease within the body of the vertebra has a tendency to extend to the exterior through the posterior surface, and more especially along the vessels entering the bones through the large nutrient foramina. At first the extension is limited by the posterior ligament. When this becomes perforated the epidural space is invaded, and pressure is at once exerted upon the cord.

2. **Membrane Causes.**—By the extension of the disease a tuberculous perimeningitis is produced; this is followed by a pachymeningitis, and later even by a leptomeningitis. As the membranes become diseased they become thickened, and then blood and lymph vessels are obliterated. In this way the cord undergoes a slow and gradual compression with resulting changes in its nerve elements.

3. **Spinal Cord Causes.**—The nervous tissue of the cord is practically never actually infected with tuberculosis; the changes which it undergoes are secondary. Its actual circumference may be flattened and constricted by pressure. Owing to the obliteration of the blood and lymph vessels in the spinal membranes, there is a local oedema of the cord, and the oedema may
become a subacute myelitis with softening. If myelitis occurs, there will be a destruction of a certain number of the nerve filaments, a proliferation of the neuroglia and sclerosis, followed at a later date by ascending and descending nerve degeneration. Fortunately it is the exception for the changes to be so severe as to produce myelitis. The nerve roots undergo changes very similar in every respect to those which occur in the spinal cord.

**Changes in the Heart and Great Vessels.**—The heart is altered in position and in size. It is altered in position as a result of the kyphosis, and naturally the most marked alterations occur when the deformity is situated in the upper and mid-dorsal regions. The change in position is of such a nature that the base of the heart is displaced downwards, while the apex appears to be tilted upwards. The heart appears to be rotated upon a transverse horizontal axis. The upward displacement of the apex is more apparent than real, as it is exaggerated by the alteration in the position of the ribs.

The size of the heart is changed by the hypertrophy which it consistently undergoes. Attention is drawn later to the kinking of the aorta. As a result of the kinking, the work of the heart is increased, and there is an hypertrophy, and later a dilatation of the left ventricle. The other chambers of the heart undergo similar changes.

The aorta and the vena cava are altered in direction and in size. The aorta is liable to become kinked in two positions, about the centre of the transverse portion and again opposite the kyphosis. The vessel may be kinked antero-posteriorly or deviated laterally, sometimes a combination of both. The antero-posterior deformity is the more serious, there is a valvular formation of the anterior wall which offers very considerable obstruction to the blood flow. The changes in the vena cava are very similar to those found in the aorta; on account of the thinness of its wall this vessel accom-
modates itself more easily to the alteration in position than is the case in the aorta.

These vascular changes are responsible for the coldness and malnutrition of the lower extremities which one so constantly finds in Pott's disease.

Changes in the Thorax.—These are so excellently summarised by Tubby that one cannot do better than quote his words: 1

"In the chest three varieties of deformity are seen: A. If the curve is high up in the dorsal region, the true ribs are held at an angle greater than the normal, the sternum is displaced downwards, and the antero-posterior diameter of the thorax is diminished. In fact the chest is in an expiratory position. B. If the disease is low down in the dorsal region, the ribs and sternum are raised, the antero-posterior diameter of the chest is lengthened, and the chest is barrel-shaped, and is in a position of inspiration. Therefore the breathing is diaphragmatic, and the patient is short of breath. C. When the lumbar region is affected the whole thorax sinks downwards and forwards, the lower ribs over-ride the pelvis, the ensiform cartilage approximates to the symphysis pubis, and the abdominal wall is thrown into folds."

Changes in the Pelvis.—Disease of the cervical or upper dorsal spine is unaccompanied by any change in the architecture of the pelvis. When the disease occurs in the dorso-lumbar region, producing there some degree of kyphosis, there are changes in the pelvis compensatory to the angulation. The sacrum is rotated upon a central, transverse, horizontal axis, its upper

1 Tubby, Deformities, including Diseases of the Bones and Joints, vol. ii. p. 95.
half is displaced backwards, while the lower half is carried forwards. The iliac crests become splayed outwards, and the inlet of the pelvis is increased in its antero-posterior and transverse diameters. The outlet of the pelvis is diminished in size by the tilting forwards of the lower part of the sacrum, and an approximation of the tuberosities. The ischia are approximated because the displaced sacrum acts as a wedge, forcing apart the upper parts of the pelvis, while the lower parts in compensation are approximated. The pelvis is said to become funnel-shaped in outline. When the disease affects the lumbosacral region, there is no tilting of the sacrum. The whole bone is displaced downwards and backwards, and therefore there is not the tendency to narrowing of the pelvic diameters which one finds in disease higher up.

Abscess Formation.—There is no more common complication met with in tuberculosis of the spine than that of abscess formation, and while it is discussed later in its clinical aspect, it is essential to study it here from its pathological side. It is calculated that 20 per cent of cases pass on to abscess formation (Townsend).¹

The Origin of the Abscess.—The caseation and rarefaction which goes on within the bone is really a modified cold abscess formation, but as long as the disease is localised to the bone the term abscess cannot be theoretically applied. In process of time the disease extends to the surface and perforates the limiting zone, or the osseous shell collapses and the caseous matter is disseminated into the soft parts around. To either of these possibilities the cold abscess owes its origin. There is a third possibility which one occasionally finds illustrated, the cold abscess may begin as an extension of tuberculous disease from the interior of the vertebra, along the course of one of the larger nutrient vessels, and more especially along the sheath of the large artery which enters the body from its posterior surface. The abscess which is really a progressive caseation in the soft tissues and intermuscular septa may remain in the proximity of the original osseous lesion, or it may become wandering or migratory.

The Course of the Abscess.—The course varies in the different regions of the spine—cervical, dorsal, or lumbar.

A. Abscesses originating in the Cervical Spine.—To understand the possible directions of a cervical abscess it is essential to describe first the relation of the deep cervical fascia, because the situations of the abscesses are guided almost entirely by the attachments of this structure.

The deep cervical Fascia.—From the spine tips of the cervical vertebrae the ligamentum nuchae passes backwards in the middle line of the neck. From the posterior edge of the ligamentum nuchae, the superficial layer of the deep cervical fascia passes forwards to reach the posterior margin of the trapezius muscle. Here the fascia divides into two lamellae, which enclose the trapezius and reunite at its anterior border. From this point the fascia sweeps forwards to form the roof of the posterior triangle, and then splits to enclose the sterno-mastoid muscle. It again reunites at

the anterior margin of the muscle, to become continuous with the fascia of the opposite side. The fascia forms a complete collar around the neck, splitting to enclose the trapezius and sterno-mastoid muscles of each side. This superficial collar has most important vertical attachments. Above, it can be traced to the superior curved line of the occiput, the mastoid process, over the parotid gland, to the zygoma, and along the inferior aspect of the lower jaw from the angle to the symphysis. Below, the fascia is attached to the spine of the scapula, the acromion process, the clavicle, and the manubrium sterni; as transversely it splits twice to enclose structures, so vertically it splits twice. Above, between the lower jaw and the hyoid bone, it embraces the submaxillary gland; below, two inches above the suprasternal notch, it separates into two lamellae, enclosing a triangular interval (Burns's space). This space contains the sternal head of the sterno-mastoid, one or two lymphatic glands and vessels, and portions of the anterior jugular veins. This layer of fascia is pierced by the external jugular vein just above the clavicle. From the deep surface of the circular superficial layer, two deep processes pass across the neck: the pretracheal and the prevertebral layers.

The pretracheal layer springs from the lamella lining, the deep surface of the sterno-mastoid muscle. It passes across the neck in front of the trachea and oesophagus, enclosing in its course the thyroid gland. It is attached to the lamella upon the deep surface of the opposite sterno-mastoid muscle. Vertically it is attached above to the hyoid bone, while below it passes into the mediastinum.

The prevertebral layer extends inwards from the deep surface of the cervical fascia as it passes across the roof of the posterior triangle. It covers the prevertebral muscles and the spinal column. Above it is attached to the base of the skull, below to the first rib, where the inner portion becomes continuous with the posterior mediastinum. The outer portion forms the sheath of the subclavian vessels, and continues downwards with them into the axilla. The carotid sheath is a special investment formed by the pretracheal and prevertebral fascia. The neck is therefore subdivided by these processes into three compartments: (a) The muscular, between the superficial and the pretracheal layers, containing the depessor muscles of the hyoid bone; (b) the visceral, between the pretracheal and prevertebral layers, containing the larynx, pharynx, oesophagus, trachea, and thyroid gland; and (c) the
vertebral compartment, behind the prevertebral layer, containing the pre-
vertebral muscles, the cervical sympathetic, and the vertebral column.

When the cold abscess is secondary to disease in the cervical spine, the
pus will follow tracks which largely depend upon the attachments of the
cervical fascia. The possibilities are as follows:

(1) The pus may accumulate behind the prevertebral fascia, between it
and the anterior surface of the cervical vertebrae. It bulges the fascia for-
wards, and it is designated a retro-pharyngeal abscess; *laterally it appears
at the posterior edge of the sterno-mastoid muscles*.

(2) The pus may penetrate the prevertebral fascia, in which case, if
situated high up, it enters the mouth, if low down it enters the visceral
compartment of the neck, infiltrating around the gullet and the air passages.
Pus in this region has no special tendency to point in the neck; it more
frequently passes downwards into the mediastinum or into the axilla. It
may find its way into the interior of the oesophagus.

(3) The pus may track along the lateral surface of the cervical vertebrae,
between the spine and the ligamentum nuchae upon the inner side, and the
posterior cervical muscles upon the outer side. It penetrates the deep
cervical fascia, and appears at one or other side of the vertebral spines.

**B. Abscesses originating in the Dorsal Spine.**—Dorsal abscesses are
generally small, and they usually remain in close contact with the spine.
Owing to the depth of the dorsal spine from the surface, the pus is frequently
retained, and it may make its way within the spinal canal, and give rise to
a paraplegia. The possible course of the abscess is guided by the anatomical
relations of the lateral aspects of the dorsal spine. With the exception of
the first rib and of the last three ribs, the head of each rib articulates with the
bodies of two vertebrae and the intervening intervertebral substance. The
heads of the first, tenth, eleventh, and twelfth ribs are implanted directly
upon the bodies of the corresponding vertebrae. Each rib is attached to
the side of the vertebrae by several ligaments, the most important of which
are the anterior capitular or stellate ligament and the superior costo-trans-
verse ligament. Between the inner edge of the superior costo-transverse
ligament and the lower and upper edges of adjacent stellate ligaments there
is a weak point in the anterolateral aspect of the spinal column.

The interval between the posterior extremities of the ribs is filled up
by the internal and external intercostal muscles and the posterior inter-
costal membrane. The external intercostal muscles extend inwards as far
as the tubercles of the ribs, the internal intercostals end at the angles of the
ribs, the further interval being filled up by the posterior intercostal mem-
brane. The inner edge of the posterior intercostal membrane is attached
to the outer edge of the superior costo-transverse ligament. The bodies
of the vertebrae are bound together in front by the anterior common ligament.
The anatomical relation of the posterior primary divisions of the dorsal
nerves must be briefly mentioned. They make their appearance in the
intervals between the transverse processes, and immediately divide into
external and internal branches. The external branches pass outwards
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under cover of the middle column of the erector spinae muscle, and of their number only the lower five become cutaneous about the position of the rib angles.

The internal branches are distributed in a fashion almost the reverse of the external; the lower five branches are very small, and they do not become superficial; the upper seven pass inwards between the multifidus spinae and the semispinalis, and after piercing the splenius, rhomboideus, and trapezius muscles they become superficial. As will be shown later, special interest attaches to the arrangement of the posterior divisions of the dorsal nerves.

The aortic intercostal arteries have important bearings upon abscess situation. One is given off to each of the nine lower intercostal spaces upon both sides of the body. In both cases they pass outwards over the body of the vertebrae, and as they leave the vertebral column to enter the intercostal spaces, each of the vessels gives off a large dorsal branch, which passes backwards in the interval between the transverse processes, and is distributed to the muscles and skin of the back. From this branch a special twig is supplied through the intervertebral foramen to the spinal cord and its membranes.

In each space the intercostal artery proceeds outwards, first lying between the pleura and the posterior intercostal membrane, and afterwards between the muscular layers of the internal and external intercostals.

These anatomical points have been given in detail because each of them...
has important bearings upon the position which a dorsal abscess may take. The various positions which a dorsal abscess may assume are as follows:

(1) It may be retained in front of the spine, behind the periosteum or the anterior common ligament (prevertebral abscess).

(2) It may extend through the anterior common ligament, and invade the space of the posterior mediastinum.

(3) It may pass more laterally and come to lie beneath the pleura, sometimes penetrating the pleura and producing a tuberculous empyema.

(4) It may gravitate downwards beneath the ligamentum arcuatum internum, and assume the positions compatible with a lumbar abscess (see below).

(5) It may make its way backwards between the transverse processes, through the weak, triangular interval, bounded by the superior costo-transverse and the stellate ligaments. When it gets into this situation its further course depends upon whether it follows the course of the blood-vessels or the posterior primary division of the nerves.

(6) Following the track of the blood-vessels, the abscess may extend along the dorsal branch of the intercostal artery, or it may pass outwards, accompanying the main intercostal vessel, and appearing on the surface, sometimes where the lateral branch is distributed and sometimes at the anterior extremity of the intercostal space.

(7) When the nerves act as guides, the abscesses may follow either the internal or the external branches of the posterior primary divisions. If the external branches are followed, the abscess appears at some distance from the middle line, and as only the five lower nerves of this group become cutaneous, abscesses are likely to appear in the corresponding positions. When the abscess tracks along the internal branch, it appears close to the middle line, and usually in the upper seven spaces, as the lower five nerves do not become superficial.

(8) An abscess from the first four dorsal vertebrae may follow the same course as a cervical abscess.

C. Abscesses originating in the Lumbar Spine. — The lumbar vertebrae are peculiarly related to the attachments of the psoas, iliac, and lumbar fasciae, and as the positions of the various abscesses are determined by these structures, it is necessary briefly to describe them. The fascia covering the psoas and iliacus is one continuous sheet. Above it is thin and comparatively narrow, covering over the psoas muscle,
below it expands to cover the psoas and iliacus muscles, and it becomes much denser and stronger. The attachments of the fascia are all important. Superiorly it forms the thickened band of the ligamentum arcuatum internum, arching over the psoas muscle, and attached by one extremity to the tip of the transverse process of the first lumbar vertebra, and by the other to the body of the second lumbar vertebra, and the tendonous part of the corresponding crus of the diaphragm. Externally its attachment differs above and below the crest of the ilium. Above it is attached, externally to the fascia covering the quadratus lum- borum, the anterior lamella of the lumbar fascia. Below, when it becomes the fascia iliaca, it is firmly fixed to the crest of the ilium. Internally its attachment also varies. In its upper part it is fixed to the spine by a series of fibrous arches which bridge over the lumbar arteries; lower down it sweeps over the psoas, and is attached to the brim of the true pelvis. Inferiorly, to the outer side of the iliac vessels, the fascia becomes adherent to the fascia transversalis, when both are attached to Poupart's ligament. Behind this outer division of the fascia the ilio-psoas, the anterior crural nerve, and the external cutaneous nerve are carried downwards into the thigh.

The inner portion of the lower end of the fascia is prolonged downwards into the thigh, behind the femoral vessels, to form the posterior wall of the femoral sheath.

The lumbar fascia is really the posterior aponeurosis of the transversalis muscle. As the fascia approaches the spine it splits into three layers or lamellae: the posterior lamella is attached to the spine tips of the vertebrae, the intermediate lamella to the tips and adjacent sides of the transverse processes, the anterior to the bodies of the vertebrae at the roots of the transverse processes. Two compartments are thus formed: in the anterior the quadratus lumborum lies, the posterior is occupied by the erector spinae. The
fascia of the anterior lamella is continuous with the outer side of the psoas fascia.

The lumbar arteries are arranged on much the same plan as the intercostal vessels. They proceed outwards upon the bodies of the lumbar vertebrae, and disappear under cover of the psoas muscle. In the intervals between the transverse processes they divide into a dorsal and an abdominal branch. The dorsal branch turns backwards, and after giving off its spinal twig to the spinal cord, pierces the posterior muscles, and ends in the integuments of the back.

The lumbar arteries are arranged on much the same plan as the intercostal vessels. They proceed outwards upon the bodies of the lumbar vertebrae, and disappear under cover of the psoas muscle. In the intervals between the transverse processes they divide into a dorsal and an abdominal branch. The dorsal branch turns backwards, and after giving off its spinal twig to the spinal cord, pierces the posterior muscles, and ends in the integuments of the back.

The posterior divisions of the lumbar nerves are very similar in arrangement to those described in the dorsal region. The internal branches are of small size, and their distribution is purely muscular. Of the external branches the upper three are of large size, and they become cutaneous by piercing the superficial lamella of the lumbar fascia.

Each of the above anatomical details has important bearings upon the abscess course.

(1) The disease originating in the front of the body of the vertebra may pass directly forwards, and failing to enter the sheath of the psoas, it passes behind the aorta, and extends downwards along the great vessels. It may extend by the external iliac into the thigh, or it may follow the internal iliac into the pelvis, and open by the side of the rectum or through the great sacro-sciatic foramen.

(2) The disease may enter the sheath of the psoas muscle, and gravitate downwards along it until it appears beneath Poupart's ligament, at either the inner or the outer side of the femoral vessels.

Menard has noticed this type of abscess extend in the thigh along the course of the internal circumflex vessels, and point behind the great trochanter.

(3) The abscess may enter the sheath of the psoas muscle, but in the lower part of its course it extends outwards beneath the fascia iliaca, to appear as an iliac abscess internal to the anterior superior spine.

(4) It may extend laterally into the sheath of the quadratus lumborum, and piercing the lamellae of the lumbar fascia, it becomes superficial above the crest of the ilium at Petit's triangle.

(5) The abscess may enter the fascial layers, further from the middle line than the quadratus lumborum, in which case it may extend forwards between the muscles as far as the anterior abdominal wall.

(6) The course of the abscess may be guided by the dorsal branches of
the lumbar arteries, and the fluctuation appears close to the spine and often below the last rib.

(7) Sometimes the disease extends along the nerve sheaths, and commonly along the three upper of the outer divisions of the posterior primary nerves, the abscess pointing some distance from the middle line.

The Natural Method of Cure.—Natural cure is most quickly brought about when the osseous surfaces come into contact. The period required is more prolonged when the diseased body remains intact than when it collapses, and in this respect the kyphosis has a certain salutary influence.

Before repairs can occur the tuberculous debris must be absorbed, or at least localised by surrounding fibrosis. The diseased area is replaced by fibrous tissue, and this at a later period by contraction may account for an apparent increase in the degree of deformity. The fibrous tissue is afterwards ossified, and until ossification is complete a cure cannot be guaranteed. The fibrosis and ossification is most prominent in relation to the body of the vertebra where the disease primarily occurred. Around the periphery of the posterior arch new bone formation may occur, binding the pedicles and occasionally the laminae together. These evidences of repair are never met with inside the neural canal.

The period of time required for complete fixation and cure varies in different regions of the spine. It is least in the lumbar spine. Under treatment fibrosis occurs during the end of the first year, and ossification is well marked at the end of the second. In the upper part of the cervical region the periods are longer, averaging two years and three years for fibrosis and ossification. The period is certainly longest in the dorsal spine. Fibrosis appears only in the end of the third year, and certainly the fifth year will have been completed before a proper ossification is recognisable. These facts are mentioned later in regard to treatment.

Spondyl Arthritis.—In the occipito-atloid and the atlo-axoid articulation there are numerous synovial articulations and the pathology of tuberculous disease in these regions is peculiar. The disease begins as a synovial tuberculosis, usually in the atlo-axoid joints, subsequently it spreads beyond the membranes, and becomes an osseous tuberculosis.

Tuberculous Disease originating in a Portion of a Vertebra other than the Body.—Occasionally one sees tuberculous disease attacking the transverse process or the vertebral spine, but such occurrences are exceedingly rare. Still more uncommon is it to find tuberculous disease originating in the costo-vertebral articulation or in the joints of the articular processes.

Symptoms and Physical Signs

Symptoms.—In enquiring into the history of Pott's disease, one is frequently told that the first thing noticed was the angulation of the spine. With some trouble, however, one can usually obtain information of a train of symptoms introductory to the actual deformity.
(1) *Latent Period.*—The original onset can frequently be traced to an attack of one of the exanthemata, and probably during the lowered resistance of convalescence the organism first gains a footing. Before any definite and specific symptoms are complained of, the child exhibits symptoms which ought to attract attention. The weight does not continue to increase, it remains stationary, or it diminishes. The general nutrition is not maintained and the child becomes thin and pale. There are slight evening temperatures, sometimes so slight as to be scarcely perceptible. The energy is lessened. A child who has been bright and active becomes dull and listless, refuses to indulge in the games of its comrades, and complains of feeling tired after the slightest exertion. This constitutes what one may term the latent or the introductory period. It may last several weeks or as many months.

(2) *Pain.*—The pain in Pott's disease may be of the nature of a referred pain or of a local pain. The local pain, that is to say the pain which occurs in the region of the spinal column, may be spontaneous or it may only be induced on movement or pressure. In character it is sharp and stabbing, and it is more especially localised to the actual diseased vertebra or vertebrae. When judged from the point of view of diagnostic value, one attaches less importance to it than to the referred variety. In attempting to induce the pain, Kirmisson recommends the examination of the whole length of the spine by percussion, tapping each individual spine with the finger. This method has two fallacies. In a nervous child the mere act of percussion produces alarm, and pain is complained of when it is not really present. Further, there are areas of the spine which one may term normally sensitive—the sixth cervical, the seventh dorsal, and the first lumbar. These areas may respond to percussion in such a way as entirely to mislead one.

Local pain may be tested for by applying over the spine a sponge wrung out of hot water. When it is brought over the site of disease, a sudden sensation of pain is induced. Ice-cold water may be used for the same purpose, producing a similar effect.

Some authors have recommended the use of an electrode with a constant current. A delicate test of the presence of pain is obtained by pressure upon the transverse processes. Rotation of the bodies occurs, and pain is at once produced. In this way the fallacy of pain from pressure on the skin is got rid of.

A local pain produced by movement of the spine, the pain being accompanied by muscular rigidity, is often present. Its diagnostic significance is discussed with the clinical feature of spinal rigidity.

But much more important than local pain is the presence of referred pain. As the disease in the spine develops, pressure comes to be exerted upon the nerve roots, and according as these are distributed, so is the pain referred. The pain is usually subacute, but it is subject to sudden exacerbation. Its distribution varies when different regions of the spine are affected. In cervical disease it may be referred to the occiput and the arm. Dorsal disease is associated with sternal or intercostal neuralgia, dorso-
lumbar with epigastric and girdle pain, lumbar disease with pains in the hips and legs. In addition to the pain being referred to a certain area, the skin over the area of distribution is hypersensitive to touch and to painful stimuli.

Referred pain is the most common cause of error in diagnosing early Pott's disease. Epigastric pain, for example, is frequently judged as being due to indigestion, when in reality it is the result of tuberculous disease in the dorsal spine.

It has been urged that it is important to induce local vertebral pain by sudden pressure upon the vertex, the pressure being exerted with the patient erect. This is a perfectly unnecessary method of demonstration. It is painful and alarming, and any knowledge it may provide can easily be determined by less barbarous means.

(3) Night Cries.—These are not so common in Pott's disease as they are in tuberculosis of the larger joints. They are sometimes met with when the disease affects the cervical and upper dorsal regions. They indicate a progressing state of the disease, and they correspond to the pathological condition in which the vertebral body has partially but not entirely collapsed. Night cries disappear quickly under suitable treatment.

(4) Symptoms dependent on Paralysis.—Paralysis occasionally comes on before spinal deformity, and by doing so may cause confusion. The symptoms appear gradually. The child is noticed to trip and stumble with a quite unusual persistence, there is difficulty in going up or in coming down stairs, and the child is conscious of a progressive stiffness and tiredness in the extremities. The physical signs found upon examination are discussed later, sufficient for the present to say that they are those of a spastic paralysis, with no involvement of sensation. Such early symptoms as have been mentioned should at once arouse one's suspicion of Pott's disease, and in every case of doubtful paralysis it is well to strip the child and carefully examine the back.

(5) Symptoms dependent on Abscess Formation.—These vary according to the position occupied by the abscess. In cervical disease, a retropharyngeal abscess being the most common complication, one may find the symptoms of dyspnœa, hoarseness of voice, and difficulty in swallowing. When the disease occurs in the upper dorsal region, and the abscess takes up an anterior position, it may press upon the recurrent laryngeal nerves, producing dyspnœa and an alteration in voice. One of the best symptomatic evidences of abscess formation is found when the abscess invades the sheath of the psoas, producing irritation and contraction of the muscle. The leading symptom is that of difficulty in walking, owing to the persistent flexion and eversion of the limb.

Physical Signs.—Method of Examination of Patient.—In examining a case of Pott's disease one ought to follow a definite scheme. The results and possible complications of the disease are so widespread and diffuse that it is easy to overlook important facts, unless some routine is followed. (1) At one's introduction to the patient one has an opportunity of studying
the body attitude and gait. There are many points to be learned from
these as they differ in each situation-development of the disease. (2)
One notes the general facial appearance and body nutrition. (3) The spine
is inspected, and any irregularities noted and localised. (4) Some form of
permanent record is made of every deformity which exists in the spine. (5)
The spinal movements are tested, each type of movement, and each region
of the spine being examined. The movements are examined when carried
out by the active muscular movements of the child, and when performed
passively. (6) Certain areas of the body are carefully examined for the
presence of cold abscesses. (7) The reflexes, superficial and deep, are tested,
and irregularities of sensation or movement noted. (8) Compensatory
changes are observed as they occur in the cranium, the thorax, or the pelvis.
(9) The heart and great vessels are examined by the usual clinical methods.
(10) The examination is concluded by the taking of one or more X-ray
photographs, illustrative of the portion of the spine affected.

Such is the scheme which one adopts, and there are no details of it which
can afford to be neglected. We shall now examine each feature in detail.

1. Attitude and Gait.—Peculiarities of attitude are usually conspicuous.
There is a distinctive general attitude, and it corresponds to what one may
term the "spring" type. All the weight-bearing joints of the body are kept
to a slight degree flexed. The child walks on its toes, the knee and hip
joints are partially flexed, the head is brought down to the shoulders, and
the arms hang loose by the side. It is an attitude of expectation, produced
by the constant fear of sustaining a sudden shock. Every joint becomes
a spring intended to minimise an injury, and all acting to lessen the impact
received by the diseased spinal column.

There are specific attitudes which correspond to disease in different
regions of the spine. In cervical disease the position of the head is changed.
It may assume a position resembling wryneck, with an approximation of
the ear to the shoulder tip, but without that rotation of the face which is
pathognomonic of wryneck. Sometimes the head is thrown well back
and to one side. Less frequently the chin droops forwards on to the chest,
and the head is supported by the palms of both hands. Sayre differentiates
between the attitudes when the disease is in the upper or in the lower cervical
region. If the upper cervical vertebrae are affected, the head takes up the
position resembling wryneck. If the disease has occurred in the lower
cervical or upper dorsal region, an effort is made to keep the head in balance
by pushing the chin forwards and throwing the occiput slightly backwards.

In the upper dorsal region the shoulders are raised, giving the appearance
of a sunken neck, and the shoulders and arms are thrown backwards in a
stiff military attitude. Owing to the displacement downwards of the ribs,
the upper part of the chest is flattened, and the lower chest and the end of
the sternum project forwards.

When mid-dorsal disease is present there is considerable spinal rigidity
and early deformity. The attitude assumed is one of a stiff, rigid back; both arms, which, owing to the displacement of the vertebral column, appear
longer than usual, hang down by the side. If there is much deformity

the thorax acquires a globular shape, with upward tilting of the ribs and displacement of the whole sternum forwards.

A typical attitude is noticed when the disease attacks the dorso-lumbar

and upper lumbar regions. The head and upper part of the body are thrown backwards. The abdomen is prominent, and the patient stands upon a broad base, with both legs well apart. He walks with what has been termed
the "alderman's gait," with the abdomen projecting and the chest and shoulders thrown well back. He tends to waddle slightly from side to side.

Pott's disease of the last lumbar vertebra produces a deformity to which the term *spondylolysis* has been applied. It depends upon a destruction of the body of the last lumbar vertebra, and a displacement forwards and downwards of the lower part of the spinal column. The attitude which characterises it is a very marked lordosis of the back and

![Fig. 20.—Dorso-lumbar Pott's disease. There is the typical "alderman gait."](image)

projection of the belly forwards. The thorax is depressed, the last rib almost touching the iliac crest. There is a deep transverse fold, which begins upon each side above the crest of the ilium, and extends across the abdominal wall at the level of the umbilicus.

These attitudes and gaits are so typical that one can frequently locate the disease in those who pass us on the street.

2. **General Appearance and Body Condition.**—Sufferers from this disease have the general appearance which one associates with tuberculosis elsewhere, and which requires no detailed description, but in addition they illustrate in their features the presence of a symptom which is so common in bone or joint disease, that of pain. The facies acquires an anxious strained
expression, the evidence of a persistent effort to prevent the sustaining of the slightest jar. The general nutrition of the body is poor, and while the disease is progressing the weight probably diminishes.
3. **Inspection of the Spine.**—For this purpose the child should be stripped. In older children a loose skirt may be fastened around the hips in such a way as to expose the whole extent of the spine. Running one’s eye along the vertebral column, one may have the attention attracted by four possible changes: *(a)* A posterior angulation of the spine affecting one or more vertebrae; *(b)* A lateral deviation of the spinal column; *(c)* An unusual degree of “boarding” or flattening of the spine; *(d)* An abnormal amount of spinal lordosis.

*(a)* **Posterior Angulation of the Spine. Kyphosis.**—This is the most strik-
ing of the deformities, and by it the disease usually declares itself. It is the result of the collapse of the body of one or more vertebrae. If a single vertebra is destroyed the angulation is sharp, and produced by the knuckle-like prominence of a single spine. When the disease has occurred in several vertebrae the projection is more rounded and diffuse. One expects the amount of displacement to be greatest in the dorsal spine, less in the cervical, and least of all in the lumbar region.

There is a diffuse superficial type of tuberculous disease which extends over the bodies of a number of vertebrae, and gives rise to a gradual kyphosis, very strongly resembling the simple round shoulders of adolescence.

(b) Lateral Deviation of the Spinal Column. Scoliosis.—It is by no means true that the curvature of Pott’s disease is invariably angular and in the middle line. In a considerable proportion of cases, and more especially in the lumbar region, the destruction of the vertebral bodies is irregular, and the result is a lateral deviation of the spine, which may in some respects resemble a scoliosis. In these cases, in almost every instance an angular curvature by means of which one may distinguish and classify the disease is added.

There is another variety of lateral deviation found in Pott’s disease which is liable to cause confusion, that is the type of lateral deviation which occurs at the very commencement of the disease, before there is any appearance of a kyphotic curvature. At first sight the superficial resemblance of this condition to a simple scoliosis may be very striking. It may be recognised by its rapid onset, and the concurrence of pain and muscular rigidity.

(c) “Boarding” or Flattening of the Spine.—The healthy spine ought to present a series of uniform curves. An interruption of those curves, as indicated by an area of flattening, is evidence of some underlying muscular
rigidity, and the muscular spasm is itself the result of disease of the vertebral column. It is one of the most valuable clinical evidences, because it is perhaps the earliest to make its appearance, and because it distinguishes tuberculous disease so absolutely from simple deformities. The phenomenon becomes more obvious when the movements of the spine are tested. Its distribution is guided by the situation of the disease, but it affects the muscles for some distance upon each side of the lesion. The explanation of the muscular spasm which produces the rigidity is simply that it is an attempt to immobilise the diseased spine, and so to lessen the amount of injury which it is liable to receive. There are very few conditions which simulate the rigidity of tuberculous disease. It is found occurring in acute and subacute infections of the vertebral column, and in the more painful varieties of scoliosis.

(d) Abnormal Degrees of Spinal Lordosis.—When a kyphosis occurs in the spinal column, the alteration which the displacement must produce in the axis of the body is compensated by lordotic curves in other situations. There is a lordosis above and below the lesion, produced at first by muscular action, and later by an adaptation in the shape of the intervertebral discs. Cervical disease is accompanied, not by an actual lordosis of the dorsal spine, but by a considerable lessening of the normal kyphosis. The lumbar region, however, shows an increased compensatory lordosis. A tuberculous dorsal
kyphosis is compensated by exaggerated lordotic curves in the cervical and lumbar regions. When the disease occurs in the lumbar region, while there can be compensation above, no lordosis can exist below. Its place is taken by a hyperextension at the hip-joint.

4. The Taking of some Form of Permanent Record of the Spinal Deformity.—It is exceedingly important to keep some permanent record of the spinal deformity, for it is obviously necessary to know at some future visit whether the deformity has increased or receded. The outlines may be cut from stiff paper, and corrected by refitting it against the spine. The actual pattern may be kept for future reference, or its outline may be transferred to soft paper, which can be rolled up into small bulk. A simple method is to use a strip of lead about eighteen inches long and half an inch wide and an eighth of an inch in thickness. This is laid along the spine and carefully moulded to the outline of the deformity. From it a tracing is made upon paper, and the tracing is kept for future use.

Dr. G. B. Young of Boston has introduced an ingenious device, by means of which the spine outline can be rapidly delineated. It consists of a wooden bar, with a slot, in which a number of pieces of wood of equal lengths play, the whole being clamped in place by a screw at one end. When the apparatus is set upright against the spine, and the screw loosened, the individual pieces of wood adjust themselves to the outlines of the spinal column. When the screw is tightened, the exact outline is retained until it has been transferred permanently to paper. A useful apparatus has been introduced by Beely. It consists of a series of horizontal movable rods, fixed in a vertical stand, and capable of apposition to the outline of the spine when the patient stands erect. The pattern is transferred from the rods to paper.
If in addition to the kyphosis there is some scoliosis, both deformities cannot be recorded upon the same scheme. A separate impression must be taken of the scoliosis. This is conveniently done as follows: A long strip of netting about 18 inches long and 4 inches wide is used. The netting has a half-inch mesh, and running lengthwise along its centre a coloured line is marked. The material is held along the spine in such a way that the median line lies exactly in the centre of the body, as judged by the seventh cervical vertebra and the natal cleft. The line of the scoliosis is marked out upon the netting with ink. In this way a permanent record can be kept, and the state of affairs compared at intervals. Ebner records the amount of lateral deviation by laying a strip of adhesive plaster, 3 inches wide, along the spine. Upon this the spinous processes are marked and outlined, and the plaster backed with brown paper for future reference.

5. Examination of the Movements of the Spine. Muscular Rigidity. —The possible movements which the spine can carry out are those of flexion extension, and hyperextension in the sagittal planes, lateral flexion in the

coronal plane, and rotation or torsion about its own long axis. Lateral flexion and rotation cannot exist as isolated movements, they are interdependent upon one another.

When tuberculous disease occurs in the vertebrae, it gives rise to a rigidity in the long para-spinal muscles, chiefly the erectors spinæ, and the resulting rigidity necessarily interferes with the carrying out of the proper spinal movements. Therefore, of all signs of vertebral disease, muscular rigidity is the most characteristic. While the interference with movement is evidenced in all the movements, it is most striking when those in the sagittal direction are performed. In each region of the spine each individual type of movement ought to be examined.

The Cervical Spine.—In the cervical spine free flexion and extension are permitted between all the cervical vertebrae, and nodding movements of the head are permitted at the occipito-atlantal articulation. Lateral flexion is free throughout the cervical region. Rotatory movements take place chiefly at the atlanto-axial joints, and to a slight degree in the lower cervical vertebrae.

In young children it may be exceedingly difficult to persuade them to carry out voluntarily the various movements, but often a simple manoeuvre overcomes the difficulty. Place the child on its back across its mother's knees, so that the head projects without support; if the spine is healthy, extension is carried out, and the head falls back. By reversing the position and placing the child face downwards flexion is tested, and in one or other lateral posture lateral flexion is brought into play. Even the youngest child can be persuaded to carry out rotation by the judicious exhibition in varying positions of attractive bright objects.

The movements are tested passively by moving the head in the direction required. Great care must be exercised in doing this to avoid any degree
of force, as when the disease attacks the atlo-axial articulation, even a slight strain might produce death by rupturing the transverse ligament, and permitting dislocation of the odontoid process and pressure upon the spinal cord.

When disease attacks the vertebrae of the cervical spine or the synovial sacs at its upper extremity, there is produced a limitation or total abolition of the spine movements, and a certain degree of muscular rigidity. The muscular rigidity is more difficult to appreciate than when it is lower down in the spine, but it may be appreciated by laying the palm of the hand across the posterior part of the neck.

Flexion and extension and lateral flexion are limited in whatever part of the cervical region the disease may appear. Rotation is only moderately affected, unless the disease has involved the atlanto-axial joints.

The Dorsal Spine.—All four movements are carried out by the dorsal spine, and it is easy to demonstrate any rigidity which may exist. The various active movements are attempted, and any limitation can at once be noticed. The flexion movement is the more valuable, and while it is being performed, the spine tips ought to be marked out with colour. In the rigid portion of the spine it will be noticed that there is no widening of the spaces between the colour dots as ought to occur in a healthy spine. While the part is moving the hands ought to be laid upon each side of the spine, and they appreciate the fact that where the disease exists several of the vertebrae move en bloc.

In testing the active movements, it is a common manoeuvre to get the child to pick something up from the floor. The act is performed with none of the quickness and the agility of health, but with a slow, deliberate action. Instead of bending the back the joints of the lower limbs are bent, and the trunk is supported by placing both hands upon the knees. In recovering the erect position the hands are used to climb up the thighs in much the same way as one finds occurring in pseudo-hypertrophic paralysis. Another favourite method of testing flexion is to ask the child while it is sitting up to touch the toes of its extended legs.

When examination of the active movements is completed the passive movements are tested. The child lies completely prone, with the elbows flexed and the arms by the sides. The lower limbs are grasped by the ankles, and gradually raised into the air. As the lower limbs are raised the spine ought to sink into an almost uniform curve. When disease is present the curve is not uniform. A portion of the spine remains flat and rigid, and the trunk is lifted from the table with the lower limbs in order to prevent any sinking of the column.

The Lumbar Spine.—Examination of the lumbar spine is carried out in a manner similar to that used in the dorsal region. The presence of rigidity is best tested by raising the lower extremities. By this act the healthy lumbar spine ought to be hyperextended; in disease it remains stiff and rigid. In judging of the value of lumbar rigidity, the close relationship of the psoas muscle to the lumbar spine must be borne in mind. Anything
which by irritation produces spasm of the psoas will certainly give rise to
rigidity of the lumbar spine. One has seen typical lumbar rigidity produced
by the tracking abscess of high dorsal tuberculous disease and by an acute
pelvic-rectal abscess which had entered the sheath of the psoas muscle.
Palpating the spine at this stage one may be able to recognise the presence
of thickening around the spines or transverse processes.

6. Examination of certain Areas for the Presence of old Abscess
Formation.—The formation of these and the course most usually followed
have been discussed. The back of the throat, sides of the neck, iliac fosse,
loins, Poupart’s ligaments, Scarpa’s triangles, and the regions of the gluteal
folds are carefully palpated for swelling and deep fluctuation. By percussion
and by X-ray examination a mediastinal or prevertebral abscess may be
discovered. A psoas abscess may be suspected before it becomes palpable
by the rigid psoas muscle preventing hyperextension of the hip.

7. Examination for Paralysis.—The paralysis is a motor one, involv-
ing usually the lower extremities. The bladder and rectum are rarely
affected, and it is unusual to have any sensory disturbance. It is the result
of pressure upon the spinal cord, and one has mentioned the various means
by which pressure may be exercised. It is often secondary to high dorsal
disease because in this situation the spinal canal is narrowest.

At first the paralysis is a spastic one, but when the degeneration of the
cord becomes advanced the paralysis is complete. In low dorsal and lumbar
disease the paralysis affects the lower limbs and sometimes the sphincters.
In this situation the paralysis may be complete from its beginning, or it
may rapidly pass from the spastic to the flaccid variety. In dorsal disease
there is a spastic paralysis of the lower limbs; it is unusual to find the
sphincters affected. If the disease is in the cervical region, the arms may
suffer before the legs. In specially high disease—occipito-atlantal disease—
the diaphragm may be paralysed, also the spinal accessory and hypoglossal
nerves.

In the examination a complete investigation must be made of the
various nerve functions. Motor functions are tested by movements and
walking. If early paralysis is present, movements are carried out in a
misguided and jerky manner. The child walks badly, with a tendency to
lose equilibrium and to stumble, the toes being dragged. Sensory dis-
turbances may be subjective in the form of dull aching pains in the body
and limbs. Objectively an actual loss of sensation may be demonstrated.
The reflexes superficial and deep are exaggerated, especially the deep re-
flexes of the knee and ankle. If the cord is degenerated, or if the lumbar
enlargement is involved, the reflexes are absent.

Examination of the sphincter may show that incontinence of urine
and faeces occurs. There may be trophic disturbances, the affected muscles
become wasted, bed sores are not uncommon, and arthropathies may occur
in the larger joints of the extremities. Vasomotor disturbances show them-
several in the form of persistent coldness of the limbs and a tendency to free
perspiration. In special regions specific nerve lesions may appear, for
example, in cervical disease the cervical sympathetic may be affected, produ-
ducing at first dilatation of the pupil, and afterwards contraction, and in
many cases flushing and sweating of the face upon one side.

8. **Compensatory Changes in the Cranium, Thorax, and Pelvis.**—
These have been fully discussed in the section on pathology. The changes
are now studied from a clinical point of view. The alteration in the position
of the head, the possible changes in the obliquity of the ribs and sternum,
and the distortion of the pelvic girdle, all should be noted.

9. **Examination of the Heart and Great Vessels.**—When a kyphosis
occurs in the dorsal region, the alteration in the internal anatomy of the
thorax may very seriously affect the heart and the large vessels. By the
usual methods of clinical examination, the presence of cardiac hypertrophy
and dilatation are discovered, valvular disease is sought for, and the relative
condition of the large blood-vessels investigated.

10. **X-Ray Examination.**—When clinical examination has afforded its
information, one’s knowledge of the case is completed by X-ray examination.
Certain facts are learned which otherwise might remain obscure. The degree
of the disease is estimated, and its extent is depicted. The presence of an
otherwise unsuspected prevertebral abscess may be demonstrated and the
situation of sequestra divulged. When the disease is healing, X-ray exam-
ination will yield information of how the cure is progressing. The radio-
graph is taken antero-posteriorly, but in the cervical region a lateral view is
necessary in order to expose the upper true vertebrae. Antero-posteriorly
they are concealed by the presence of the lower jaw.

**Symptoms and Signs in Special Regions.**—The symptoms and signs
vary in different parts of the spine, and while they have been discussed
generally, it is necessary to individualise in special regions.

(a) **Upper Cervical Disease.**—Here the disease really begins as a syno-
vitis, involving the occipito-atloid and atlo-axoid articulations, from which
it spreads to the underlying bones. The odontoid process is early affected,
and also the anterior arch of the atlas.

In the introductory stages of the disease the leading symptoms are
those of difficulty in moving the head, local pain over the spine, and referred
pain radiating about the back of the head and along the course of the upper
cervical nerves. Pressure upon the vertex causes pain, the movements of
nodding and rotation are limited or abolished, there may be a deformity
which closely resembles wryneck, and the hollow of the suboccipital region
frequently becomes filled up.

In the absence of treatment the amount of pain increases, the weight
of the head becomes unbearable, and the patient supports his head on
his hands or by lying down. An abscess may form and take up the position
of a retropharyngeal collection or of an accumulation in the suboccipital
region. At any moment grave symptoms of spinal compression may appear
as the result of a thickening of the soft tissues or of a displacement of the
bones. In the latter case the odontoid process is most frequently to blame,
and immediate death may occur. Much more commonly the paralysis
comes on as an increasing feebleness of the limbs, the arms being usually first affected and then the lower extremities. When recovery takes place, ankylosis is usually the result.

(b) Cervical and Cervico-dorsal Disease.—In this region the spinal rigidity is very apparent, and there are probably the associated deformities of wry-neck, shortening of the neck, and angular curvature. In upper dorsal disease the position of the ribs becomes altered, and they pass almost vertically downwards, reducing the antero-posterior diameter of the thorax. Pain is present, and it is referred to the branch distribution of the cervical or brachial plexuses. If abscesses appear they are retropharyngeal, supraclavicular, or mediastinal in position.

Cord pressure effects are not so common as in the other regions of the cord. If they occur the upper extremities are usually first affected, and afterwards the lower limbs. Very often there are nerve pressure effects, pupillary changes from sympathetic pressure—myosis or mydriasis—recurrent laryngeal and vagus effects, as evidenced by cough, slow pulse, vomiting, etc. There may be the characteristic signs of turning the head and body to look at an object, and in upper dorsal disease the grunting breathing which denotes pressure on the intercostal nerves.

(c) Dorsal and Dorso-lumbar Disease.—The deformity of the spine is usually striking, and from the displacement upwards of the ribs and the projection forwards of the sternum, the antero-posterior diameter of the thorax is increased. There may be local spine pains and referred pains which are of the girdle variety. Sometimes pains are referred down the lower limbs.

Paralysis is common in disease of the mid-dorsal region; it is not so frequent in lumbar disease. When the pressure is at the level of the lumbar enlargement the limbs remain flaccid, the reflexes are feeble or abolished, and there is incontinence of urine and faeces.

(d) Lumbo-sacral Disease.—There is usually only a slight amount of deformity. Sometimes a vertebral thickening indicates the site of the disease. Occasionally the somewhat rare deformity of spondylolysthesis occurs. The pelvis is apt to be deformed, and in children it may become funnel-shaped. Pain is present, and it is referred chiefly to the outer side of the thighs.

The nerve troubles which result are due to neuritis, and therefore they are chiefly local in their distribution, affecting individual groups of muscles which are not necessarily symmetrical or bilateral.

Diagnosis of Pott's Disease

The diagnosis of Pott's disease offers few difficulties if deformity is present, but from the point of view of successful treatment it is essential that the disease should be recognised while it is in its earliest stages. The diagnosis is made to a certain extent from the history, but more especially from the physical examination. The most important point in history is
the occurrence of referred pain, referred to the arms or legs or the anterior middle line of the body. Sternal or epigastric pain in a child should at once suggest the possibility of Pott's disease. Referred pain is of more value than local pain as a diagnostic feature. More productive than symptomatology is the physical examination. Muscular spasm is one of the first signs to appear. In exceptional cases its duration is a short one, and it may be overlooked, but it occurs at some period in every instance. It should be evidenced on active and on passive movement. When the angular deformity is visible the diagnosis may be said to be removed beyond doubt.

Abscess formation may be among the first signs of Pott's disease, and it is important to remember that a cold abscess may appear suddenly: even in the course of a single night. This more especially happens when the abscess appears in a dependent position.

It remains to mention the importance of recognising early spastic paralysis; it may appear before there are any other evidences of spinal disease.

The type of Pott's disease in which compression symptoms come on without any vertebral irregularity may give rise to considerable difficulty in diagnosis. The subject is exhaustively dealt with by Alquier, whose papers ought to be consulted.

An X-ray examination is unnecessary for making a diagnosis in the majority of cases, but in doubtful instances it may be of inestimable value.

**Differential Diagnosis.**—The differential diagnosis only presents difficulties in the early stages, and at this period many experienced surgeons have been at fault. There are cases which appear to conform to no rules, the symptoms of which appear absolutely contradictory.

**Tuberculous disease of the cervical spine** may be confounded with:

1. **Torticollis.**—This one recognises by the presence of shortened muscles and fasciae, the rotation of the face towards the opposite shoulder, and the hemiatrophy of the face.

2. **Stiff Neck, Acute Wryneck.**—The attitude of this condition may strongly suggest cervical caries, but it may be distinguished by the acuteness of its history, and the rapidity with which it yields to treatment.

In the upper dorsal spine simple round shoulders with stiffness may simulate Pott's disease. The former lacks the muscular spasm of the tuberculous condition, and any dubiety remaining may be removed by the use of the X-rays.

**Dorsal Pott's disease** is simulated by:

1. **A Rachitic Kyphosis.**—The points of distinction in favour of rickets are the absence of muscular spasm, the non-existence of pain, and the evenness of the kyphotic curve.

2. **Simple Scoliosis.**—The diagnosis of this condition is generally easy. There is usually absence of muscular rigidity and pain, and the rotation of the vertebrae and ribs produces the typical posterior rib hump. In scoliosis

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the ribs rotate backwards on the convex side, in caries on the concave side.

(3) Syphilitic Kyphosis.—This condition is rare in children, and it can only be distinguished by the occurrence of other syphilitic phenomena.

(4) Spinal Neuralgia.—An error which is frequently made consists in confounding vertebral disease with what has been called spinal neuralgia. This latter occurs in nervous young girls, and there are many features which differentiate it from tuberculosis. The pain is much more diffuse, and extends over a considerable part of the vertebral column. It is more superficial and much more acute. The rigidity so characteristic of Pott's disease is entirely absent.

(5) Anatomical Abnormalities.—In the lower dorsal region an anatomical abnormality is sometimes met with which may raise difficulties in diagnosis. The abnormality consists in an unusual prominence of certain of the vertebral spines closely simulating a kyphosis. The physical examination is sufficient to establish a distinction.

The Lumbar Spine is the situation in which the most difficulties in diagnosis arise. There are several reasons for this. The lumbar vertebrae are more deeply situated, and physical signs are therefore apt to be masked for a considerable time. The movements of the lower part of the spine are so limited that neither symptoms nor deformity may constitute prominent features in the case.

Confusion may arise with the conditions which have been mentioned in the diagnosis of dorsal disease. In addition there are certain difficulties which are peculiar to this situation.

(1) Hip-joint Disease.—It might seem impossible that this could be mistaken for lumbar disease, but mistakes are frequently made. From a focus in the lumbar spine a cold abscess tracks its way into the psoas muscle and sheath. Contraction of the psoas is set up, and there is produced a deformity of the leg with flexion and eversion of the thigh. Superficially the attitude resembles that found in hip-joint disease. The most satisfactory method of differentiation is that of testing the movements of the hip. In coxitis all the movements are limited or abolished. In the pseudo-coxitis of lumbar disease extension and hyperextension are the only movements which are markedly interfered with. In exceptional instances lumbar disease and hip disease may co-exist. Parsons draws attention to a most important point in the differential diagnosis of hip disease from spinal caries. The distinction is based upon the principle laid down by John Hilton, that the same trunks of nerves, the branches of which supply the groups of muscles moving any joint, furnish also a distribution of nerves to the skin over the same muscles and their insertions, while the interior of the joint receives its nerves from the same source. A hip-joint may be fixed by muscular spasm, which is the result, not of disease of the joint, but of irritation of the nerve trunks by a lumbar caries. A distinction is made by noting the distribution of the cutaneous pain. In lumbar disease the affected cutaneous

1 Parsons, B.M.J., 1910, ii. 1126.
distribution would include the front of the lower part of the abdomen, the 
front of the thigh, the region over the great trochanter, and to the inner side 
of the knee. In hip disease, the cutaneous affection, in addition to the 
above, includes the distribution of branches of the sacral plexus, because the 
interior of the joint is partly supplied by branches from the nerve to the 
quadratus femoris and from the great sciatic. The cutaneous distribution 
of these branches is limited to the skin over the buttock and the upper 
and back parts of the thigh.

(2) Sacro-iliac Disease.—Sacro-iliac disease is distinguished by the 
absence of spinal rigidity and the elicitation of pain at the synchondrosis 
by pressing the two iliac bones together anteriorly.

(3) Perinephritis and Perityphlitis.—These in children may simulate 
Pott’s disease, because they are associated with contraction of the psoas 
muscle. A distinction is made by examination of the spine, the abdomen, 
and the urine, and by an X-ray investigation.

If there is much difficulty in coming to a diagnosis it is a good plan to 
temporise, keeping the child in complete recumbency for a few days. Pott’s 
disease remains unaltered at the end of the period. Simulating conditions 
may have disappeared.

Prognosis in Pott’s Disease

The prognosis as regards life is good. Tuberculous meningitis, for 
example, claims fewer victims in Pott’s disease than it does in hip-joint 
disease. If death should occur the causes in addition to meningitis are 
pulmonary tuberculosis, acute miliary tuberculosis, amyloid degeneration 
of the spleen, liver, and kidneys, and exhaustion. The prognosis is 
exceedingly grave when the disease occurs during the first two years of 
life. The life prognosis is endangered by formation of abscesses, sinuses 
with mixed infection, and the spread of tubercle elsewhere.

The ultimate duration of life is not a long one. Neidert has shown that 
of all cured cases of Pott’s disease attaining adult life, the total expectation 
of life was not more than 49½ years. This is almost entirely the result of 
kinking and displacement of the larger vessels, with consequent hypertrophy 
and dilatation of the heart chambers.

The prognosis as to the amount of deformity depends very largely upon 
the condition of the spine at the time treatment is begun. If the disease 
is early, appropriate and thorough treatment ought to prevent any marked 
degree of kyphosis occurring. If a kyphosis has occurred, but has not yet 
become a fixed one, corrective measures may be employed to diminish the 
deformity.

As regards the effect of the situation of the disease, cases of cervical 
and lumbar caries recover with less deformity than do the dorsal ones, on 
account of the physiological lordosis which is already existent, and—this 
applies to the lower lumbar spine—the slight degree of movement which 
occurs.

1 Neidert, Inaugural Dissertation, Munich, 1886.
The prognosis of the duration of treatment varies considerably in dorsal disease, it probably should not be less than four to five years. In cervical and lumbar disease, for reasons stated above, the duration often does not exceed three years.

Treatment of Pott's Disease

The treatment of Pott's disease is general and local.

General Treatment.—The principles embodied in this line of treatment have been already fully discussed. The patient should have an abundance of nourishing food, and be kept out of doors as much as is possible. As recumbency is an important factor in the local treatment, a spinal carriage must be provided in which the patient can be wheeled about from place to place. The whole day is spent out of doors, and at night the child should sleep in a shelter, which during winter may be artificially heated. Under conditions such as these, children improve very rapidly. The use of drugs is unsatisfactory, with the exception of these which act as general tonics.

Local Treatment.—The principles underlying the local treatment of Pott's disease aim at removing from the focus the dangerous influences of movement, weight, and pressure; to fix the spine, as it were, in splints, and having fixed it, to hold it so.

The Principles of Mechanical Treatment.—Normally the weight of the head, and often the weight of the thoracic and abdominal viscera, tend to bend the spine forwards and downwards. This is resisted by the posterior spinal muscles. If the body of a vertebra becomes destroyed, the tendency to bend is increased, and the pressure of superincumbent weight in the upright posture is a most important factor in the production of the deformity. Therefore the principles in mechanical treatment are: (1) To support the back and to prevent further bending; (2) To extend the back, and so diminish the strain on the posterior muscles; (3) To apply traction, and thus prevent antero-posterior deformity.

Local treatment may be divided into two groups: (A) Treatment by recumbency; (B) Ambulatory treatment. The value of each varies according to the age of the patient, the state of the disease, and the portion of the spine affected.

A. Recumbency.—This method consists in keeping the patient lying in such a position that movements of the spine are abolished, and all weight bearing is removed from the vertebrae.

Indications.—The indications for its use are as follows: (1) In cases of Pott's disease which come under treatment before a spinal deformity has appeared. (2) Whenever the symptoms are acute (pain). (3) When ambulatory treatment has been tried and has failed to give satisfaction. (4) When paralysis has appeared, or is threatening. (5) When the spinal disease is complicated by a lateral deviation or a psoas contraction, either of which complications render an ordinary support inefficient. (6) When abscess formation has occurred.
Explanation of Benefit.—The question may be asked, What is the reason of the improvement which results from the treatment? That there is great improvement is obvious to every one who has seen the method employed. The pain disappears, the irritability diminishes, the patient gains in weight, and the face loses its anxious tense expression. The explanation of the improvement may be said to be a double one. Tuberculous disease is an inflammatory lesion, and in common with all inflammatory lesions, it benefits from the provision of complete rest. Recumbency ensures this rest. The second explanation depends upon the counteraction of muscular spasm. Muscular rigidity is the result of a certain degree of destruction of the body of the vertebra. Essentially it is protective, being nature’s method of lessening the possible movement of the diseased part, but actually it is productive of further harm. The eroded vertebra, under the constant strain of the contracted muscles, gradually gives way. As it does so, the diseased bone surfaces come together, and a further reflex spasm is set up, in fact a vicious circle is brought into action. When the vertebral body has partially collapsed the shortening of the anterior spinal muscles places these at a mechanical advantage over the posterior ones, and the continued contraction of the former increases and aggravates the deformity. If recumbency is properly carried out, it provides more than simple rest to the spine; it ought to provide some degree of counter-extension, an opening out of the collapsing vertebra, and a lengthening of the contracted anterior muscles. The muscular balance is restored, the spinal deformity is lessened, and as the diseased surfaces do not now irritate one another, the symptoms are relieved.

Disadvantages.—There are certain disadvantages associated with recumbency. When the case is an out-patient, with imperfect home conditions, it is exceedingly difficult to ensure that the treatment is being thoroughly and conscientiously carried out. Yielding to the entreaties of the child, an unscrupulous mother will allow the child to sit up in spite of the most solemn warning of the danger it may entail. Parents frequently complain of the trouble which there is in carrying the child about. Undoubtedly this is a disadvantage; it may be minimised by the use of a spinal carriage or go-cart. In many of the recumbent methods nursing is carried on at a disadvantage. This, however, does not apply to the more recent introductions.

Advantages.—The advantages far outbalance the disadvantages. They are the relief of pain, the arrest and improvement of the deformity, the gradual improvement of paresis, and the arrest of the increase in size of an abscess.

Appliances.—Of the various appliances for securing recumbency, mention will be made of a simple bed prepared for recumbency; Tubby’s spinal pillow; Fisher’s frame; the double Hamilton splint; the double Thomas splint with head-piece; Bradford’s bed frame; Whitman’s stretcher frame; the plaster bed of Lorenz and Hoffa; Gauvain’s spinal board; the back door splint; the wheelbarrow splint.
Special Requirements.—Any application to be suitable must fulfil four requirements: It must permit of easy nursing; it must ensure absolute rest to the spine; the apparatus when applied should provide a certain degree of hyperextension of the vertebral column; if double extension is necessary, the splint must be of such a kind that extension apparatus can be easily applied to it. Each type of apparatus will now be examined in detail.

Bed specially adapted to Recumbency.—There are patients who refuse to allow any treatment which is associated with the application of splints, and yet are quite willing to undergo recumbency as long as it is carried out in bed. For this reason, and occasionally for that of expense, it becomes necessary to fit up a bed in such a way that the treatment is possible. The bed employed must be a narrow one, as it facilitates the nursing; and it ought to be provided with wheels in order to permit of the patient being wheeled into the open air.

It is essential that the patient should lie upon a firm, unyielding surface, otherwise sagging of the spine and increased deformity will occur. A suitable surface is provided by placing beneath the mattress an ordinary broad fracture board. The usual head pillows must be removed, but two small oblong pillows ought to be attached to the sheet in such a way that they lie one on each side of the vertebral column, opposite the kyphosis. A simple ring pad may be allowed, to prevent pressure upon the back of the head, but there must be no employment of air or water cushions.

The position of the patient in bed is a matter about which there is difference of opinion. In cervical caries, when extension becomes necessary, the dorsal position is essential, but when disease attacks the dorsal or the lumbar spine, either the supine or the prone position may be chosen. The supine position is the more comfortable, but it may tend to aggravate a deformity. The prone position is certainly uncomfortable, but it diminishes muscular spasm, it counteracts the deformity, and it certainly lessens the congestion of the spine. The clothing worn by the patient is important. Flannel ought to be used, and the garments ought to take the form of nightgowns, which can be put on from the front and button at the back.

Some form of retention apparatus requires to be fitted to the bed. Efficient fixation is given by two broad straps, one passing across the chest at the level of the upper chest, and ringed to fit each shoulder, the other passing at the level of the iliac bones. Both of these straps are made cheaply,
yet quite efficiently, of strong canvas. When they are fastened, the buckles must be upon the under part of the bed, otherwise they are being continually undone by the child. If it is considered desirable to fasten the lower limbs,

![Fig. 38. — Head extension applied for tuberculous disease of the cervical spine.](image)

they are best secured by a simple ring or clove hitch round the ankle, fastened by a strap to the lower posts of the bed. Narrow sand pillows must be

![Fig. 39. — Tubby's spinal pillow.](image)

available in case it is necessary to fix a part, and wooden blocks are required to tilt the end of the bed during extension.

When extension becomes necessary it may be applied as single or as
double extension. When it is applied to the lower extremities, the foot of
the bed is raised to provide the counter-extension of the body. The limbs
are extended by weights passing over pulleys, or by elastic bands fastened
to the limbs and to the foot of the bed. In head extension the upper end of
the bed is raised, and a bridle attached to the head, with straps passing
beneath the chin, below the occiput, and around the forehead. The point
of junction of these straps is fastened upon each side of the head to a weight
apparatus.

*Tubby's Spinal Pillow.*—Tubby has introduced a pillow which is a com-
fortable and useful means of treatment. His own description of the article
is quoted: 1

I have designed and largely used a pillow, which is placed beneath the
seat of the disease and for some distance above and below it. It is convex
from above downwards, and is centrally grooved in the same direction so as to
receive the spinous processes, whilst pressure is made upon the transverse
processes. It is stiffened in the required situations with felt. To each side of
the pillow two pieces of stay material are attached. The upper pieces from
each side are of such a size and so provided with lacing that they can be laced
across the chest, and help to keep the child recumbent. The lower pieces on
each side are fixed by safety pins, or by stitching them to the sheet and mattress
so as to prevent movement or any attempt at turning over. If the pillow itself
is covered with macintosh it is easily cleaned. After a month or so it requires
making up again, as the effect of constant pressure is to flatten it. Its use
prevents deformity in early cases, and helps its recession and sometimes its
disappearance.

This apparatus has one disadvantage in so far as it is difficult to fit it
up with extension appliance. The difficulty which is ex-
perienced in providing exten-
sion on a bed or pillow may
be obviated by using a
*Fisher's Bed Frame,* in which
the extension is carried from
the shoulders, and fixation
at the same time secured.
From the extremities of a
transverse bar, which lies
above the head, two vertical
bars are hinged in such a
way that they extend down-
wards one along each side of
the body; where they pass
beneath the shoulders, leather
loops are attached, through
which the patient's arms are passed; from the transverse bar two leather
or elastic bands extend to the bed rail. It is a cheap and an easy fitting

1 Tubby, *loc. sup. cit.,* vol. ii. p. 140.
appliance, but the degree of recumbency which it induces is insufficient unless it is combined with body bands of some description.

The Double Hamilton Splint. — In out-patient hospital work this is a favourite type of splint, its chief recommendation being the easiness and rapidity with which it can be made, and the comparative cheapness of the completed article. It can only be employed in mid-dorsal and dorso-lumbar disease, and at best it provides but imperfect fixation. Two pieces of wood extend one upon each side of the body, from the axillæ to about six inches beyond the feet. These two lateral halves are fastened together by a transverse bar, which extends between the lower ends at a level just above the heel. The distance between the lower ends of the splint varies, but the most suitable position for nursing is one of slight double abduction. The contact portions of the splint are well padded. The limbs are fastened to it by ordinary roller bandages, the body by means of a binder. The special disadvantages of the splint are its non-control of the upper part of the vertebral column, the posterior sagging of the spine, and the trouble which there is in securing the bandages.

The Double Thomas Splint. — This form of splint is useful, especially
when it is fitted with a support for the cervical spine. The usual pattern can be improved by a few alterations. The ordinary double Thomas hip-splint is made by joining two single splints, united by the chest band above and a cross bar below. In adapting the splint to spinal use, the two vertical pieces are carried in upon each side to near the middle line, so that they lie upon the transverse processes of each side. They end opposite the posterior-superior spines of the iliac bones, where they are attached to a semicircular piece extending outwards upon each side. The ends of this semicircular portion pass down the posterior aspects of the thighs as in an ordinary double Thomas splint. The vertical spinal portions are moulded to fit any kyphosis which may be present. The moulding ought to be somewhat less than the degree of actual bend, as in this way some degree of extension is maintained on the spine. The efficacy of the support is considerably increased by fitting to the body transverse some vertical apparatus which will control the head and neck. The advantages of the splint are the ease with which the patient can be carried about, the degree of fixation which it affords, the continuous hyperextension, and the facility of nursing. Its disadvantages are its expense, and the degree of care with which it requires to be made and fitted. A badly-fitting splint of this type is worse than useless.

Bradford Bed Frame.—The bed frame of Bradford keeps the patient in a horizontal recumbent position. It is a rigid rectangle, usually made of four pieces of ¾-inch galvanised iron gas-piping, screwed into an elbow at each corner; one elbow has a reverse screw to allow of putting the whole together. The width should be equal to the distance between the shoulder tips, and the length a few inches more than the height of the patient. The rectangle is wound with two pieces of cotton sheeting, double thickness, with a four-inch space between the two pieces to permit of nursing. The covers are cut to three times the width of the frame, they are doubled and laced behind with a sail needle and strong cord. Two linen pads are placed upon the canvas opposite the diseased portion of the spine. They exert no pressure upon the spinous processes, but instead they raise and hyperextend the spine. The child wears an undershirt and a cotton night-gown, opening behind.

To prevent the patient wriggling about, he is secured to the frame by two webbing straps, buckled round the frame and across the chest like a
soldier's cross belts, the buckle being on the under surface of the frame. Two loops are with advantage fastened to the canvas in order to secure the shoulders. The pelvis is secured by a broad binder pinned round the frame, and the knees by a towel. No pillow is allowed, or only a flat ring-pad. In attending to the hygiene of the back, the child is laid face downwards, the splint removed, and the back bathed with alcohol and powdered with talc.

In feeding, some difficulty may be experienced at first in the taking of fluids. This can be overcome by using a "feeding duck" or tube. The child and splint can be completely wrapped up in blankets, and there is no danger of catching cold.

This is a most excellent form of splint; it is comfortable, cheap, and efficacious. It is suitable for a lesion in any part of the spinal column, and if extension becomes necessary, this can be easily adjusted to either end.

Whitman Stretcher Frame.—This is very similar in character to the Bradford frame, but it carries out a continual hyperextension. It is much narrower, and it is bent so as to lie convexly upon the back opposite the kyphosis. It is made of iron gas-piping, and while it is about six inches longer than the child, it is of such a breadth that the sides of the frame lie
opposite the glenoid cavities and the acetabula. The cover is a single piece of stout canvas, laced posteriorly from end to end. Upon the canvas felt pads three-quarters of an inch thick are sewed, so as to press upon either side of the spinous process at the level of the deformity.

The patient is fastened to the frame by an apron, which extends over the abdomen and the lower chest, and is fastened by buckles to the under surface of the canvas upon each side. At first the frame is bent slightly opposite the angulation on the spine. The bend is increased each day until the deformity and the physiological dorsal curve have become obliterated. When the frame is sufficiently arched, double traction is exerted by the weight of the head and the legs.

The child should be clothed in a cotton under-vest, but the outer garment should include both the frame and the child.

The splint possesses all the advantages of the Bradford frame, and in addition it possesses the benefit of keeping up a continual hyperextension. It is perhaps less comfortable than the Bradford frame on account of its narrowness, and the uninterrupted stretch of canvas makes the nursing slightly more difficult.

The Plaster Bed.¹—A plaster shell is fitted to the back, and in it the patient is kept recumbent. To make it, an ordinary hammock is arranged, and upon it the patient is laid face downwards. By adjusting the hammock screw the spine can be hyperextended to different degrees. When the hyperextension is suitable, the patient’s skin is well oiled, and the hair protected with linen pads. Plaster bandages are applied evenly over the back, from the top of the head to half way between the gluteal fold and the bend of the knee. It is advised to apply five layers of bandages running parallel to the long axis of the body, three layers extending radially from the deformity, and two layers

¹ Hoffa, Lehrbuch der orthopädischen Chir., p. 313.
to the sides of the bed in straight longitudinal turns. The shell is completed by numerous cross turns, binding the whole fabric together. Weak points are strengthened by incorporating strips of aluminium, wire-gauze, or cotton padding wrung out of plaster cream.

When the case is well hardened it is lifted off, and the patient's back washed and dried. The walls of the plaster bed are carefully smoothed and cut away from the arm-pits. The case is then thoroughly dried, and varnished outside and inside with shellac. When it is thoroughly dry the interior is lined with padded muslin, stork linen being specially fitted to the portion over the buttocks. The patient is secured in the bed by circular turns of bandage.

The above is the simplest method of making the plaster bed, but it possesses one disadvantage. When the plaster is moulded directly to the skin, it allows of no after-contraction in the plaster, and when the bed is completed, it may be found that it fits so tight as to be distinctly uncomfortable, more especially when the thickness of lining is added. It is therefore preferable to first take a plaster cast of the entire back. Plaster bandages are applied directly to the oiled skin, and carefully moulded to the anatomical irregularities. When the casing is hard it is removed, and the inner surface having been well oiled, a positive is taken either by filling the shell with plaster or by means of a layer of plaster bandages. When the positive is thoroughly dry, its size is increased by covering it evenly with a thin layer of plaster of Paris about one-quarter of an inch in depth. Upon this the plaster bed is moulded as described above, and there is now no risk of a misfit.

This appliance gives perhaps the most complete and absolute recumbency of all others, but it possesses many disadvantages. Its manufacture is difficult, tedious, and uncertain; although one would expect it to be comfortable, it is as a matter of fact most irksome; it is readily broken; and its weight is a distinct drawback.

It is difficult to apply traction, but it may be done by cutting away the head portion, and using head bands with weight and pulley. A jury-mast may be used, the upright being incorporated in the wall of the plaster bed.

Helbing strongly advocates the use of the plaster bed during the active stage of the disease. He considers it excellent in the treatment of very young children, and he continues it for one to three years.

Phelps' Bed is made in a slightly different way. A thin board is cut to the outline of the body and the extended legs. It is padded with wadding and covered with cotton cloth. The patient is placed upon it, and plaster bandages are applied to encase the body and the legs. Later the front is cut away so that the patient may be removed from the bed.

1 Helbing, Berlin klin. Wochenschr., Nov. 13 and 20, 1905.
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Gauvain's Spinal Board.—This is a modification of the board used at the Maritime Hospital, Berck-sur-mer. It has been modified by Gauvain of Alton, and his description of the apparatus is quoted:

The board consists of an oblong tray made of strong but light wood. The length should be from 12 to 18 inches longer than the patient, and the width about 8 inches greater than his greatest width. The sides of the board are about the same height as an ordinary Phelps' box, roughly 3 or 4 inches, with the exception of the foot end, which is raised to a height of from 15 to 18 inches, and thereby takes away from the patient's feet the weight of the bed clothes, and tends to prevent the onset of foot drop. The bottom of the board is perforated with numerous holes to admit ample ventilation of the mattress. The corners are bound with sheet-iron angle pieces. . . . Across the board is placed a piece of wood of suitable height, usually 2 to 3 or 4 inches, and of almost the same width, which stretches from one side of the board to the other, and is designed to be placed immediately under the most prominent part of the angular curvature. It is fixed by means of two iron pins, which serve a double purpose. (1) To retain the cross-piece in position; (2) To indicate at a glance where on the patient the angular curvature is.

A firm pillow, if fixed, forms a suitable substitute for the wooden cross-piece, a well-prepared horse-hair mattress occupies the tray over the cross-piece, and on it the patient reclines. At the head and foot ends of the board are slits cut for the hands to facilitate transport. At the head end of the board two pieces of strong elastic webbing, 1 inch wide and about 6 inches long, are attached, and to them a bridle can be buckled when head extension is desired.

At the foot end . . . are two longitudinal slits, through which the cords of a leg extension can be passed over a suitable pulley. This pulley is fixed to two perforated, upright pieces of wood, attached to the board on each side of each longitudinal slit, and these are so arranged that between them an upright extension rod can be arranged if there is much flexion. . . . The patient is fixed to the board in a simple and effective manner. A jacket composed of stout jean, fitted accurately to the body and preferably stiffened with whalebone, encases the patient. On the back of the jacket two strips of webbing are let in, which strips cross each other as a St. Andrew's cross, and these are buckled to the sides of the board, and effectually prevent the patient from moving in any direction, and keep him in the exact position which has been decided upon as desirable. The jacket should be laced and buckled over the front of the patient.

This splint has many advantages: it is simple, light, efficacious, and convenient. It possesses two disadvantages: the first is the tendency

1 Menard, Étude pratique sur le mal de Pott, Masson et Cie, 1900.
towards the development of pressure sores, the second is the liability for the jacket to loosen, permitting movement which depreciates its value.

Gauvain's Back-Door Splint.—The great majority of splints have the common disadvantage that if they are to be efficacious in controlling the spine, there will result a corresponding difficulty in attending to the hygiene of the back. To overcome this difficulty, Dr. Gauvain has introduced what he calls the back-door splint. The original description of it is quoted:

Measurement of the Splint.—The patient is stretched on his back on a piece of paper, the head is held by one assistant and the legs by another, and the contour of the trunk is traced out. The splint should be a shade smaller than the contour of the trunk. The bottom of the splint should be just above the natal cleft. The tracing is then cut out and a piece of beech-wood cut to exactly a similar size. Well-seasoned beech is especially chosen, because experiment has shown that it is very strong, that it does not warp readily, and it has the additional advantage of being cheap. The outer part of this is cut away 1 inch from the periphery all round, forming an outer frame. This is covered with sheet-iron screwed to the frame, and forms a strong and rigid framework. The iron is then lacquered to prevent it rusting when subjected to the heat and moisture of the body. The inner part or back door, which fits into the outer frame accurately, is pared down a little so that it can be removed and replaced with great ease, and is perforated with holes for a double purpose—both to ventilate and to assist in fixing the padding which is later to be applied to it.

The Padded Outer Frame and Back Door.—The outer frame is padded evenly all round, but especial care must be taken in padding that part which will come in contact with the sacrum. The padding should be perfectly even, and the best material to employ is animal wool, because this never cakes, and has a springiness and elasticity which make it peculiarly suitable for this purpose. The padding is firmly bound down to the splint by splint linen, and should be covered on the lower part with jaconet to prevent it being soiled or saturated if the patient is not able properly to control his evacuations. The back door has on the lower aspect a suitable handle, which facilitates its introduction or removal from the outer frame. It is kept in position by four small clips, which are attached to the outer frame. The surface of the back door next to the body is also padded thickly with animal wool, and this padding should be especially thick and firm at the site of the disease, so that due hyperextension of the spine may be obtained. It will be found convenient to use tape in the fixing of the splint lining instead of ordinary thread, as with the tape the padding can be made more secure and much more durable. The patient is fixed on to this splint by means either of a jacket or by webbing. Webbing is simpler to apply and is
better in warm weather, but the jacket is neat, and gives the apparatus a more finished appearance when in use. If a jacket is employed it will be found most convenient to attach it to the outer frame on its inner side, and the jacket should be made in two pieces, each in duplicate, so that should it become soiled the soiled portion can be immediately removed and replaced. In any case it would be desirable to remove the jacket at intervals so that it may be cleaned—about once monthly is commonly sufficient. To facilitate the removal, it will be found convenient to employ patent placket fasteners. By the use of these the jacket can be removed with the greatest ease and speed, and be instantly replaced. The jacket should be strapped and laced over the front of the patient, as in the manner described previously. Should webbing be used in place of the jacket, a piece of webbing should come over each shoulder. Two pieces should come round the trunk, and all should be fixed to the inner side of the outer frame of the splint. They should be buckled appropriately on the front of the trunk. It will be found that by employing a splint of this nature the patient's back can be attended to without the patient being moved, and with the very greatest ease.

![Fig. 52. — Gauvain's posterior suspensory splint.](image)

When extension becomes necessary it can be arranged. For head extension a simple bridle may be employed, or the outer framework of the splint may be prolonged on each side of the head to terminate in an upright iron bar, to which the bridle is attached by elastic extension. In dorsal or lumbar disease, extension is obtained by swinging the patient in his splint, so that the head and the lower extremities are gradually dependent. The same result may be obtained by mounting the outer frame of the splint upon short legs, the head and the legs being dependent.

*The Wheelbarrow Splint.*—When there is spinal disease associated with spasm of the psoas muscle or with a psoas abscess, Dr. Gauvain has introduced what he calls "the wheelbarrow splint." The back-door splint, already described, is made, and supported upon four short legs. The patient's legs are attached to posterior splints, which are fixed to the splint frame by special hinges which permit of abduction, adduction, and hyperextension, but no degree of flexion, inversion, or eversion. When it is desired to apply extension to the lower limbs,
small wooden foot-splints are fastened on, and the extension strapping is fastened directly to them. In this way the entire weight of extension comes directly on the splint. Head extension may be applied by means of a bridle.

*Phelps' Box.*—This is a good splint for use among the poorer class of patients. It is best understood by reference to illustrations. A shallow wooden box is made to fit the patient's entire stature, both legs being slightly abducted. The required shape is cut with a fret-saw from a flat piece of beech wood, and boards of sufficient depth are screwed to the sides. Lateral slits are cut to accommodate the shoulders. The box is lined, and a cushion is fixed to the bottom opposite the situation of the spinal prominence. At each of the upper angles of the box curved steel supports are fastened, and to these supports a chin strap is secured. It is impossible to apply extension to the lower limbs.

**Recumbency in Application to Special Regions.**—*Cervical Region.*—
Disease in the cervical spine has two peculiarities, which render the choice of recumbent splints rather limited. These peculiarities are: (1) The difficulty in properly fixing the head and neck; (2) The necessity in many cases of applying extension.

The patient may be kept in a bed prepared for recumbency, but special
precautions must be taken in regard to the head and neck. If head extension is in use, it is sufficient to fix the head laterally by two heavy sand-bags, placed one on each side of the head. Around the sand-bags a towel is rolled, and passed across the forehead. If no head extension is applied, a special sand-pillow is used, shaped like a U. The transverse part of the U is about 2 inches thick, and it lies against the nape of the neck. The limbs of the U are much larger and heavier, being about 6 inches in depth; they lie one on each side of the head; a narrow towel is fastened as before round the limbs of the sand-bag and across the forehead.

The Bradford frame, the Whitman frame, and Gauvain’s spinal board are excellent for use in cervical disease. In each of these the head and neck is partially controlled, and extension can be readily applied. Phelps’s box is useful, and also the plaster bed, if it is made to include the head and neck; but the usefulness of both is lessened by the difficulty in fastening extension apparatus.

Dorsal Region.—When expense has to be avoided, a dorsal lesion can be excellently treated in bed. For out-patient work the spinal board and the Phelps’s box are very suitable, because they are the easiest in transport. In private work, where expense is probably not so important a consideration, one frequently advises a Bradford or a Whitman frame, the latter when the symptoms are urgent. Gauvain’s back-door and wheelbarrow splints require a considerable amount of manipulation and attention, and for that reason one uses them most frequently in hospital cases, where good nursing facilities are always at hand.

Lumbar Region.—Owing to the tendency which lumbar disease has to be associated with psoas spasm and flexion of the thigh, one is careful in recommending a splint for this region to choose one in which extension can be readily applied. Otherwise one is guided by much the same principles as hold good in the dorsal region of the spine.

Duration of Treatment by Recumbency.—It is essential that recumbency must not be given up until the disease in the vertebrae has ceased to spread, in other words, until the process of cure has been begun. In point of time, one knows that this never occurs in less than one year, and in all probability the greater part of two years has elapsed before signs of commencing cure are apparent. Complete recumbency must therefore
continue for at least one year, or preferably for a year and a half. At the end of that period, if the signs are favourable, the ambulatory treatment may be begun. There are certain indications which one assumes as favourable to the commencement of the ambulatory stage. 1. All pains, local or referred, must have disappeared. 2. No deformity should be present, or if such existed before the treatment was begun, the degree of kyphosis should not have increased. 3. The evening temperature must have remained normal for some months. 4. The child becomes restless, and is perpetually making efforts to get up. 5. The weight has increased. 6. On examination of the back, it is found that the situation of the disease is firm and unyielding. If it is decided that the conditions favour the commencement of the ambulatory stage, it must be remembered that it is unwise to allow the patient immediately to assume the vertical position. He has been so long in the horizontal position that any sudden change to the vertical is associated with considerable changes in blood pressure, and if these facts are not borne in mind, alarming symptoms may develop when the patient is suddenly set upright. He should therefore be gradually raised upon his couch to the upright sitting position, later he is allowed to walk about, at first for a few minutes only, the time being gradually extended. He must never be allowed to assume the vertical position without wearing some form of spinal support.

Gauvain has overcome the difficulty of gradual elevation by using a stand in which the patient may be placed in any position or angle. His original description is quoted:

The essentials in this stand are that the patient at will may occupy any position, either horizontal or vertical, or at any intermediate angle. This alteration is very simply effected by merely turning a handle, which governs a screw fitted into the cogs of a semicircular piece of brass, which will be seen attached to the under-surface of the spinal board. The patient when tilted in this way should have, at any rate in the case of an adult or large child, additional support to that given by the jacket before described, for while this jacket alone will hold him firmly, yet without other assistance it may cause him undue and unnecessary discomfort. It will therefore be found desirable to have two pieces of webbing passing longitudinally down the board from the head end and let into the back of the spinal jacket on either side of the spine. These pieces are continued under

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FIG. 57.—Gauvain’s apparatus for the gradual assumption of the vertical position.
the crutch, and are there padded with a small pad of animal wool and covered with jaconet, and this pad is so adjusted that it will press on each of the tuber ischii. The webbing continued from the crutch passes over the front of the patient, and is strapped to the board on each side at about the level of the nipple. This simple contrivance will effectually and comfortably support the patient even in the vertical position, and will not in any way bring undue pressure to bear upon his spinal lesion provided he has in the first place been so placed on his board that the spine is sufficiently hyper-extended. In many cases it is permissible to allow the patient to rest on a seat, which can be suitably adjusted to the spinal board. This is permissible when there has been no spasm of the psoas muscle, or when there have been no complications, such as gluteal abscesses. It will be at once seen that when the patient is in this position he has the great advantage of seeing surrounding objects with ease, and when a suitable book-rest is adjusted to the board he can read and feed himself with comfort in the natural position. Such a contrivance will be found of the very greatest service to these patients, who are so helpless and so debarred from simple pleasures and conveniences, and it will be of particular value in the case of children, who can thereby continue their education within reasonable limits without in any way complicating or interfering with the treatment which is being applied. It will be noted that this tilting stand is mounted on wheels, and can easily be wheeled out of the ward or room into the open air, and in fact can be wheeled anywhere as easily as could a bath-chair, and the delight which this possibility of change of scene gives to the child is of value and assistance in the treatment. He can be conveniently and expeditiously removed out of doors and attended to throughout the day, and this in itself is, as will be readily seen, of the greatest value.

B. Ambulatory Treatment.—This term is applied to the course of treatment when the patient is allowed to go about, his spinal column being supported and stiffened by some type of apparatus. The various forms of appliance are described as spinal supports and head supports.

Characteristics of efficient Spinal Supports.—It is a matter of regret that in the making of these supports instrument dealers too often neglect the very points which ensure successful treatment. An appliance which comes short of certain necessities is a useless encumbrance. A serviceable support must fulfil the following conditions:

(1) As its principle is to exert a considerable amount of pressure upon the spinal column, it is essential that there shall be a fixed point from which this pressure can be exerted. This fixed point is usually obtained by an accurately fitting pelvic band.

(2) The pressure brought to bear upon the spine should be exerted along the transverse processes of each side.

(3) The support must be of such a kind that it does not compress the lateral chest wall, and so interfere with the healthy respiratory movements.

(4) In dorsal and in lumbar disease the posterior pressure on the spine must be counterbalanced by support given to the chest in front. If this is not provided, the pressure exerted upon the spine behind is simply accommodated for by a compensatory anterior enlargement of the chest or abdomen.

(5) If the disease is situated above the tenth dorsal vertebra and below the level of the eighth, the support must extend above and in front of the
shoulders; if it lies above the level of the eighth dorsal vertebra, the head and neck must be included in the support.

*Indications for Ambulatory Treatment.*—Briefly it may be said that ambulatory treatment is indicated when the active stage of the disease is ended, when there is no indication of a further extension of the disease, and when there is a reasonable prospect of the diseased spine becoming completely cured, if it is efficiently immobilised.

**Spinal Supports**

**The Plaster Jacket.**—One has no hesitation in saying that a properly applied plaster jacket is the most effective immobiliser of the spine which we possess.

*Advantages and Disadvantages.*—Many arguments have been urged against it: its efficacy has been doubted; it is said to be unsuitable for children; its weight has been condemned; it is said that if it is applied sufficiently accurately to be of any real value it must of necessity interfere considerably with respiration and digestion; and finally it has been objected to as insanitary. Most if not all of these charges are groundless. When properly applied, the spine can have no more efficacious support, because the plaster can be so accurately moulded to the spinal outline. Its use in children has been opposed, because the pelvis is said to be so insufficiently developed that a proper purchase cannot be obtained. As a matter of fact the jacket can be fitted to a child's pelvis just as efficiently as to that of an adult. The weight depends entirely upon the amount of plaster used in making the jacket. As the operator's skill increases, the amount of plaster required to give fixation is lessened; and when the support is completed, its weight can be greatly reduced by cutting out anterior and lateral windows. By the removal of windows the objection of impeded respiration and digestion is removed. The argument of the jacket being insanitary has some foundation. It should not therefore be employed in the poorer class of out-patients, but rather in those whose cleanliness can be trusted.

*Indications.*—The cases which one considers as favourable for treatment are those which have reached a degree of cure permitting ambulatory methods, which are physically strong, and which have the privileges of conscientious parents and good homes.

The situation of the disease matters little. It is of course easier to apply a plaster jacket for low dorsal disease than one for cervical disease, but both can be applied to act equally well. The presence of a sinus or of an abscess is not a contra-indication, if it is possible to cut a window in the jacket in such a position as to give free admission to the part.

*Method of Application.*—The method of making plaster bandages has been detailed. It remains to describe the technique observed in the application of a plaster jacket.

*Gauvain's Method.*—The patient has been educated to assume the vertical
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position until he is able to stand upright without any danger of syncope occurring. The skin is carefully cleansed and powdered, the bowels are thoroughly emptied, and food likely to cause flatulence is avoided. A closely fitting vest is applied to the patient’s body, and over the epigastric region, beneath the vest, a pad of cotton wool is placed, so that if distention should occur before a window is cut out no discomfort will ensue. The lower part of the vest is pinned in the perineum. If the cervico-dorsal or cervical spine is diseased, the vest is carried upwards as far as the occiput, and this is best done by using a vest with a specially long neck, which is drawn over the head and pinned above. A diagonal window is cut out opposite the nose, and when the window is stretched the patient can see and breathe.

The patient is now ready for suspension. A bridle specially made for each individual case is fitted to his head. The bridle is made by tying an ordinary knot in a 2-inch calico bandage 4 feet long. The knot is tied in such a way that there is a free loop. The knot is placed immediately above the right ear. One limb of the bandage is now passed beneath the chin and the second limb beneath the occiput, and both are tied above the left ear. One end of the bandage is passed through the loop left from the knot upon the right side, and the free ends of the bandage are firmly tied. The patient is suspended from a gallows by the bandage passing across the top of the head. By altering the situation of the knots the position of the head is changed; the more anterior the knot the more extended does the head become, the more posterior the knot the more flexed the head.

The patient is suspended to such a degree of extension that the heels are off the ground, and he rests entirely upon his toes. He acquires a certain amount of support by holding adjustable pegs fixed to the sides of the gallows. The bandages are now applied, those 6 inches wide are employed, and each bandage is wrung out of cold water. The operator stands in front of his patient and an assistant behind. The free end of the bandage is applied below the crest of the ilium upon the right side, and the roller is unwound, covering in the body from below upwards. At least once in each circuit the bandage is pleated by doubling it backwards in its course for about one inch, and then proceeding as before. Pleating has a double advantage—it allows the jacket a comfortable degree of yield before it actually sets, and after a pleat is made, the bandage can be carried in any desired direction. No reverse must be made. After each circuit the bandage is gently rubbed into the turn lying immediately beneath. When the patient’s trunk has
been efficiently encircled, and usually three 6-inch bandages are sufficient for the purpose, the technique of moulding to the pelvic bones is proceeded with. This is carried out very carefully, and the secret of the success of the method is to avoid all pressure upon the bony pelvis, but to centre one's pressure upon the soft parts immediately above. When this is complete the shoulders are incorporated in the bandage. They are pressed well back, and a bandage is passed backwards and forwards above them until sufficient support has been gained. The cross bandages are held in position by circular turns passing below the axilla.

The system of moulding is now applied above and below the clavicles. The neck is encased by successive turns of the bandage, and in each circular turn at least two pleats are included. The bandage passes from the neck, around the head, under the chin, and under the occiput. It is carefully moulded under the chin, under both mastoid processes, and beneath the occiput. When the jacket has hardened sufficiently, windows are marked out; they are not, however, cut until the second day after application of the plaster. A large window is cut out in front to allow free respiration and digestion, and if there is any angulation of the spine, a window is cut out over
it. The plaster is cut away around the head, below each ear, and in its lower part, to allow free flexion of the thighs. The plaster is cut with a small, strong penknife, the blade of which is continually moistened with water, and when the various windows have been cut and edges trimmed, the vest is turned back over the plaster, and fastened securely around by a layer of plaster cream. The whole surface of the jacket is afterwards covered with a thin layer of plaster made up in 3 parts of water to 5 parts of plaster.

When the jacket extends so high as to be below the jaw, the mastoid, and the occiput, the name "Minerva" is applied. It has the disadvantage that it interferes with mastication, and in eating the patient has to keep continually throwing his head back. To overcome this difficulty, and the further one that it interferes with the development of the lower jaw, Gauvain introduced the type of jacket which he calls "the Fillet." It will be understood on reference to the illustration. While the head portion is moulded carefully to the mastoids and the occiput, the anterior portion does not come into contact with the lower jaw. Fixation is gained instead by carrying a narrow band of the plaster around the forehead in such a position as to keep the head extended.

The Hammock Frame Method.—In this method the jacket is applied with the child lying prone upon a strip of cloth, the cloth being attached to a frame by which it can be tightened or loosened at will. The cloth or hammock is made from cotton sheeting. It is double the width between the iliac spines, and it is some inches longer than the child. In use it is doubled, and a wide hem made at each end. The frame is a parallelogram of 1-inch galvanised iron piping. It usually measures 6 feet by 2 feet, and it is fixed in such a position that the upper end is 6 inches higher than the lower one. At the upper end of the frame there is a transverse iron rod attached to the upper end by two S hooks. At the lower end a bar stretches across the breadth of the frame, and the bar can be revolved by turning a winch handle at the side. A ratchet is provided to control the amount of reverse move-
ment of the bar; near the centre is a second bar, similar to that at the upper end.

The hammock is attached to the frame by passing the two transverse bars through the hems in the canvas. The upper bar is fastened to the frame by its screws, the lower bar is connected with cords to the ratchet bar at the extreme lower end of the frame, and by manipulating the screw handle the hammock can be loosened or tightened at will. The child is placed upon the hammock face downwards, and the screw is loosened sufficiently to produce the requisite amount of lordosis. The arms of the child grasp the top bar of the frame, and additional support is given by broad webbing straps which pass across beneath the upper chest and the knees.

The child's trunk is clothed in stockingette, and padding is adjusted to protect the sacrum, the crests of the ilia, the sternum, the clavicles, and the axillae. Felt pads are placed upon each side of the deformity. The plaster
bandages are applied below and to include the point of deformity, and when 
the plaster has set the hammock is further loosened. There is a corresponding 
sagging of the body, but as the lumbar spine is fixed in the plaster which has 
been already applied, and cannot therefore bend further back, the pressure 
is exerted upon the deformity, which improves in degree and may even 
disappear. In this corrected position the application of the jacket is com-
pleted. When the jacket has hardened, the child is removed from the frame 
by cutting the hammock cloth above and below—the cloth of course being 
retained as part of the jacket.

The advantages of this method are the comfort of the child during 
application, the absence of any tendency to syncope, and the correction by 
hyperextension which can be obtained.

The Goldthwait Method.—Goldthwait uses a frame very similar to that 
employed in the hammock frame method, but instead of the patient being 
prone he lies on his back. The frame is, as before, a gas-pipe frame measur-
ing 6 feet by 2 feet. Suspended from the frame there is a cross bar from 
the centre of which rises a vertical bar, forked at the top and extending 
upwards to a level with the frame. The position of the cross bar can be 
altered at will, as it is suspended from the frame. A simple transverse bar 
rests on the frame lower down, the distance between the two usually being 
about 16 inches. Upon the vertical fork above and the transverse bar below 
rest two malleable steel bars about 18 inches long. They are fixed in grooves 
about 1 inch apart, and they are moulded to conform with the curve of 
the lumbar spine. The patient is clothed in a vest of stockingette, and laid 
on the parallel steels, which are specially padded with thick felt.

When the patient is in position the upper ends of the bars project one 
inch beyond the deformity, while the buttocks lie opposite the lower cross 
bar. The legs are supported by bands of webbing, which pass beneath 
them and can be tightened at will. At first the head is supported by the 
operator's hand, and allowed to sag until the spine is sufficiently hyper-
extended. The head is then supported by a broad band of webbing, and the 
plaster jacket is applied with the steel bars inside it. After setting, the 
patient is lifted off the frame and the bars slipped out. The jacket is 
trimmed in the usual way.

Brackett's Method.—Brackett uses a frame in which the patient lies on 
his back. The patient is supported at the kyphosis by two short metal plates 
which impinge one on each side of the middle line. These plates are padded 
with felt, and they can be raised or lowered at pleasure by a Y-shaped support. 
By elevating the plates the deformity is gradually corrected. When the 
jacket is applied the plates remain inside it. The head is supported upon a 
series of parallel transverse bands which can be tightened or loosened at 
will, while the feet rest upon a board.

Lovett's Method.—Lovett also employs a frame. The patient lies on his 
face on two broad straps of webbing, with one cross strap at the trochanters, 
and one at the level of the forehead. The upper part of the frame is made 
double and hinged so that it can be raised at will. The first part of the
jacket is put on below and up to the level of the deformity. It is applied with a straight lumbar spine, and this is secured by having the patient’s body resting upon the frame straps while his legs hang down. When the first half of the jacket has hardened, a thickly padded webbing strap is tied across the child’s back opposite the deformity. The hinged front half of the frame is raised, and a corrective pressure is exercised by the webbing upon the kyphosis. In this position the application of the jacket is completed.

![Fig. 64.—A modification of the Brackett apparatus for applying a plaster jacket.](image)

**Metal Braces**

**The Taylor Brace.**—In 1863 C. F. Taylor published a description of a brace which was intended to oppose forward movement of the spine. With certain minor modifications this splint is still largely used. The brace is made of steel, and it consists of two uprights, a base, two shoulder-pieces, and one or two cross bars. The uprights are two vertical bars of malleable steel, \( \frac{1}{8} \) inch thick and \( \frac{1}{2} \) inch wide, which lie one upon each side of the middle line over the transverse processes. They are curved to fit the outline of the spine with the patient lying down, and in length they extend from the seventh cervical spine to 1 inch below the posterior-superior spine of the ilium. The lower ends of the uprights must pass between the posterior-superior spines, and yet leave an interval of \( \frac{3}{4} \) inch. If the child is so small that this is impossible, the uprights must then end at the horizontal part of the brace. Opposite the deformity in the spine, each upright has attached to it a thin steel plate \( \frac{1}{4} \) inch wider than the upright, and curved to fit the back from above, downwards and laterally. These plates are made of spring steel No. 22 gauge. They should be perforated around the free border to allow a pad to be stitched in place, and if they are intended to exert special pressure upon the spine, they are carried forward some distance in front of the upright. The bottom piece or base may vary in shape; usually it takes that of an inverted U. The transverse portion crosses the lower part of the back, above
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the sacrum, and to it the lower ends of the uprights are attached. The
inverted limbs extend downwards on each side, two finger-breadths within
the inner side of the trochanter, and end above the ischial tuberosities, so
that they do not interfere with sitting. Each free end is provided with a
circular leather-covered pad. The shoulder-pieces are separate pieces,
each \( \frac{3}{4} \) inch wide and \( \frac{1}{16} \) of an inch thick, attached behind by
rivets to the upper ends of the uprights. They are first bent outwards
on the flat at an angle of 45 degrees, and then they are bent over so as
to conform to the outline of the root of the neck. In front they end at the
dge of the trapezius muscle. The cross bars are usually two in number;
the upper one is attached just below the pos-
terior border of the axilla, the second one
lower down. They are \( \frac{3}{4} \) inch wide and \( \frac{1}{16} \)
inch thick, they are a little shorter than the
breadth of the trunk, and they are fastened
by rivets to the posterior surface of the up-
rights. For fastening the brace to the body
buckles are used. These are 1 inch wide, and
they are secured by copper rivets. Buckles
are fastened to each of the tips of the \( \cap \),
one to each corner, and one to the end of
each cross bar. To the extremity of the
shoulder-piece a webbing strap 1 inch wide is
riveted. The front of the body is covered
with an apron of stout drilling or canvas.
In width it extends from one posterior axil-
ary line to the other, ending above at the
axilla and below at the symphysis pubis.
The corners of the jacket are cut away so
that they do not interfere with flexion of the
thighs or movement of the pectorals. If the
apron is stiffened at the sides by bones there
is less liability to crinkling. The edges are
hemmed, and to them, webbing straps are
fastened which are attached to the buckles on
the brace. Webbing straps are fastened one on each side about an inch
above the lower end of the jacket. They pass across the perineum, and are
attached to the buckles at the tips of the \( \cap \)-shaped base. In this way the
tendency of the brace to slip upwards is prevented.

If in association with Pott’s disease the shoulders are displaced
forwards, it becomes necessary to attach a Taylor chest-piece to the
ordinary brace. This consists of two triangular pads of hard rubber, made
to fit into the chest wall beneath the clavicles, and joined to one another
by a jointed bar of iron, which can be shortened or extended at will. The
pads are attached above by straps to the shoulder-pieces and below to the
extremities of the upper cross bar. When the caries is situated higher than
the seventh dorsal vertebra, a Taylor head support is added to the brace. This is described later.

Whitman recommends that if there is no deformity when the brace is applied, the uprights ought to follow exactly the spinal outline. But if there is an existing deformity, the uprights should be made somewhat straighter than the curve of the kyphosis, so that a corrective pressure is exerted.

The brace has many advantages to recommend it: it acts as a most efficient spine immobiliser and it is light. As the child grows the brace can be easily altered to suit the requirements of increasing girth and height. The objections which have been urged against it are few and unimportant. It is said to be uncomfortable, but the discomfort quickly lessens and eventually is unnoticed. Pressure sores are said to have been produced, but with care and attention to cleanliness they should never occur. Perhaps the only real objection is the difficulty which there is in obtaining an accurately fitting brace. The apparatus requires to be made with great care, as its efficacy entirely depends on its correct fit. It ought to be made directly under the surgeon's supervision and guidance.

Schapp's Brace. — Schapp criticises the types of spinal support, and describes a modification of the Taylor brace which is worth attention. There is a flat steel band, which crosses the abdomen as low as possible without being displaced by the thighs when the patient sits, and extends closely around the sides of the pelvis and downwards for 2 or 3 inches. It is then connected with the horns of a posterior hip band by straps. The pelvis is actually clamped between the bands. The anterior-superior spines are protected by pads of kersey and leather, and the middle portion of the front band is arched forwards, so that when the patient is supine there is a space behind it of 1½ inches or more. This will be filled by the abdomen when the patient stands. At the location of the anterior-superior spines, flat uprights are riveted at right angles; they reach nearly to the top of the chest, and at the level of the axilla are crossed by a flat band extending round the sides of the chest and nearly meeting.

Davies' Quadrilateral Brace. — Taylor's brace, while it prevents antero-posterior movement of the spine, does not prohibit a certain degree of lateral movement. Davies' brace was designed to combine the action of a back brace with that of a side support. It consists of a base or pelvic band, two uprights, a top bar, and a pad plate bar. The pelvic band is made of No. 15 gauge cast-sheet steel. It is moulded to fit the back just above the trochanters, and in front it ends behind and slightly below the anterior-superior spines. Its ends are usually joined in front by a strap of webbing. The uprights are made of No. 12 gauge flat steel. They are half an inch wide, and they are riveted to the pelvic band, one on each side, about one inch beyond the posterior-superior spines. They end a finger-breadth above the spines of the scapulae, they follow the curves of the flanks, and when the shoulder- straps are tightened they exert most pressure upon the posterior

1 Schapp, Medical Record, Sept. 9, 1905.
surfaces of the scapulae. The top bar passes across the upper end of the chest. In length it is equal to the distance between the glenoid cavities, when the shoulders are pressed back. Its ends are bent downwards to a right angle, and they are riveted to the upper extremities of the uprights. The pad plate bar is a horizontal bar of half-inch flat steel, No. 14 gauge, which is fastened to the uprights by screws opposite the kyphosis. At its centre the bar is bent into a semicircle, convex backwards. In order to avoid pressure upon the spinous processes, and just before the bend begins upon each side, pad plates are attached. These pad plates are made of No. 18 gauge steel, they measure \( \frac{3}{8} \) inch by \( 3\frac{1}{2} \) inches, they are fixed with the long axes vertical, so as to press directly upon the transverse processes. The pad plate bar is not fastened with rivets, but with slots and adjustable screws, so that the position of the pressure of the pads can be altered at will. The front of the body is covered with an apron of soft leather \( \frac{1}{8} \) to \( \frac{1}{8} \) of an inch in thickness. It extends from the level of the ensiform cartilage to the symphysis pubis in the middle line, and 1 inch below the anterior-superior spines laterally. Webbing straps from the apron are fastened to buckles on the brace. These buckles are attached at each upper corner—three at intervals along the sides of the uprights, and one at each end of the pelvic band. The special head support for attachment to this brace is described later.

Thornton's Back Brace.—This brace is most suitable for use in Pott's disease of the lower dorsal and dorso-lumbar spine. The advantages claimed for it are those of secure fixation and the encouragement of free chest and lung expansion. It is composed of a base-piece, two uprights carrying pad plates, cross bars, and a shoulder-piece. The base-piece is shaped like a...
widely separated V. It covers most of the sacrum, and laterally the limbs extend outwards just below the iliac crests to a point behind and below the anterior-superior spines. The uprights are placed in exactly the same position as in a Taylor brace, and opposite the deformity pad plates are used. The lower cross bar is attached just above the iliac crests, and it is moulded to the curves of the loin. The upper cross bar is placed below the tips of the scapulae. The uprights are riveted above to a steel plate, V-shaped. The size at the apex is equal to the distance between the uprights, while above the limbs are 3 or 4 inches apart. At the extremities of this plate L-shaped steel pieces are loosely riveted. The vertical limb of the L runs outwards to the glenoid cavity, then there is the angle, and the horizontal limb passes vertically downwards to the lower fold of the axilla and curves slightly forwards. From the angle of the L to the end in the axilla a buckling strap passes, and in front of the body there is an apron of leather or cloth, extending mesially from the nipple to the symphysis and laterally from the eighth rib in the mid-axillary line to just below the anterior-superior iliac spine. The apron is attached to the brace by straps and buckles.

**The Flexible Steel Brace.**—In the convalescent stages of Pott’s disease, when the spine requires only a slight degree of protection, the essentials are supplied by a flexible steel brace. A horizontal pelvic band encircles the posterior part of the pelvis, and ends on each side at a point 1 inch behind the antero-superior spine of the ilium. This band is carefully figured to a paper pattern. It is 1½ inches wide, and it is cut from No. 16 gauge sheet-steel. The uprights are fastened to the pelvic band, 1½ inches apart. They pass upwards on each side of the middle line until they reach the first dorsal vertebra, when they are 1 inch apart. From this point they bend outwards at an angle of 45 degrees, extending as shoulder-pieces for 2 inches. A cross bar ½ inch wide is riveted to the uprights 1 inch below the posterior axillary folds. It extends upon each side to within 1 inch of the width of the body. Straps connect the tips of the shoulder-pieces to the ends of the cross bar, the straps arching across the front of the shoulders.
The ends of the pelvic band are united in front with strap and buckle, and it is a further benefit to have a broad abdominal belt, divided into two halves, each attached to the upright behind and the half of the opposite side in front.

**Tubby's Spinal Support.**—This is an apparatus which acts on the principle of a Taylor brace. It affords considerable lateral and antero-posterior fixation. The original description is as follows:

The first essential is a good base of support, which is afforded by a well-fitting and accurately adjusted pelvic band, so arranged that it can be opened in front. The band has fixed to it two pieces of steel, each arching over on either side from just in front of the anterior-superior to the posterior-superior spines. At the centre of the pelvic band, posteriorly, a double steel upright is fixed, which reaches above to a little below the level of the line joining the spines of the scapula, thence two transverse steel bands pass outwards to beneath the axillae. In order to ensure sufficient rigidity, two lateral steel uprights pass from the pelvic band, and are joined to the upper transverse bands just below the axillae, and end in horned and pear-shaped extremities. They lie between the coracoid processes and the heads of the humeri. The utility of the apparatus depends upon an accurate fitting, which is made while the patient is suspended, and when it is removed at night the patient ought to be lying down. It is replaced in the morning before the patient rises from the horizontal position. The posterior uprights lie exactly in the lines of the transverse processes, and there must be no pressure on the transverse processes nor on the ribs. The uprights are made so that they first fall short of exactly following the curves of the vertebral column, thus exercising a lever-like action, as in the Taylor brace. When the posterior deformity is small and the vertebrae are not fully ankylosed, advancing plates may be fitted to the uprights, so as to bring moderate pressure to bear on the transverse processes at the projection. The main object of the apparatus is to exert antero-posterior leverage on the spinal curvature, exactly in the same way as if one stands behind a healthy person and puts the arms and hands beneath the subject's axillae and exerts backward traction. The effect is that the patient is absolutely prevented from flexing his spine. To cover the chest and abdomen, stay material with lacing down the front is used, and further, if the disease is above the eighth dorsal vertebra, a head support with a chin piece is added.¹

**Leather Jackets.**—In the later stages of convalescence leather jackets may be used. A plaster cast is first taken of the chest and spine. If an old jacket is available, a cast may be obtained by blocking up its apertures with brown paper and filling the interior with plaster. If this is not possible a negative is taken of the chest with plaster bandages (see later) and a positive made. By adding an additional thin layer of plaster the size of the cast is slightly and evenly increased. This is necessary as the leather contracts during its application and drying, and what may appear to be a well-fitting jacket is actually too small. Oak-tanned English leather is used. It is soaked in water until thoroughly soft, and then stretched upon the cast. It is made to conform to every outline and hollow. One edge is secured to the cast by tacks, and the other edge secured when it is properly fitted. Sometimes it may be adapted by tightly and evenly winding a

small rope round the cast with the leather in position, or it may be tightly bandaged on with webbing. The leather is allowed to harden at ordinary temperature, or it may be baked at a temperature not exceeding 120° F. When it is thoroughly dry, hot bayberry wax is painted on until no more is absorbed. The wax has a double advantage—it bears a dull non-absorbent surface which is pleasant to the touch, and if any portion of the jacket requires to be remodelled, this can easily be done by heating the part. The wax melts, the leather softens, and the part may be remodelled as desired. The jacket may be painted with three or four coats of shellac. This increases its durability. The free edges of the jacket are bound with strips of soft sheepskin, and if any portion of the border sticks inwards and is uncom-

Celluloid Jackets.—Jackets made of celluloid have many advantages. They are comparatively cheaply made; as they are made upon a cast their fit can be guaranteed; they combine lightness and a certain degree of elasticity with considerable strength.

A plaster cast is first taken of the patient’s body. For this purpose the patient is held in a position of slight extension, most conveniently by being suspended from a gallows. In this position the part to be cast is thoroughly anointed with vaseline or warm olive oil, and, beginning below, the trunk is encased with a plaster bandage; the first turns of the bandage encircle the trunk below the iliac crests and at the level of the symphysis pubis.
It then gradually rises, and the shoulders are included by cross turns passing from chest to back and vice versa. If the neck is to be included the case extends upwards as far as the occiput. As the plaster is drying it is carefully moulded to certain body outlines: below the iliac crests, above the symphysis pubis, along the length of the spine, and over the outlines of the scapulae, above and below the clavicles, and, in a high case, around the occiput and the mastoid processes. When the plaster has sufficiently set, the casting is removed from the body by slitting it up one side of the body, above the shoulders and along the side of the neck. In removing the casting it may sometimes be difficult to avoid cutting the patient's skin. The risk is obviated by laying a narrow strip of boracic lint upon the skin beneath the plaster and along the line of removal. The shape is carefully restored. It is kept in proper position with a few turns of a plaster bandage, and the jacket is allowed to harden. The positive is now made. The interior of the negative is carefully oiled. It is placed upright in a box of sand so that its lower outlet is closed, and the arm openings are obliterated by a few turns.
of a plaster bandage. A quantity of the ordinary commercial plaster is made up, using 5 parts of water to 3 parts of dry plaster, and the interior of the mould filled with it. As the plaster is hardening, a stout wooden rod is thrust into it to form a useful handle, projecting above the cast. As soon as the plaster is hard the negative is removed, and the work of modelling the positive is begun. With a strong penknife it is sculptured so as to accentuate the depressions from which the jacket will take its purchase. This manipulation requires to be carried out with great judgment and care. The whole of the cast is now covered with a thin additional layer of plaster to increase uniformly the bulk of the cast, and so ensure the better fit of the jacket. Over the cast a vest of cotton or stockingette is drawn. It must fit the cast outline exactly, and therefore it ought to be in actual size somewhat smaller. Its fit is made accurate by a few adjusting stitches, and by bands of narrow tape that stretch across uneven places and are stitched upon the under surface.

The celluloid solution has meantime been prepared by dissolving celluloid cuttings in a solution of acetone. To render the mixture non-inflammable, to every 150 oz. of celluloid dissolved in acetone 5 oz. of a solution of calcium chloride in water is added, the strength of the calcium chloride solution being in the proportion of 3 oz. of calcium chloride to 2 oz. of water (Gauvain).
This mixture is painted on to the vest with an ordinary stiff brush, and thoroughly worked in. As each coat dries, a successive one is painted on until three or four layers have been applied. When this original application has dried, and it requires about four hours to do so, a layer of unstiffened book-muslin is applied to the cast in two antero-posterior halves, overlapping at the sides. The layer of muslin is impregnated with celluloid and allowed to dry. Successive layers are thus applied until a sufficient strength has been obtained. Anything from ten to twenty layers may be required.

Portions of the jacket which are likely to bear the greatest strain are specially strengthened by small additional layers, and the jacket is finished by the addition of several coats of celluloid. The jacket is removed from the cast usually by cutting it anteriorly up the middle line. It is now placed on the patient and carefully fitted. The edges are trimmed, and with a pencil the windows to be cut out are marked. A large anterior window is the most essential. The interior of the jacket is lined with wash leather, and the edges are bound with strips of similar material. Along opposite sides of the middle line a number of lacing hooks are inserted.

The lower part of the jacket is sometimes complained of as giving rise to pressure. In front it ought to extend just to the upper border of the pubis; laterally it extends over the centre of Poupart's ligament, and just above both great trochanters; posteriorly it passes across the centre of the sacrum; above it ought to be cut away freely beneath the arms.

This form of jacket will be found a most excellent splint during convalescence.

The Knight Spinal Brace.—In the final stage of treatment, when convalescence is well advanced and cure is practically complete, it may be of advantage to supply the patient with a brace which gives support and a
slight amount of fixation. An ordinary long corset, strengthened by steel bars along the spine, may be used, or a Knight spinal brace. The structure of the latter is best understood by reference to Fig. 74. A pelvic band of light steel passes round the pelvis, below the crest of the ilium, and ends below and behind the anterior-superior spine of each side. Two vertical steel bands 1 inch wide extend upwards from the pelvic band upon each side of the spine to the level of the sixth dorsal vertebra. Their upper ends are connected by a costal band, which from the level of the sixth dorsal vertebra passes obliquely downwards into the centre of the axilla. It ends on each side at the anterior axillary line. The termination of the costal and pelvic bands are united by vertical bands on each side. There is a single cross-bar at the centre of the posterior part of the brace. Support is given in front by a lacing corset. Other varieties of jacket have been made from poroplast, aluminium, papier maché, and silicate of potash. Each of these substances possess disadvantages, which render them inferior to the materials already described.

Head Supports

For cervical disease, cervico-dorsal disease, and dorsal disease occurring above the level of the seventh dorsal vertebra, certain modifications have to be added to the brace or jacket to support the head. The more important of these various supports are now described.

The Jury-mast.—The jury-mast should be made of tempered steel. Its base is composed of a flat bar, measuring usually 3 inches by 1½ inches. To the extremities of this bar are riveted flat steels curving downwards and outwards, and upon the lateral steels, at their extremities and at their centres, plates of perforated tin are fastened. The base piece is intended to be incorporated in a plaster jacket, the transverse bar crosses opposite the second dorsal vertebra, and the lateral pieces pass over the scapula of each side.

The upright of the jury-mast must be made of tempered steel, sufficiently strong to bear the weight of a halter which is attached to its extremity. It is riveted below to the centre of the cross-piece of the base. It passes upwards to below the occiput when it is curved backwards, conforming to the outline of the skull, but being about 1½ inches distant from it. It ends over the centre of the vertex and about 2 inches above it. To its extremity a cross-bar of narrow but strong tempered steel is riveted by its centre. The cross-bar extends laterally to a level with the lateral aspect of the skull. Round the chin and below the occiput leather bands are attached. They meet at a point above the ear, and from the junction they are attached by an adjustable strap to the extremities of
the cross-bar. The halter, the term applied to the leather head bands, should be applied with as much tension as can be borne comfortably by the patient. The chin should be tilted slightly upwards in order to extend the cervical spine, and this is done by carrying the strap junction somewhat forwards in front of the ear.

If it is desirable to prevent lateral movement of the head a modification is applied. From the curved upright, lateral bands pass forwards above the ears, and lie in contact with the side of the skull. They extend forwards to a level with the external angular process, and they are united in front with a strap of webbing. They very efficiently prevent lateral movement. The jury-mast has the advantage of combining traction of the spine with a certain degree of fixation. Its disadvantage lies in the fact that the fixation afforded is by no means absolute. It is most frequently used in conjunction with a plaster jacket, but by slightly varying the base piece it may be conveniently fitted to any form of spinal support.

The Taylor Ring.—This is an attachment of the Taylor brace, and it is used in cases of caries higher than the seventh dorsal vertebra. It consists of a ring, a spindle, and a socket. The ring is oval in shape. Antero-posteriorly it extends from occiput to the tip of the chin; laterally it is wider than the breadth between the angles of the jaw. Opposite the left jaw angle a hinge is placed which allows the ring to open horizontally into an anterior and a posterior division. The halves are united opposite the right jaw angle, with a pin and a ring clasp. The ring is made of steel spring, measuring \( \frac{1}{8} \) by \( \frac{1}{4} \) inch. Upon that portion of the ring which lies beneath the chin, a small tin plate is soldered, measuring about 1\( \frac{1}{4} \) inches wide and \( \frac{3}{4} \) of an inch long. To the plate a moulded pad of hard rubber is fastened to support the chin. To the back of the ring a piece of forged steel is fastened to support the chin. To the back of the ring a piece of forged steel is fastened to support the chin. To the back of the ring a piece of forged steel is fastened to support the chin. To the back of the ring a piece of forged steel is fastened to support the chin. To the back of the ring a piece of forged steel is fastened to support the chin. To the back of the ring a piece of forged steel is fastened to support the chin. To the back of the ring a piece of forged steel is fastened to support the chin. To the back of the ring a piece of forged steel is fastened to support the chin. To the back of the ring a piece of forged steel is fastened to support the chin.

The posterior spine brace with Taylor ring attachment for high dorsal Pott’s disease.
permits of rotation of the head, but this may be checked by a screw. The spindle is made of soft steel. In its lower two-thirds it is flat in front and rounded behind, in its upper third it becomes circular to fit the socket at the back of the ring. A shoulder attached to the spindle below the socket prevents undue descent of the head support. The socket by which the spindle is fastened to the brace is made of machine steel $\frac{1}{2}$ inch wide and $\frac{3}{8}$ inch thick. Through its centre there is a hole which admits the lower flat end of the spindle. The movements of the spindle in the socket are controlled by two set screws turning in threaded holes, and fitting into depressions on the posterior half of the socket.

If absolute fixation of the head is indicated, as in disease at or near the occipito-axoid region, two steel uprights are attached to the back of the ring, and bent to fit closely the posterior and lateral aspects of the head. A band of webbing passes in front of the forehead from one upright to another. In applying the support the chin must always be tilted slightly upwards in order to throw the weight of the head backwards.

Shaffer has recommended that the attachment of the ring to the spindle should be made by means of a ball and socket joint regulated by a screw and key. This arrangement permits of an easier adjustment of the ring and therefore of the head.

The Taylor ring has one disadvantage—the continuous pressure of the anterior portion of the ring upon the chin ultimately causes a recession of that structure, with a result which may be exceedingly unseemly. If this is feared, the position of the ring may be altered to pass beneath the occiput and in front of the forehead.

The Loop Head Support.—If the disease in the spine is at a low level, and all that is required as a head support is something to prevent forward inclination of the head, this can be obtained by using the loop head support. It consists of a loop of steel which, attached behind to the cross-bar or the uprights of the brace, passes forwards in front of the neck below the chin. For convenience of application it ought to be provided with a lateral hinge to enable the anterior portion to open forwards. Beyond limiting flexion it provides little support to the head.

The Wire Chin Rest.—This application may be used either with a plaster jacket or with a steel brace. The fixation which it affords is unequal to that of the jury-mast or the Taylor ring. Its anterior part is manufactured of wire, the posterior or occipital portion is of steel. The wire portion is made first. It is modelled in soft flexible wire, and completed in strong wire, No. 5 or 6 gauge. A large U with a square foot is made to fit the chest in such a way that the transverse bar lies across the xiphisternum, while the vertical bars rise one on each side over the centre of the clavicles as far as the edges of the trapezius muscles. These vertical bars are well sprung forward when they pass over the clavicles, so that no unnecessary pressure is exerted. At the edge of the trapezius the wire is bent so that it rises vertically upwards to behind and just outside the angles of the jaw. It is there bent forwards, and following the line of the lower jaw it passes beneath
the chin. When this is satisfactorily modelled a permanent duplicate is made in the No. 5 gauge wire, care being taken that the joining of the wire occurs in the centre of the transverse bar of the U, not beneath the chin. The wire portion is completed with certain additions. Under the horizontal portion of the U, and under 3 inches of each vertical limb, there is soldered a flat piece of tin 2 inches wide and lined with leather. It secures a good apposition upon the chest. Beneath the angles where the uprights rise at the root of the neck, and extending for 1\(\frac{1}{2}\) inches forwards and backwards, are soldered oblong pressure pads of steel \(\frac{3}{4}\) inch wide and 3 inches long. Upon the centre of the chin loop a small piece of tin is soldered, with a rubber pad to fit the chin upon its upper surface. The occipital portion of the rest is made of a half-band of flat malleable steel \(\frac{1}{4}\) by \(\frac{1}{16}\) inch. By one side it is attached to the right vertical wire behind the angle of the jaw, upon the left side it is clasped by its hooked extremity to the corresponding vertical wire, and where it passes behind the occiput two pad plates are fastened. Vertical movement is prevented in the posterior part by stops which are soldered to the wire.

The principal advantage claimed for this apparatus is that of lightness: further, it is easily made and requires no special skill. It is, however, not rigid enough to be an efficient support. Its use ought to be limited, therefore, to convalescents.

**The Goldthwait Head Support.**—The Goldthwait head support consists in the upper part of a wire chin rest, fastened to yoke-like metal bands which pass over each shoulder. The yoke-piece is first carefully moulded from a strip of thin lead \(\frac{1}{2}\) inch wide. From the lead copy a careful paper pattern is made, and a piece of flat malleable steel, \(\frac{1}{2}\) inch wide and \(\frac{1}{16}\) inch thick, bent to correspond with the paper pattern. In front the yoke passes collar-wise across the upper end of the sternum, opposite the junction of the manubrium and body. It bends backwards over the shoulders, and extends down the back as far as the lumbar region. The wire portion is made exactly the same as for a wire chin rest. The upright wires at their base are
bent forwards for about 2 inches, and soldered to the yoke on each side, where it bends over the top of the shoulder. The apparatus is fastened in position by straps and buckles. One strap encircles the body from the tips of the yoke. Other straps upon each side pass from the yoke tips to buckles on the curved portion of the yoke in front. The apparatus is applied by opening the posterior band of the head-piece, pushing the yoke ends over the shoulders and down the back until it falls comfortably into position. The posterior band is then closed.

There are no special advantages to be claimed for this appliance. It is more stable than the wire chin rest.

**Davies Head Support.**—This is especially for use with Davies' quadrilateral back brace, but it may be modified to suit other forms of spinal support. It consists of two flat uprights, a sling for the occiput, and a strap for the forehead. The uprights are bars of flat malleable steel \( \frac{3}{4} \) inch wide and \( \frac{1}{12} \) inch thick. They pass upwards on each side of the middle line, and they are attached to one or more of the cross-bars of the brace. They are attached to the cross-bars by means of sockets and set screws, so that their vertical position can be altered at will. The uprights pass straight upwards to about 1 inch below the occiput, when they curve upwards and outwards to a point 1 inch above and \( \frac{1}{4} \) inch behind the ears. Again their direction alters, and they pass directly forwards to the level of the external angular process. Buckles are here provided for attachment of the forehead strap, which is made of soft leather 1 inch wide. The occipital strap passes from that portion of the upright above the ear to a corresponding point on the opposite side. It passes behind the occiput, and it is reinforced on the outside with a thin strip of brass to prevent curling.

**The Thomas Collar.**—In disease of the cervical spine a certain amount of support and fixation may be obtained by collars. Various materials have been used for this purpose—poroplast, etc. The Thomas collar is the best of this type of support, and it is the only one which will be described. The original Thomas collar was made by stuffing a tube of soft calf-skin with sawdust, the diameter being greatest beneath the chin, and smallest under the ears. It was secured at the back of the neck with straps and buckles. A more efficient collar is made by cutting out from a thin sheet of steel a metal pattern wide enough to reach from the sternum to the chin in front, and from the back of the neck to the occiput. The edges of the metal are carefully turned out all round, so that no harmful pressure is exerted upon the neck. The metal
is covered with felt, and if necessary padded. When fitted round the neck the collar is secured in place by a strap and buckle fastening behind.

Many other forms of support of greater or less merit might be described, but space forbids their inclusion. The most important ones have been mentioned.

**General Routine of Treatment**

Amidst the medley of appliances which have been described, one is apt to lose sight of the scheme of treatment which ought to underlie one's dealings with every case. Therefore it will be of advantage at this stage to summarise the detail which has been dealt with, and apply it in its proper sequence.

**Recumbency.**—It is one's practice to treat every case of the disease in its early stages by complete recumbency, and this is done quite irrespective of the situation in which the disease occurs. The recumbency is always associated with some degree of hyperextension of the spine. The method of applying this and the reason of its value have been already described. If the disease is associated with pain or considerable muscular spasm, one combines traction with the recumbency and hyperextension. The traction is continued until the symptoms disappear.

**Duration.**—The duration of recumbency varies in different parts of the spine.

**The Lumbar Region.**—In the lumbar region the prognosis is good, and in the absence of complications one considers the recumbent period sufficient if it extends over twelve months. The occurrence of symptoms in the shape of psoas contraction, night pains, and abscess formation must be considered as absolute indications for a further continuance of recumbency.

**Lower Dorsal Region.**—In the lower dorsal region the duration of recumbency need not be any longer than in the lumbar region. It is a favourable part of the spine from the view of treatment, because there is not the tendency to deformity which occurs higher up, and there is an absence of those complications (psoasitis, etc.) which one finds in the lumbar spine. One advises, therefore, a minimum of twelve months' recumbency.

**The Middle and Upper Dorsal Regions.**—From the point of view of the prevention of deformity this is the most difficult region of the spine to treat, although symptomatically it may be quickly improved. There is no better method of preventing deformity, and during its early stages of improving it, than recumbency combined with hyperextension. The treatment must be maintained for a longer period than in the other situations. Eighteen months is certainly the minimum required.

**The Cervical Region.**—This is the most favourable region of the spine for treatment. The disease is rarely extensive on account of the comparatively small size of the bodies involved. The weight-bearing necessities are minor, and the tendency to deformity is correspondingly lessened. When deformity does occur, the mobility of the cervical region is so great that it
readily compensates for it. Recumbency is carried out for about six months, and during the greater part of that time it is combined with head-traction.

The Occipito-axoid Region.—Under efficient treatment the prognosis is good, and recovery without deformity should be the rule. The proximity of the disease to the vital centres makes the prognosis a guarded one, however. The course of the disease is short, probably because it begins as an arthritis. Recumbency is carried out for six months, and light traction is maintained until the symptoms have disappeared.

Type of Apparatus.—As regards the apparatus used in carrying out the recumbency, one’s best results have undoubtedly been obtained by the use of the Bradford bed frame and the Whitman stretcher frame. In lumbar and lower dorsal caries one recommends the Bradford frame, because the tendency to deformity is small, and therefore little hyperextension is required. The Whitman frame is indicated in mid dorsal, high dorsal, and cervical caries, as the bend in the frame permits of a thorough hyperextension of the spine, and a continuous double extension is carried out.

Ambulatory Treatment.—With the completion of recumbency, ambulatory treatment is begun.

Type of Apparatus.—One recommends that a plaster jacket or a Taylor brace be the spinal support chosen; both are equally good but the plaster case is cheaper. Among the poorer classes of patients one therefore recommends it in preference to the brace. In upper dorsal and cervical caries the plaster jacket is applied as a “Minerva” or as a “Fillet” jacket, or a jury-mast is incorporated into the jacket. Similarly with the brace a head support should be added, and from experience one favours the Taylor ring.

If the disease is low down, at the lumbo-sacral junction for example, the steel support is better than the jacket, as the former can be carried lower down and more closely fitted. And when it is necessary to support the head it is wiser to use a steel brace than plaster, because of the better attachment for the head-piece. A plaster of Paris jacket is most useful in disease of the spine from the tenth dorsal to the third lumbar vertebra.¹

A spinal support of this kind is worn for one year, except in the mid and upper dorsal regions, when it is continued for eighteen months. A less absolute support is then used, and it has become one’s routine practice to employ for this purpose a celluloid jacket. This is worn for a varying period, from one year to two, and with its removal the cure ought to be complete. If any further support is required a light Knight brace is ordered.

A considerable amount of moral courage is necessary to insist upon the completion of treatment so prolonged, but half-measures are worse than useless; and it is wise to thoroughly explain the situation to the parents, and obtain their co-operation. In one’s out-patient work these cases are detailed in a spinal case-book and register. They report for examination at stated intervals, and every effort is made to trace the progress from start to finish.

¹ Tubby, loc. sup. cit. vol. ii. p. 163.
The Abolition of the Deformity by Correction

Under this heading two distinct lines of treatment are described: (1) A rapid method of correction, in which the ideal aimed at is to dispose of the deformity at a single sitting. (2) A gradual method of correction, in which the obliteration of the deformity is carried out by a series of gradual corrections.

(1) Rapid Correction of the Deformity.—In 1895 Chipault published a paper in which he described a revival of a very much older method of correcting by force the deformity of Pott’s disease. Further papers followed in the successive years of 1896 and 1897. The method was taken up by Calôt of Berck-sur-mer, who popularised it, and published an account of it in 1897. Since Calôt’s original publication hundreds of these operations have been performed, and it has been demonstrated that if suitable cases are chosen, it is possible entirely to correct a Pott’s deformity at one or more sittings with but little danger to the patient.

The Operation.—As ordinarily performed, the patient is anaesthetised and suspended face downwards in the horizontal position by five assistants, who exert traction upon each of the extremities and upon the head. There need be no fear of injuring the neck, as the amount of force expended cannot possibly do any harm. While the traction is being exerted, the surgeon, standing by the side of the patient, gently presses directly downwards upon the kyphosis. The angulation gradually yields and straightens, and as it does so, there is often the audible yielding of adhesions. Calôt states that the amount of pressure required to correct the deformity varies from 30 to 80 lb. When the correction is successfully completed, or when it has been improved as far as possible, the spine is hyperextended, and in this position a plaster jacket is applied. If the disease is in the lumbar or lower dorsal regions, the shoulders are braced well back and included in the jacket; if the disease is of the upper dorsal region, the head and neck must be included. In applying the jacket it is recommended that the bony prominences be carefully padded with thick felt; this is probably unnecessary. A large window is cut out in front to prevent interference with respiration or digestion. In the after-fixation of the spine all surgeons do not apply plaster jackets; some prefer a well-fitting brace, and others the Whitman stretcher frame. The after-treatment consists in keeping the patient at rest in the recumbent position for from three to six months. He is then allowed to get up and go about, but a spinal support is worn for at least another year.

Indications for the Operation.—The most suitable cases are those in which the deformity is of short standing. In such, adhesions and changes in the soft parts are not sufficiently developed to offer undue resistance, and the internal organs have not become displaced or compressed. The middle and lower dorsal regions of the spine are the most suitable for treatment.

Contra-indications.—The most unfavourable cases are those of fixed

1 Chipault, *Travaux de neurologie chir.*, 1895.
deformity, in which repair is well advanced or completed, and in which soft tissues and internal organs have become altered in shape and position. The presence of an abscess should contra-indicate the operation, but the occurrence of paralysis does not; in fact, in many instances the operation relieves a paraplegia. As a rule, deformity of the lumbar and of the cervical regions is not sufficient to require a forcible correction.

Results of the Operation.—One of the most complete analyses has been carried out by Bradford and Cotton.\(^1\) Six hundred and thirty-nine cases were corrected by thirty-four operators. The time elapsed since operation varied from a few days up to three years or more. Of the isolated cases, in 7 more than one year had elapsed, in 35 more than six months. The total number of deaths from all causes was 25, and the distribution as follows: from various causes, 5; from general tuberculosis, 4; from trauma of the operation and chloroform, 5; from intercurrent disease, 7. As regards immediate consequences of the operation, 7 suffered from respiratory embarrassment, 6 from severe pain, and 3 from severe shock. In 19 cases abscess was present before operation, 4 of these ruptured with deleterious results, 6 were benefited and in some cases absorbed. In two instances abscesses appeared after the operation. Paralysis was present before operation in 23 cases, 17 of these were relieved, 2 were not relieved, and 1 case was made distinctly worse. The operation was followed by paralysis in 4 cases. As regards the direct effect on the deformity, this was estimated in 240 cases—130 showed complete correction, 94 an incomplete improvement. In 77 cases the ultimate result was judged to be that in 20 cases no relapse had resulted, in 50 cases there was some relapse, in 7 cases the deformity had recurred as badly as before.

Jones and Tubby\(^2\) published in 1898 and 1900 their experiences with 79 cases. They found that the results of the operation were by no means discouraging. In applying the plaster jacket, after rapid correction of the deformity, Tubby and Jones criticise the method recommended by Redard and Calot. They point out the great tendency for the jacket to become infected with vermin. To avoid this they recommend thorough and complete skin disinfection, the use of tarry tow as a lining, and the application of pressure on the hump by means of boiler felt. They believe that the amount of hyperextension required is so great as to make the patient’s life miserable, and that difficulty during anaesthesia is a very real danger. Instead of the plaster jacket they recommend the use of a modified Thomas splint. The great disadvantage of the operation is the marked tendency towards recurrence, and the feeling at the present day is that the method about to be detailed, that of gradual reduction, is preferable.

(2) Gradual Correction of the Deformity.—A beneficial pressure is exerted upon the deformity during and after the application of a plaster jacket. Three methods will be described: (a) Goldthwait’s method by

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horizontal traction and leverage; (b) The method of the extension couch and weight traction; (c) Calôt's method.

(a) Goldthwait's Method.—This has been alluded to in the application of a simple jacket (page 169) and need not be fully redetailed. The principle is that the patient rests supine upon a frame in such a posture that the spine is hyperextended, and in this position a plaster of Paris jacket is applied. To secure the maximum hyperextension, traction may be desirable, and if so it can be applied by means of a windlass which is attached to each end of the frame. The method is repeated at intervals.

(b) The Extension Couch and Weight Traction.—The patient is placed on an extension couch, and by leverage and weights the maximum degree of correction is obtained. A steel support is added, and the support is provided with advancing plates and screws which exert a steady corrective action upon the deformity. The application is maintained and repeated until the correction is complete.

(c) Calôt's Method of Gradual Correction.—Advantage is taken of the ordinary plaster jacket to act as the source of leverage. After the jacket is applied, a small window is cut out posteriorly over the deformity and a large window in front. The skin over the deformity is covered with a thick layer of vaseline. A number of sheets of wadding are cut, each a little larger in size than the posterior window, and each about 1 cm. in thickness. These are carefully introduced through the posterior window, all around between the jacket wall and the skin over the deformity. For the first compression eight or ten layers of wadding are sufficient. The introduced material bulges out through the opening on the jacket, and further compression is exerted by forcing it inwards with the successive turns of a bandage of plaster of Paris or gum. The total amount of wadding introduced varies; if there is no actual deformity, one insertion of eight or ten layers is sufficient to guard against the appearance of the deformity. If there is a deformity, there will be of course much greater difficulty in introducing a sufficiency of packing. At the third or fourth insertion fifteen to eighteen layers ought to have been inserted. This may appear to be an enormous amount, but it is marvellous how quickly it becomes accommodated. A gradual reduction of the deformity is thus obtained.

Operative Treatment of the Gibbosity

Under this heading one does not include operative measures for the relief of abscess formation, but those which are directly concerned with the reduction or the fixation of the gibbosity. Many years ago Calôt advocated an operative reduction of the deformity. The operation entailed chiselling through the ankylosed vertebrae and removing the spinous processes. Calôt attempted to completely correct the deformity. This operation is not now performed.

In 1891 B. E. Hadra advocated the wiring together of the spinous processes.
processes of the diseased and the neighbouring vertebrae. The spines are exposed by a median incision, the centre of the incision being over the diseased vertebra. The longitudinal muscles are separated from each side and retracted, and the tissues in the interspinous spaces are divided with a knife. Silver wire is threaded in a strong, curved needle, and carried through the interspinous spaces above and below the processes in a figure of eight fashion. The ends of the wire are secured by twisting. In children it is advisable to wire at least three spinous processes, as the tissues are apt to lose their hold upon the wire loops. The wound is completely closed. The results of this operation are disappointing, and its employment has been abandoned.

The next attempt at operative interference was made by Lange.\(^1\) He advocated the replacement of external support by internal splints. Splints made of tin-plated steel 10 cm. by 5 mm. are used. Incisions are made through the skin and fascia corresponding to the upper and lower ends of the splints. The latter are inserted beneath the muscles, close to the spinous processes, one on either side of the diseased vertebrae. The splints are provided with bulbous extremities, and these extremities are attached to the spinous processes by silk threads. For six weeks a Calôt plaster jacket with a posterior window is used, and at the end of that time a celluloid jacket. The operation has two outstanding disadvantages—the splints do not afford sufficient fixation, and they frequently give rise to irritation and have to be removed. More recent attempts have been made to fix the diseased vertebrae with transplanted bone, and Albee's\(^2\) operation is based on this principle. The patient is placed in the vertical position, and an incision is made over the tips of the spinous processes with the kyphosis in the centre. Each process is split longitudinally for about \(1\frac{1}{2}\) inches into two portions, one-third of the process on the left and two-thirds on the right. The soft tissues between the spines are separated with a scalpel. Greenstick fractures are produced at the base of the left one-third portion of each of the processes. A wedge-shaped cavity is thus produced. From the tibia of either leg a prism-shaped portion of tibia, measuring 4 by 1\(\frac{1}{2}\) by 1\(\frac{1}{2}\) inches, is removed, and placed in the gap between the spinous processes. The dense fascia over the tips of the processes is united to keep the graft in position. Dobrotworski\(^3\) has recommended that a portion of rib be used in preference to tibia. The immediate results of this operation are good, but sufficient time has not yet elapsed to enable one to judge of the ultimate measure of success.

Dr. Russel H. Hibbs\(^4\) has recently introduced an operation which aims to produce a fusion of the posterior aspect of the vertebrae, to obliterate motion of the vertebral articulations over the diseased area, and to relieve pressure on the involved bodies, thereby hastening the cure and preventing

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the deformity. The proposal is to accomplish by operation what nature attempts to do, viz. to eliminate motion of the diseased joints by an extraordinary bony growth. The operation is described as follows:

A longitudinal incision is made directly over the spinous processes through the skin, supraspinous ligament, and periosteum to the tips of the spinous processes. The periosteum is split over both the upper and lower borders of the spinous processes and the laminae, and stripped from them to the base of the transverse processes. The spinous processes are partially fractured, and used for bridging the gap between the vertebrae. The lateral walls of periosteum and of the split supraspinous ligament are brought together over these processes by interrupted chromic catgut sutures. The skin wound is closed by silk and a steel brace applied, with the space between the uprights increased somewhat at the site of the wound, so as not to make pressure upon it.

The author reports a number of cases with excellent results.

The Treatment of Complications

Abscess Formation.—This has been already thoroughly discussed from a general point of view. It remains to discuss some specific points, more especially the various operative measures which spinal abscesses necessitate. Abscess formation is a most troublesome complication of Pott’s disease. It interferes with appropriate mechanical treatment, it produces additional temporary and permanent deformities (hip flexion, etc.), it extends the boundaries of the disease by its ever-present tendency to migrate, and when it becomes secondarily infected, prolonged suppuration, waxy disease, and death may result. The treatment of spinal abscesses may be grouped into three classes: (1) Expectant treatment; (2) Conservative treatment; (3) Operative treatment.

1. Expectant Treatment.—Of necessity this is sometimes the treatment adopted, because the situation of the abscess is so inaccessible that other measures are impossible. And in certain cases the inactivity is justified by the fact that the abscess spontaneously resolves into a collection of caseo-calcareous debris. Prevertebral collections are the most important group under this heading.

2. Conservative Treatment.—By this term one means the treatment by aspiration and the injection of various kinds of medicaments. The various points have already been fully discussed.

3. Operative Treatment.—This may be the treatment of choice, and there is a school which recommends it in every available instance; or it may be the treatment of necessity for the relief of pressure symptoms (retropharyngeal abscesses). If operative treatment is decided on, situation is no bar. Certain abscesses are more difficult of access than others, but almost without exception methods have been devised for their exploration.

There are certain principles which ought to guide one’s operative technique. They are well summarised by Tubby,1 and briefly they are as follows:

1 Tubby, loc. sup. cit. vol. ii. p. 175.
(a) Let the patient remain recumbent, and if the abscess is increasing, allow it to make its way as much as possible into a place where it may be reached easily.

(b) Place the incisions as far as possible from sources of contamination.

(c) Single incisions into abscesses of any size are hopeless; at least two or three openings are required. With a single incision into a psoas abscess free evacuation from remote corners is prevented, because the pressure of the air on the opened sac holds back the pus and the caseous material. One incision must be near the source of the mischief, and at least one if not more at a distance.

(d) Endeavour to get primary union.

(e) Always apply firm pressure with pads along the track of the abscess.

(f) Asepsis from the first incision until every drop of pus has ceased to flow is the prime necessity, and let the surgeon always remember that slips in aseptic technique may cost the patient his life.

(g) Remember that recumbency in the open air always assists the disappearance of the abscess.

**Retro-pharyngeal or Prevertebral Cervical Abscess.**—This abscess must not be opened from the mouth, as such a procedure would certainly be followed by all the dangers of secondary infection. It is opened under strict aseptic precautions by an incision behind the upper third of the posterior border of the sterno-mastoid muscle. That side is chosen towards which the abscess inclines. After the incision is deepened the spinal accessory nerve is exposed, leaving the posterior border of the muscle, and as it is very superficial here, care must be taken to avoid injuring it. The posterior border of the muscle is freed and retracted forwards. Its retraction can be facilitated if the muscle is partially divided transversely just below the mastoid process. The separation of the sterno-mastoid exposes the fibres of the splenius and levator anguli scapulae muscles as they pass downwards from the transverse processes of the vertebrae. The abscess lies immediately in front of the transverse processes, and its cavity is entered by passing one’s finger inwards along their anterior surface. The internal jugular vein, covered by its sheath, lies in front of the abscess, and it is displaced forwards by the finger as the latter enters the abscess. The cavity is emptied as completely as possible by pressure upon the opposite side of the neck. Curettage is dangerous on account of the liability of perforating the posterior pharyngeal wall, and the cavity is most safely and thoroughly cleaned with a plug of dry gauze.

If the abscess extends across the neck to the opposite side, a counter opening should be made behind the opposite sterno-mastoid. It is wiser
not to close the wound completely, but to secure drainage for a few days with a strip of iodoform gauze or rubber drain.

After-treatment. — These cases require careful watching after operation. A certain proportion of them develop oedema glottidis, and require immediate attention. The head is immobilised by lateral sand-bags, and it is an advantage to apply weight extension. When the wound is healed, steps must be taken to secure fixation of the head and the usual treatment of tuberculous spondylitis.

When there is urgent dyspnœa and dysphagia it may be justifiable to open the abscess through the mouth. No anaesthesia is used, or the child is kept very lightly under with chloroform. The mouth is forced wide open with a gag, and the child is placed with the head hanging well over the edge of the table; this obviates any possibility of aspiration of the pus.

One usually employs a fine tenotomy knife to open the abscess, and the pus is swabbed away as quickly as possible. The child is quickly turned over upon its face, and kept in this position until the abscess cavity is evacuated. The after-treatment is similar to that described when the abscess is opened from the exterior, but in addition weak antiseptic mouth washes are recommended.

Supra-clavicular Tuberculous Abscesses. — When tuberculous disease of the middle cervical spine gives rise to abscess formation, the pus passes outwards to the interval between the trapezius and sterno-mastoid muscles, and bulges in the posterior triangle above the clavicle. The operative procedure is very similar to that employed in the retropharyngeal abscess. An incision is made along the posterior border of the sterno-mastoid muscle in its lower two-thirds; the spinal accessory nerve is defined and preserved. The posterior border of the sterno-mastoid muscle is cleared and retracted inwards until the outer edge of the scalenus anticus comes into view. The pus passes outwards between the scaleni and the longus colli muscles, and the interval between them is enlarged with the finger or forceps. The wound may be drained or immediately closed. The post-operative treatment is similar to that already described.

Prevertebral Thoracic Abscess. — As a rule an abscess in this situation gives rise to no symptoms. At first it is a subperiosteal collection of pus; the periosteum later becomes perforated, and the matter collects between the mediastinal pleura and the bodies of the vertebrae. Operative interference becomes justifiable when pressure symptoms appear, and pressure may be exercised upon the oesophagus, the trachea, the left recurrent laryngeal nerve, or the spinal cord.

Operation. — In some cases an area of dulness may be demonstrated

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**Fig. 82.** Incision for supra-clavicular abscess.
upon one or other side of the spine. If the abscess lies in the middle line it may not be demonstrable by clinical means, except by X-ray examination, and in such cases it is recommended to choose the right side for one's exploration. The operation may take the form of a rib resection, or of a resection of the transverse process of the vertebra, together with a portion of the rib (costo-transversectomy 1).

Rib Resection.—The patient is placed semi-prone, with the side to be operated on uppermost. A vertical incision is made parallel to the spinous processes, and about 1½ inches from the middle line. The articulations between the transverse processes and the ribs are exposed. The periosteum over the posterior surface of usually two ribs is divided and separated from the bone. A portion of each rib is removed external to the costo-transverse articulation. The anterior periosteum is divided, and the finger is inserted inwards and forwards along the anterior surface of the transverse process and in front of the body of the vertebra. The abscess cavity is then opened, a tube is inserted, and the cavity drained. The operation has three disadvantages: (1) By this route the abscess cavity is difficult of access; (2) When the cavity is entered the drainage secured is imperfect; (3) The pleura is liable to be injured during its separation from the front of the ribs.

Costo-transversectomy.—To obviate these disadvantages the operation of costo-transversectomy (costo-transverse excision) was introduced by Heidenhain, practised by Menard, and modified and improved by Kocher. Heidenhain employed a straight vertical incision close to the spines. The soft tissues are separated outwards from the laminae as far as the tubercle of the rib, the transverse process is resected first, and then the head and neck of the rib. Heidenhain has shown that by the resection of a single costo-transverse articulation one is enabled to introduce the finger, strip the pleura from the side of the vertebra, and penetrate the abscess. Kocher has modified the operation by using an oblique incision, which is begun over the most prominent dorsal spine, and carried obliquely downwards and outwards along the line of the rib which is to be resected.

1 The term "costo-transversectomy" is not a good one, but, for its use, one has the precedent of many eminent authorities. It would be better to employ the term "costo-transverse excision."
After dividing the integuments, the trapezius and then the rhomboids, the cellular interval is reached between these muscles and the fascia covering the divisions of the erector spine (sacro-spinalis) muscles. The longissimus dorsi and accessorius (ilio-costalis dorsi) are divided in the line of the original incision.

The cross division of the deep muscles is of no moment, as they possess a segmental nerve supply... The periosteum of the exposed rib is divided for a short distance external to its tubercle. The muscular attachments, along with the periosteum and the posterior costo-transverse ligament, are then separated from the transverse process, and its base is snipped through with a pair of curved bone forceps.

The divided process is seized with bone or necrosis forceps, held in the left hand, while the knife is used to free it from the remaining ligamentous attachments, namely, from the superior costo-transverse ligament, passing from the neck of the rib below to its lower border, and from the middle costo-transverse ligament, which passes between its anterior surface and the posterior aspect of the neck of the rib with which it articulates.

The next step consists in the removal of the head, neck, and tubercle of the rib. The periosteum is first separated from the posterior aspect of the neck, and a strong hook is then inserted into the end of the divided rib, which is dragged backwards, while the periosteum is detached from its anterior aspect, carrying with it the costal attachment of the anterior costo-vertebral (stellate) ligament.

When this has been done, the freed portion of the rib is seized with necrosis forceps and twisted away from the spine. The pleura is not injured. Care must be taken not to wound the intercostal vessels, which pass outwards a little below the lower border of the neck of the rib. If the forefinger be now introduced into the bottom of the wound, it will enter the abscess cavity which occupies the cellular tissue of the posterior mediastinum... If more room be desired in order to reach the upper of the two vertebrae into which the rib articulates, the upper edge of the wound must be retracted, and a second transverse process removed. If the mediastinal abscess be small it may be gently packed with iodoform gauze for a few days, and the wound then allowed to heal. As a rule, however, if the cavity be large, and especially if paraplegia be present, a drainage tube should be inserted and kept in for a considerable time.1

When an abscess involves the spinal canal, it is more satisfactorily dealt with by costo-transversectomy (costo-transverse excision) than by laminectomy, because the latter operation exposes the posterior part of the cord rather than the actual site of the disease.

After-treatment.—The patient is kept recumbent for at least one year after the operation, and if at the end of that time ambulatory treatment is begun, fixation of the spine must be secured with a well-fitting brace.

Lumbar Abscess.—When there is disease of the lower dorsal and the lumbar spine, pus may appear in the loin in one of two common situations—in the angle between the erector spinae and the last rib, or above the crest of the ilium in Petit’s triangle.

Subcostal Abscess.—When the abscess lies beneath the last rib an incision is made from the outer edge of the erector spine beneath and parallel to the rib. The latissimus dorsi and the serratus posticus inferior are divided, and, lying deeper, the outer fibres of the quadratus lumborum

and the middle layer of the lumbar fascia. The abscess is usually small in amount, and the wound can be immediately closed.

**Abscess in Petit's Triangle.**

An abscess in this situation is most commonly one which has extended laterally into the sheath of the quadratus lumborum, and piercing the lamella of the lumbar fascia, has become superficial above the crest of the ilium. It may be entered by an oblique incision running parallel to the posterior cutaneous branches of the lumbar nerves; that is to say passing obliquely downwards and outwards. Petit's triangle is exposed, and its boundaries are enlarged by division of the structures in its posterior wall, *i.e.* the outer border of the latissimus dorsi, the quadratus lumborum, and the middle layer of the lumbar aponeurosis. The abscess is exposed, lying close in front of and partly to the outer side of the transverse processes of the fourth and fifth lumbar vertebra.

Treves advocated an extension of this operation, with a view to removing the disease in those cases in which it was localised to a single vertebra, or was complicated by the presence of a sequestrum. Treves' description of the operation is as follows: 1

The patient's loin having been exposed, a vertical incision, some 2.5 inches in length, is made through the integuments. The centre of this cut should lie about midway between the crest of the ilium and the last rib, and the cut should be so placed as to correspond to a vertical line parallel with the vertebral side of the outer border of the erector spinae. . . After cutting through the superficial fascia the dense aponeurosis is exposed, which covers the posterior surface of the erector spinae. . . . The dense aponeurosis, with its attached muscular fibres, having been divided in the full length of the incision, the erector spinae is exposed. . . . The outer border of the muscle should now be sought for, and the whole mass drawn by means of retraction as far as possible towards the middle line of the back. In this way the anterior part of the sheath of the muscle, known as the middle layer of the fascia lumborum, is readily exposed. . . . The anterior layer of the sheath, as now exposed, is seen to be made up of dense white glistening fibres, which are all more or less transverse in direction. Through this sheath the transverse processes of the lumbar vertebrae should be sought for.

The longest and most conspicuous process is that belonging to the third vertebra.

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... The anterior layer of the sheath must be divided vertically as near to the transverse processes as convenient. By this incision the quadratus lumborum muscle is exposed. ... The muscle should be divided close to the extremity of a transverse process, and the incision carefully enlarged until the muscle is divided to the full extent of the skin wound. ... The inner edge of the quadratus is overlapped by the psoas muscle, so that when the former is divided the latter is exposed. ... Some of the tendinous fibres of the psoas having been divided close to a transverse process, the finger is introduced beneath the muscle, and gently insinuated along the process until the anterior aspect of the bodies of the vertebrae is reached.

Iliac Abscess.—An iliac abscess is best opened by an incision running obliquely downwards and inwards, a finger-breadth internal to the anterior superior spine of the ilium, and parallel to the external oblique fibres. The fibres of the external oblique are split, and internal oblique and transversalis muscles are split or divided. The fascia transversalis is thus exposed close to its junction with the fascia iliaca. The dissection is carried outside the fascia transversalis, close to the anterior superior spine, and in this way behind the fascia iliaca. The abscess cavity is entered from the outer side. If the abscess is prolonged downwards into the thigh, a second opening must be made at a more dependent point, and for this purpose an incision is made a little below the anterior superior spine of the ilium, along the curve on the outer edge of the sartorius muscle. The abscess cavity is reached by pulling the sartorius outwards or inwards, and entering the thickened fascia over the ilio-psoas internal to the tendon of the rectus femoris. When the abscess cavity has been thoroughly emptied the incisions should be closed at once.

In opening a psoas abscess Wallis recommends an incision similar to that employed for ligature of the external iliac artery.

The after treatment consists in keeping the patient recumbent for at least one year. When he is allowed up, it is with the addition of a well-fitting spinal support.

The Treatment of Paralysis

The treatment of the paralysis is included in the treatment of the disease of which it is a complication, except that even greater care is taken to secure fixation of the spine. When paralysis appears, absolute

Recumbency is indicated, and recumbency in such a position that the spine is hyperextended. This is best secured by a well-fitting Whitman stretcher frame. In addition to fixation and hyperextension, counterextension should be carried out by means of weights and pulleys from the head and from the lower limbs. If there is any doubt about the amount of fixation secured by the bed frame, it is well to apply in addition a well-fitting brace, modified to fit the change in the shape of the spine induced by recumbency.

Manipulation or massage of the limbs is contra-indicated because it stimulates the reflex centres, but the nutrition of the muscles may be maintained and improved by the daily application of galvanism.

The tendency to the formation of trophic sores must be carefully guarded against by attention to the hygiene of the skin.

If deformities arise from muscular contraction, they are corrected by weight extension or if necessary by splints.

Of the internal remedies, iodide of potash is said to produce benefit by causing the absorption of the tuberculous granulation tissue.

In the treatment of paraplegia, Schilling recommends the use of the Rauchfuss sling. It consists of a broad band of cotton or linen webbing, suspended from one or two cross-pieces, extending lengthwise over the patient's bed, and lifting the patient, at the highest point of the gibbus, above the surface of the bed, producing a pronounced lordosis. The gibbus may be protected against undue pressure by a large water cushion, held in place by the sling.

In properly treated cases, the percentage of recovery is high, probably about 60 per cent, but it must be remembered that the condition is liable to relapse.

When improvement appears, it will be noticed by a lessening of the muscular rigidity, an increasing ability to move the toes, and a diminution of the exaggerated reflexes.

If conservative measures have been adopted for eighteen months, and there is no sign of improvement; if the symptoms, in spite of treatment, are increasing in severity; or if there is evidence that the integrity of the cord is being threatened by the displacement of bone or the pressure of an abscess, operative measures become justifiable.

Operation.—Two types of operation have been tried: (1) Costo-transversectomy, and (2) Laminectomy.

Costo-transversectomy (Costo-transverse excision).—This has been fully described (see page. 194). It is indicated in cases in which the paraplegia results from the pressure of an abscess. The results obtained by the operation have been encouraging. Wassiliew relates his experiences concerning the operative treatment of paraplegia in tuberculous spondylitis by costo-transversectomy. Of five patients affected, in which the pre-vertebral space was opened, four recovered. In the post-operative treatment a drainage tube is inserted into the abscess cavity and tincture of iodine injected.
Laminectomy.—Laminectomy was first performed for the relief of paralysis in 1882. So far its results have not justified its use. The mortality is large (50 per cent), and as the posterior part of the spinal cord is exposed rather than the site of the disease, the results of the operation are not good. It further weakens the osseous structure of the spine upon which one depends for fixation. Its procedure is briefly as follows:

"An incision is made in the middle line down to the spines of the vertebrae to be operated on, and by means of a periosteum detacher, the muscles and periosteum are peeled off each side so as to expose the laminae. The spine or spines are then clipped off with curved bone forceps, and by means of a saw the laminae are nearly sawn through, the division being completed with bone forceps. The ligaments being then divided at the lower part, the plate of laminae and ligaments can be turned up like the lid of a box, and either removed at once or left attached, and replaced after completion of the operation. The cord is then exposed, covered with dura mater, and the soft tissue in front clipped or curetted away. If the whole dura mater is thickened it can be split open, and room be obtained in this way for the cord. Spicules of bone are removed and pus evacuated if necessary." *Elsberg 2 has recently published the results which he has obtained in sixty cases. His observations are distinctly encouraging.

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Symptoms and Physical Signs


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HIP-JOINT DISEASE

Etiology

An infection of the synovial membrane of the hip-joint is designated hip-joint disease, but often the term is somewhat loosely applied to tuberculous infection of the surrounding bones. There are certain factors which influence the occurrence of the disease.

Frequency.—Whitman found that in a total of 7845 cases of tuberculous disease treated in the Hospital for Ruptured and Crippled during fifteen years, the distribution was as follows: 3203 suffered from Pott's disease, 2230 from hip disease, and 2412 from diseases of the other joints. These statistics bear out the generally accepted view that disease of the hip-joint ranks second in the frequency of occurrence, Pott's disease being first among tuberculous diseases of the bones and joints.

Age.—It is essentially a disease of children. Ninety per cent of the cases occur during the first decade of life, and to localise the period more exactly, 50 per cent of the cases first appear in the interval of two years, between 3 and 5.

Sex.—The disease is very equally distributed in its occurrence in boys and girls. It is probably the increased liability to injury in the former which explains the slightly greater proportion in favour of boys.

Side.—The disease is more commonly found on the right side than on the left. In a study of 1000 cases, Whitman found the right side affected in 506 instances and the left side in 483. Fortunately double hip-joint disease is exceedingly rare.

The etiological factors of traumatism and heredity differ in no respect from similar bearings discussed as regards other situations.

Pathology

Anatomy of the Hip Joint.—The hip-joint is one of the most perfect examples of an enarthrodial diarthrosis. It combines a wide variety of movement with great stability, and yet its mechanical adaptations are such that the erect attitude may be preserved without any great degree of sustained muscular effort. The globular head of the femur fits into the deep cup-shaped acetabulum, the cavity of which is increased by the cotyloid ligament attached to the entire rim of the cup. The free edge of this ligament is somewhat contracted, so that it actually grasps the head of the

femur which it encircles. The acetabular rim is interrupted in its lowest part by the acetabular notch, and the notch is partly filled up by the transverse ligament. Between the transverse ligament and the bone of the acetabulum, there is a space through which the blood-vessels and nerves enter the cup. The joint cavity is entirely invested by the capsular ligament, reinforced by ligamentous thickenings, to which special names have been attached—the ilio-femoral, pubo-femoral, and ischio-capsular ligaments. Passing from a pit or depression on the head of the femur to the lower edge of the articular surface of the transverse ligament is the ligamentum teres. The bottom or non-articular area of the acetabulum is filled with a mass of fat, covered with synovial membrane—the so-called Haversian gland. It is continuous with the extra-capsular fat, through the acetabular notch, and in its base the blood-vessels of the synovial membrane anastomose with those of the os innominatum.

From a pathological point of view, most interest attaches to the synovial membrane. It lines the inner surface of the capsule, and its distribution closely follows the attachment of the latter, therefore it clothes the femoral neck more completely anteriorly than posteriorly. From the capsule it is reflected close up to the articular margin of the head of the femur, and upon the upper and lower surfaces of the neck it is reduplicated into a number of folds, which are called the cervical ligaments of Stanley. At the acetabular end, the membrane is prolonged from the inside of the capsule to the inner or articular surfaces of the cotyloid and transverse ligaments. It further provides a covering for the fat at the bottom of the acetabular fossa, as well as a tubular investment for the ligamentum teres. Occasionally a bursa beneath the tendon of the ilio-psoas communicates with the interior of the joint by a small opening in the capsule.

Blood Supply.—The blood-vessels supplying the hip-joint are derived from the internal circumflex and the obturator arteries. After perforating the capsular ligament they anastomose in the extra-synovial tissues, and at both the femoral and the acetabular extremities of the synovial membrane they form a distinct circus vasculosus; that at the femoral end is more distinct than that at the acetabular. From the synovial vessels there is a communication with those in the interior of the bone, and the
anastomosis is especially well marked in two situations. Upon the under surface of the neck, vessels from the circus vasculosus pass along the cervical ligaments into the bone, and at the acetabular extremity a junction is established between the circus vasculosus and the vessels of the interior of the acetabulum through the pad of fat which marks the attachment of the ligamentum teres.

The author has shown that by injection of the aorta with lampblack, the femoral artery being tied at the middle of the thigh, there is produced in the femur upon the under surface of the neck a wedge-shaped mass of injection, sufficient evidence of the peculiarly localised condition of the anastomosis.

Pathology.—Situation of the Disease.—The disease may originate in the synovial membrane or in the neighbouring bone. König found that out of 15 cases, the disease was primarily osseous in 8 and synovial in 7. Haberen’s statistics showed that in 132 cases 80 were certainly primarily osseous, 23 certainly primarily synovial, while the origin of 29 was doubtful. Ashby and Wright believe that in children the disease always begins in the bony tissue.

Method of Infection.—The infection is borne by the blood stream, and when it affects the synovial membrane it is most marked at the synovial reflexion and usually at the femoral one. From the reflexion it spreads throughout the membrane, and it may involve the underlying bone. It is probable that a primary osseous focus is more common than a primary synovial one. The two sites of election in which the bone becomes diseased are (1) a wedge-shaped area upon the under surface of the femoral neck, at the diaphyseal side of the epiphyseal cartilage; (2) upon the surface of the acetabulum, where the Haversian pad of fat is situated. Both of these situations are explained by the vascular distribution already described. The situation is influenced by two factors—by the position of the reflexion of the synovial membrane, and by the site of entrance of the anastomosis between the synovial and the osseous blood-vessels; therefore it is that the epiphysis is never infected unless secondary to disease of the joint, while the under surfaces of the metaphysis is so frequently the situation of disease. From the bone focus the synovial membrane may be infected secondarily.

Whether synovial or osseous in its origin, the disease soon becomes general. The synovial membrane is converted into tuberculous granulation tissue. The joint cavity becomes filled and distended with fluid and debris. The articular cartilages become diseased and detached. The spaces of the underlying bone become filled with tuberculous granulation tissue, and the rarefaction coupled with the pressure of the body weight produces an absorption and disappearance of the bone. The femoral head is gradually destroyed, and it may become detached at its epiphyseal cartilage. The femoral neck is shortened, and a wedge-shaped sequestrum is commonly found on its under surface. The acetabulum is eroded.

upwards and backwards from the pressure of the opposing head, and frequently its base is destroyed and the pelvic cavity penetrated. The soft tissues around the joint become invaded by the disease and peri-articular cold abscesses develop. From an osseous focus the abscesses appear extrasynovial, and usually upon the inner side of the joint among the adductor muscles of the thigh. From synovial disease it often first involves the bursa beneath the ilio-psoas tendon, and an abscess develops upon the front of the joint.

The migration and destruction of the acetabulum and the gradual absorption of the head and neck of the femur produce a shortening of the limb and a displacement from its natural position. There is a secondary contraction of the longitudinal pelvi-crural muscles. When the disease is well marked and has existed for some time, the blood-vessels in the neighbourhood of the joint become thickened by a process of endarteritis obliterans, and many years ago A. G. Miller pointed out that this toxic endarteritis affected the femoral artery, producing a considerable diminution in its bore. The endarteritis is probably responsible for a considerable amount of the muscular atrophy which is so characteristic of the disease. A natural cure results in one of several ways: By absorption of the tuberculous tissue at an early stage of the disease, by calcification of the material at a more advanced stage, or by evacuation and discharge through an external opening. The last is the method which nature most commonly employs. When the disease is purely osseous, changes occur in the joint which are not tuberculous but reflex in origin, and are secondary to the irritation of the bone focus. These changes consist in hyperemia of the synovial membrane and an accumulation of clear fluid within the joint cavity.

Summary.—In a well-established case one would summarise the pathological appearances as follows: The interior of the joint is filled with a varying quantity of fluid, usually semi-purulent, and containing a quantity of debris. The synovial membrane is irregular, in some parts thickened with a grey oedematous appearance, in others ulcerated and eroded. The cartilage is in one of two conditions: it is either fibrous, wasted, and pitted in appearance (perichondral ulceration); or it is of a dull yellow colour, and is being detached from the underlying bone in flakes (subchondral ulceration). When the bone is not actually diseased its structure is nevertheless altered, the bone lamellae are rarefied, and the spaces are filled with a yellow myxomatous marrow. The bone which is actually diseased looks eroded and worm-eaten. There are irregular cavities filled with tuberculous granulation tissue in varying stages of development. There are many small sequestra, and frequently a wedge-shaped one of appreciable size upon the under surface of the neck.

The contour of the head and neck may be considerably altered; the complete head may be loose in the joint cavity, separated at its epiphyseal attachment. The neck may be shortened by absorption in its long axis, or it may be altered in its angle into a condition of coxa vara. The
acetabulum is affected primarily or secondarily. Primarily it is the result of disease originating in its substance, when there is an area of erosion in the lower part of its floor. Secondarily it is due to absorption produced by the pressure of the femoral head, and an extension of the acetabular cavity upwards and backwards—a wandering acetabulum. The capsular ligament and its accessories are softened and relaxed; the ligamentum teres early becomes invaded and disappears. In the extracapsular tissue cold abscesses may develop upon the anterior and the internal aspects.

**Symptoms**

The onset is usually insidious. The history is often introduced by the account of an injury, sustained a varying period before. The value to be attached to such a precedent has been discussed, but it occurs too constantly to be entirely neglected.

**Stiffness.**—A stiff joint in the morning is an early symptom. When the child first rises the stiffness is remarked upon, but as the day passes it gradually lessens, and by night-time it has disappeared. It may appear on getting up after a rest of a few hours. It is supposed that pathologically it corresponds to an early stage of the disease, which is associated with a diminution in the amount of synovial fluid and an alteration in its healthy composition. The stiffness results from this. As movement is re-established, the vascularity of the synovial membrane increases, a further amount of synovial
fluid appears, the joint surfaces are better lubricated, and the stiffness disappears.

Lameness.—There is a certain degree of temporary limp associated with the stiffness, and this, at first almost unnoticeable, later becomes well established. There are two varieties of limp—early and late. The early limp is an effort to avoid weight-bearing by the diseased limb, the knee is slightly bent, and the pelvis tilted down, the thigh is somewhat abducted, the toes are pointed and the foot everted. The patient spends as little time as possible upon the diseased limb. The late limp is partly due to pain and stiffness in the joint, but in addition it is secondary to mechanical alterations in the relative positions of the bones—adduction, abduction, etc. Its characteristics are discussed later among the physical signs.

Pain.—Few cases have pain directly localised to the hip. It is usually referred, by a nerve distribution, either to the front of the thigh or the inner side of the knee-joint. As the disease progresses and malpositions appear, pain may then be localised in the joint. It is due to abnormal pressure of adjacent bony surfaces or to tension upon ligaments or muscles.

Self-protection.—The child learns by experience that jars and movements increase the local or referred pains, and to diminish the chance of injury, attitudes are adopted which may be called "positions of self-protection." They are really points for discussion in the physical examination, but they are often included and mentioned in the symptomatic history. These positions of self-protection are of two kinds: (1) In the early stages of the disease an attitude is taken up which steadies the affected limb. The toes of the healthy foot are placed beneath the sole of the diseased foot, so as to steady and support the latter. (2) At a later period, when the disease has become more established, extension is required for the relief of symptoms. The patient ingeniously obtains extension by resting the sole of the healthy foot upon the dorsum of the diseased one, and gradually extending the diseased limb by means of the healthy one.
Night Cries.—Night cries are present sooner or later. As the child drops off to sleep, the muscles which during consciousness have fixed the joint in a painless position relax, and the joint in consequence moves. The child wakens with a startled cry, and does not know what hurt him. The cries are typical of most forms of tuberculous joint disease.

Changes in General Health.—While a few patients retain their general health for a time, the majority are debilitated from the first. The onset of the disease is marked by general malaise; the child becomes cross and restless. The appetite begins to fail, and the weight lessens. There is often a slight rise of temperature in the evening. If abscess formation occurs the general symptoms become more marked. The loss of health is rapid, and the evening temperature may reach a height of 101 or 102 degrees. When the disease is complicated by sinus formation, then and almost essentially by a mixed infection, the symptoms of cachexia and waxy disease may appear.

Physical Examination

Physical Signs.—The child must be stripped from the waist downwards, and a thorough routine examination gone through.

General Inspection. —Appearance.—The child may appear wonderfully well-nourished and healthy, but more commonly there is some loss of flesh, and the face acquires a prematurely aged and distinctly anxious expression.

Position of Limbs at Rest.—Mention has been made of the two attitudes of self-protection, one securing fixation of the limb, the other providing extension. There are other alterations in position which may be called distortions of the limb. They are combined varieties of flexion, abduction, adduction, external rotation, internal rotation, apparent lengthening, apparent shortening, actual shortening, and lordosis. These deformities have been grouped together in various ways, and by their arrangement they have been responsible for the division of hip disease into three different stages. The deformity of the first stage may be one of pure flexion, or a slight degree of flexion combined with some abduction. Pathologically, the period corresponds to a pure synovial lesion, or to a bone lesion which has not yet opened freely into the joint. The explanation of the deformity is partly a reflex muscular irritation and partly a voluntary effort to reduce the shock and jar upon the sensitive limb.

The second stage is typically represented by a position of flexion, abduction, and eversion. When the deformity is corrected there is a lordosis of the lumbar spine and an apparent lengthening of the
HIP-JOINT DISEASE

affected limb. The apparent lengthening results from bringing the abducted limb parallel to its fellow. This can only be accomplished by a considerable tilting downwards of the pelvis upon the affected side, and a resulting apparent lengthening of the limb. The disease in the joint has become at this stage more extensive, and it has been said that the deformity is the result of an accumulation of fluid within the joint. The articular cartilages are being destroyed, and there is progressive involvement of all the structures of the joint.

The explanation of the deformity may be partly the accumulation of fluid within the capsule, but it is more probably the attitude which gives the greatest relief from pain, and therefore assumed both consciously and unconsciously.

The third stage of the disease is characterised by flexion, adduction, and inversion, with apparent or real shortening. The flexion, adduction, and inversion are mechanically combined, for as the joint irritation increases the more powerful adductors overcome the weaker abductors. The apparent shortening is secondary to the adduction, as bringing the limbs parallel must of necessity raise the pelvis upon the affected side. Real shortening has several explanations. It may be due to partial or entire absorption of the head of the femur, widening and migration of the acetabulum, atrophy of the bone, and retardation of growth, a coxa vara, or a pathological dislocation of the femoral head. It must be remembered that these combinations of deformity are not universally constant, but they are sufficiently so to form a convenient mode of subclassifying the disease.

Alterations in Walking. The Limp and its Characteristics.—From being at first almost imperceptible, the lameness increases, and the limp becomes more and more noticeable. In exceptionally acute cases of the disease the

Fig. 92.—Position of the affected limb in advanced hip-joint disease. The limb is held in a position of flexion, adduction, and internal rotation.

Fig. 93.—The gait in advanced left hip-joint disease. The pelvis is tilted upwards on the left side to accommodate for the adduction which is present.
pain may be so severe that the child may refuse absolutely to use the leg, or the malposition may be so excessive that walking is impossible. But in general, walking with a limp is carried on until late in the course of the illness. At first the limp is the result of stiffness, and its characteristic is a tendency to drag the affected limb. The foot is not lifted freely from the ground, but is swung round in an everted position with each step. As the disease progresses a more decided limp appears. There is a change in the rhythm of the gait, a long step alternating with a short one. The foot is held pointed and the weight is borne upon the anterior portion of the foot. At a later period, and before walking is given up, the lameness is pitiful. The hip and knee-joints are flexed, and there is a lordosis in the lumbar spine. The foot is strongly pointed, and the patient walks upon the very front of the foot. The shortest possible time is spent upon the affected limb, and with each step there is a drooping of the pelvis.

Alteration in Contour of the Joint and its Surroundings.—When the child is stripped for examination, the surgeon immediately notices the wasting of the muscles of the affected limb. The cause is doubtful; it is said to be reflex and secondary to the disease in the joint. Recent experiments of A. T. Legg would seem to point to the fact that it is largely the result of disuse. The wasting is most marked in the buttock of the affected side. There are alterations in the groin fold and in the buttock fold. The groin fold disappears when the limb is abducted and rotated outwards. Its depth is increased when the limb is adducted and rotated inwards. Its depth is also increased with flexion of the limb. As regards the gluteal fold, its position is lowered and its depth diminished when the limb is flexed, abducted, and rotated outwards. The fold is elevated and its depth diminished if the limb is flexed, adducted, and rotated inwards. The great trochanter is more prominent when the leg is adducted; it is less so when the limb is abducted. A localised fulness may be noticed around the outline of the joint; it usually means the formation of a cold abscess. A bulging in front of the groin may mean an enlargement of the ilio-psoas bursa, and this, according to D'Arcy Power, is an early sign of disease of the underlying joint. Wright attaches considerable importance to an enlargement of the inguinal glands.

Palpation of the Joint and the surrounding Bony Outlines.—It is possible to palpate the capsule of the joint by sinking one's fingers inwards behind the trochanter. An effusion into the joint may thus be appreciated, and when the joint is diseased the region is tender to pressure. It is not possible to investigate the joint by anterior palpation. The soft tissues around
are carefully investigated for the presence of inflammatory effusions and cold abscesses. Examination of the rectum must never be omitted, by it alone can an intra-pelvic effusion be recognised. The trochanter is palpated, and its size compared with that of the opposite side. Osseous disease is often associated with a distinct enlargement of that portion of the bone. By the delineation of Nelaton’s lines and Bryant’s triangles, an idea is gained of the presence and the degree of elevation of the trochanter. One expects an elevation when there is absorption of the neck of the bone or migration of the acetabulum. This portion of the examination is concluded by palpating the iliac fossa to exclude the presence of an iliac abscess, and by examining the groin for the presence of enlarged lymphatic glands.

Muscular Spasm.—Muscular spasm is the “splint” which nature employs to reduce the discomfort and pain of joint movements. It may be present only at the extremes of movement in one or more directions, or it may be so absolute as to simulate ankylosis. It disappears entirely under anaesthesia, and reappears with returning consciousness. Its origin is a double one; it is due in part to a reflex stimulus induced by the diseased synovial membrane, and in part to a voluntary effort, preventing the coaptation of diseased articular surfaces. The phenomenon becomes at once obvious when joint movements are investigated, but its presence may be demonstrated without arousing the pain which movement induces. Its occurrence is shown by manipulating the sound limb and observing the related changes in position of the suspected leg. By fully flexing the sound limb, the lumbar spine is pressed firmly upon the table, and any lordosis which may have existed is abolished. If lordosis has existed its presence may have been sufficient to mask a persistent flexion of the hip-joint, but when the lordosis is corrected the flexion of the hip at once becomes apparent (Thomas’s test). The flexion is the result of a persistent muscular spasm. Similarly, move-

![Fig. 95.—Thomas’s test to demonstrate the persistent muscular spasm producing flexion of the right hip-joint in hip-joint disease (right).](image)
ments of abduction in the sound limb will be accompanied by adduction of the affected leg, and adduction of the one by abduction of the other.

**Examination of Joint Movements.**—It is one of the most striking characteristics of hip-joint disease that the muscular spasm, which the disease gives rise to, induces a considerable limitation in the movements which a healthy joint ought to possess. Each movement ought to be examined in detail. This is a stage of the examination which may be associated with considerable pain to the patient, and it must be accomplished as gently as possible. To gain the sufferer’s confidence and to help in disarming his suspicion, it is well to begin by manipulating the healthy limb. The movements of which the hip-joint is capable are those of flexion, extension,
the foot with the right hand, and laying the palm of the left hand upon the sacrum in such a way that the fingers can investigate the right trochanter and the thumb the left. With the right hand movements of rotation, internal and external, are performed on each joint. If muscular spasm is present it is readily appreciated by the sudden arrest of the movement, the involuntary contraction of the gluteal muscles, and the rocking of the pelvis if further movement is attempted.

Hyperextension is estimated by fixing the pelvis with the open left hand, bending the knee to a right angle, grasping the ankle with the right hand, and steadily lifting the whole limb. Normally the degree of hyperextension ought to amount to 30 degrees.

Nothing is to be gained by the investigation of circumduction, and as any estimation of it is accompanied by intense pain, its examination should never be pursued.

**Measurements of Limb and Displacements.**—Estimations are required of the amount of real or apparent lengthening, of real or apparent shortening, of the degrees of flexion, abduction, or adduction, and of the circumference of the limb. To measure these amounts, certain landmarks are recognised and marked. They are the anterior superior spines, the internal malleoli, the posterior superior angles of the trochanters, the tuberosities of the ischia, and the umbilicus.

*Real lengthening* may be said for all practical purposes never to occur. Cases have been recorded in which, from stimulation of an epiphysis by neighbouring disease, limbs have increased in length. If it is present, its amount is estimated by comparing the measurements upon each side between the anterior superior spine and internal malleolus. *Apparent lengthening* is associated with abduction and tilting downwards of the pelvis upon the affected side. Its estimation is made by measuring the distance from the umbilicus to the internal malleoli upon both sides.

*Real shortening* is estimated by the comparative measurements from anterior superior spine to internal malleolus. The various causes which may give rise to shortening have been already mentioned. *Apparent shortening* depends upon adduction and upward tilting of the pelvis, and it is measured by the umbilico-malleolar line.

**Estimation of Flexion.**—This is estimated by Kingsley's method in the following manner: The patient lies on his back on a table, while the surgeon lifts the limb until the lordosis disappears and the pelvis lies in normal relation to the trunk. A measurement is taken from the table along the thigh for any distance, following the line of the femur, and from the extremity of this measurement a vertical line is dropped to the table. The exact length of both lines is noted. The decimal fraction obtained by dividing the length of the vertical line by the length of the line measured along the limb will give the sine of the angle between the limb and the table. By consulting a book of mathematical tables the exact size of the angle can be estimated. Kingsley measures a constant length of 24 inches

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along the thigh, and publishes a table showing the angle corresponding to the length of each vertical line from 1 to 24 inches.

**Kingsley's Table**

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**Estimation of Abduction and Adduction.**—The degree of these deformities is estimated by Lovett's method. With the patient's legs lying parallel, measurements are taken from the anterior superior spine to the internal malleolus upon each side, and similarly from the umbilicus to the internal malleoli. By these means the amount of real and the amount of apparent shortening are estimated. A further measurement is taken, namely, the distance between the anterior superior spines. If the apparent shortening is greater than the actual shortening, the displacement in the limb is one of adduction; if the apparent shortening is less than the real shortening, the limb is ab ducted. In order to make the calculation of the degree of abduction or adduction, two figures are required—the difference in inches between the real and the apparent shortening, and the distance between the anterior superior spines. The further estimation is made from Lovett's table:

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These estimations and measurements are important, because the question of diagnosis may occasionally depend upon their results.

The Investigation of Abscess Formation.—The tendency to the formation of abscesses in hip disease is considerable, and the condition must be looked for in every examination. Abscesses are in the majority of cases primarily intra-articular, but extracapsular ones may develop from bone foci lying outside the attachments of the ligaments. When the pus has originally formed within the joint, it usually penetrates through the weakest part of the capsule at a point upon the posterior inferior quadrant. Having gained the periarticular soft tissues, it may take up various positions.

(1) It may pass outwards beneath the attachment of the rectus femoris muscle, and appear on the thigh at the anterior border of the great trochanter, or more anteriorly at the outer side of the sartorius muscle.

(2) It may extend inwards, and appear as a cold abscess among the attachments of the adductor muscles at the inner side of the thigh.

(3) It may pass backwards, often along the course of the internal circumflex artery, appearing at the posterior edge of the great trochanter or the lower border of the gluteus maximus.

(4) It may travel along the sheath of the psoas and point above Poupart's ligament, or it may pass over the brim of the pelvis into the abdominal cavity.

(5) When the disease is markedly acetabular, the floor of that structure may be penetrated, and an abscess appear upon the inner surface of the bone which is palpable per rectum.

(6) By gravity and by the following of fascial and intermuscular planes, pus may travel a considerable distance, and become apparent at a point very remote from its site of origin.

Even when an abscess is not actually apparent its presence may be
suspected by an increase in general symptoms, more especially an increased swing in temperature.

**X-Ray Examination.** — By a radiographic examination certain information becomes available regarding the joint cavity, the synovial membrane, the bones, and the soft parts around.

*The Joint Cavity.*—Attention should be directed to the space which exists between the head of the femur and the surface of the acetabulum. If this space is much increased, and there is apparently a displacement outwards of the femoral head from the pelvic girdle, it probably means an accumulation of fluid within the joint cavity. Lying within the cavity osseous debris and small sequestra may be apparent.

*The Synovial Membrane.*—When the synovial membrane is diseased, it is often possible to delineate its thickened outline at the points where the thickening is greatest, namely, the synovial reflexions. Sometimes localised patches may appear specially prominent with disease. The synovial outline must not be mistaken for that of muscles and tendons around the joint.

*The Bones.*—There may be changes in the gross anatomy of the bones or in their intimate structure. The derangements of gross anatomy may include such changes as separation of the epiphysis, a tuberculous coxa vara, or an actual pathological dislocation. The more intimate bone structures show different changes in different stages of the disease. In early synovial disease the passage of the rays is less free than in a healthy hip, and the bony outline appears indistinct and hazy. Watson Cheyne believes that this blurring is the result of a pretuberculous thickening of the bony trabeculae. It is more likely the result of the increased thickening and vascularity at the synovial reflexion, with a correspondingly greater resistance to the passage of the rays, and therefore a blurring of the bony outline. Changes become apparent to the X-rays at the edges of the articular cartilages, more especially that covering the head of the femur. The free edges of the cartilage show a pitted, worm-eaten appearance. With more extensive disease, the joint outline is altogether altered. The head of the femur becomes eroded and irregular, areas of disease appear in the underlying bone, and the head may appear displaced at its epiphyseal attachment. The outline of the acetabulum becomes irregular, and a perforation into the pelvis may be apparent.

*The Soft Parts.*—A cold abscess becomes demonstrable among the soft parts as a clear area of increased resistance to the X-rays.¹

### Diagnosis

**Absolute Diagnosis.** — What are the points which lead one to make the diagnosis of hip-joint disease?

*The History.*—The history is essentially chronic, it may have existed for months before it comes under the care of the surgeon. It is the history of a disease which is confined to a single joint, and further there is a steady and

¹ These remarks are in terms of the negative.
progressive increase in the symptoms and signs. But it is on the revelations of physical examination that one bases one's diagnosis.

The Attitude of the Limb.—This is extremely suggestive—the early flexion, abduction, and eversion; the late flexion, adduction, and internal rotation.

The Gait.—The gait of a fully established case is typical of the disease, more especially the alternate long step and short, the bending of the joints and the flexion of the toes.

The Joint Outline.—Information gained from this is more confirmatory than diagnostic. Valuable signs will be found in the wasting of the buttocks, and the changes in the gluteal and groin folds.

Movements of the Joint and Muscular Spasm.—Limitation of movement and muscular spasm are interdependent, and from a diagnostic point of view they are by far the most valuable of all physical signs. Of the various movements which are limited, one attaches most importance to rotation, for the reason that it is usually the first to be interfered with.

Deformities of the Limb.—In all probability the diagnosis will have been made before this becomes apparent. In late cases of the disease it shows striking features. Flexion is not pathognomonic, as it is merely a position of rest, and one which is induced by a wide variety of diseases. The displacements of abduction, adduction, external and internal rotation are of much more significance.

X-Ray Examination.—The changes of early hip-joint disease may be practically imperceptible in the X-ray plate. The first feature to make its appearance will be the blurring and indistinctness of the femoral epiphysis. In the later stages X-rays are not so much a diagnostic aid as a means of telling one the extent and limitation of the disease.

Differential Diagnosis.—The following conditions may require to be excluded:

Local Irritation.—Irritation or disease of the genitals may produce persistent flexion of the thigh and considerable pain on movement, and in young girls vaginitis may produce signs which bear a very close resemblance to hip disease. The causes of the irritation are apparent on inspection, and with their cure the hip symptoms disappear.

Acute Adenitis.—Associated with this there is always a certain degree of flexion, but there is none of the muscular spasm of hip-joint disease, and further the enlarged groin glands are sufficiently obvious.

Local Injury.—Injury to the joint, often quite trivial in degree, may cause congestion of the epiphysis and some effusion into the joint cavity. The resulting symptoms may resemble hip-joint disease in so far as they are those of a limp, pain, and discomfort, but they are purely temporary, and at the end of a week or two they have disappeared.

Anterior Poliomyelitis.—The introductory stages of infantile paralysis may be associated with local pain in the affected limb. Any difficulty in diagnosis is temporary, and it is cleared up by the onset of paralysis.

Acute Arthritis and Epiphysitis.—This is not uncommon in young children as a sequel to the exanthemata, pneumonia, or diphtheria. It may
be distinguished from tuberculous disease by the sudden onset of symptoms, by the high fever and severe constitutional disturbance, and by the frequency with which several joints are involved.

Rheumatism.—Rheumatism is usually of sudden onset. It is always migratory in character and accompanied by fever. In children it is sometimes confined to a single large joint, and for a time its diagnosis may be doubtful. In a questionable case salicylates should be administered; a rheumatic joint is relieved, a tuberculous joint is not affected.

Lumbar Pott’s Disease.—The first symptom of this condition may be a limp and restriction of movement in one leg. This is due to an infiltration of the psoas muscle with tuberculous disease and an irritation and contraction of its fibres. It is recognised by the presence of rigidity in the lumbar spine, and by the fact that the only movement limited in the hip-joint is one of extension. It may also be excluded by the distribution of superficial pain (page 145).

Knee-joint Disease.—It is essential to draw attention to the fact that hip-joint disease is often associated with the presence of pain referred to the knee. Examination will show which part is affected. It is a rule well worth remembering, “In every case of painful hip examine the spine, and in every case of painful knee examine the hip.”

Coxa Vara.—This distortion of the neck of the femur may lead to difficulties and errors in diagnosis. The signs which induce confusion are those of shortening and limping. A diagnosis should be made by examination of the movements. In coxa vara either the movements are uniformly free or abduction alone is limited; in tuberculous disease of the joint there is a general limitation.

Hysterical Joint Affection.—Confusion with this condition arises more commonly at a later life-period, but before puberty nervous children may simulate tuberculous disease by a condition of joint sensitiveness with lameness and pain. The characteristics of the functional disorders are the variability of their intensity and their inconsistency.

Periarticular Disease which has not yet involved the Joint.—Clinically this is suggested by a symptomatology which resembles tuberculous joint disease, and yet on physical examination the typical muscular rigidity is not shown. The most reliable of all the methods of physical examination is the limitation of the movements of rotation. Limitation of these is strongly in favour of the joint being involved.

Perinephritis and Appendicitis.—These have been mistaken for hip disease because of the psoas contraction which they produce. They are distinguished by their history and by the limitation of movement being restricted to a single movement—that of extension.

Prognosis

Functional Prognosis.—Cure may result with a complete recovery of usefulness and movement. This is exceptional; usually there is a varying
amount of limitation of movement, and quite often there is complete ankylosis. The functional result depends upon four factors—(1) the condition of the disease when it first came under treatment; (2) the thoroughness and efficiency of the treatment which has been adopted; (3) the severity of the disease in the course which it has run; (4) the resistance of the individual whom it has attacked.

Length of Time under Treatment.—The early discontinuance of treatment is a serious mistake; relapses are liable to occur, and the relapse is frequently worse than the original disease. Treatment must be continued until the joint is able to bear a considerable amount of weight and strain without pain or muscular spasm resulting. Mechanical treatment must be continued for a long period after all active symptoms have disappeared. Two years at least are necessary to produce a cure.

Life Prognosis.—Actual statistics of the mortality of hip disease are not very reliable. It of course varies widely and in different sections of the community; under efficient treatment and proper surroundings it is certainly not high. The mortality is due almost entirely to the immediate or the remote effect of abscess formation. This is well illustrated by the statistics of Bruns. He showed that the mortality in non-suppurative cases was 23 per cent, while in cases in which suppuration was present it amounted to 52 per cent. Wagner¹ found at Tübingen that the mortality amounted to 40 per cent. At Heidelberg, according to Huismans,² it was 46.6 per cent in non-operative cases and 58 per cent in operative cases. The mortality among the patients in German cliniques is undoubtedly much higher than it is among the same class of patient in this country and America. In 288 cases treated at the Hospital for Ruptured and Crippled, New York, the death-rate was 12.5 per cent (Gibney).³ And in this country the average mortality varies from 10 to 18 per cent.

Death results from a variety of causes. The most common are: (1) miliary tuberculosis; (2) tuberculous meningitis; (3) pulmonary tuberculosis; (4) waxy disease; (5) exhaustion; (6) intercurrent disease. It is believed that operative interference is the predisposing cause of general tuberculosis and tuberculous meningitis. Statistics do not bear out this assertion. It is estimated that 75 per cent of the death-rate is directly or indirectly due to suppuration.

Treatment

General Treatment

The improvement of hip disease by sunshine and fresh air is of the utmost importance. Food, sunlight, and healthy environment are the first considerations, and by them is the inherent resistant force increased. A cure very largely depends upon the wise oversight and management of these

¹ Wagner, Beitr. z. klin. Chir., 1895, Bd. xiii.
³ Gibney, New York Medical Journal, July and August 1877.
general factors. For a discussion of this portion of the treatment the reader is referred to page 64.

**Local Treatment**

To increase the practical interest the local treatment will be considered in the sequence in which it is actually employed. It may be divided into:

1. Treatment for the relief of acute symptoms.
2. Fixative or recumbent treatment.
5. Treatment of deformities.
6. Treatment of complications.

(1) **Treatment for the Relief of Acute Symptoms**

When the patient is first brought to the surgeon it is common to find that the child's leading signs are those of pain in the joint, muscular spasm, and flexion of the diseased hip. It ought to be one's first duty to relieve these, and the best method with which to gain relief is extension by weight and pulley. The child is put in a bed which has been specially prepared for extension by the insertion of a firm mattress. It is well to control the body by means of some variety of double splint. A Hamilton's or a Bryant's is the best, but in the event of these not being available there is no great disadvantage experienced. Extension strapping is applied to the diseased limb (for method see p. 101), and a stirrup and weight are attached to the end of the extension tapes. The amount of weight used varies according to the age and the muscularity of the child. A more complete extension is obtained by raising the foot of the bed. Extension applied in this way usually gives most rapid relief to the distressing symptoms. If it is found that the pain is not relieved an explanation must be sought, and it is one of two: it may be due to an error in the amount of weight used, too much or too little—the error is more frequently the former; or it may be the result of an imperfect separation of the articular surfaces. When the latter is the fault it is often remedied by combining the extension in the long axis of the limb with an extension parallel to the axis of the neck of the femur. This lateral traction is carried out by passing a bandage round the thigh at the upper end of the femur; the ends of the
bandage are connected with a weight hanging over the side of the bed. Traction is thus produced in the axis of the neck of the femur. Counter extension is secured by passing a bandage round the pelvis upon the diseased side and connecting it to a weight.

When flexion or the deformities of abduction or adduction are present an alteration must be made in the usual method of extension. The traction must not be indiscriminately applied in the position which the limb ought to occupy, but it should be applied at first in the axis of the deformity. Gradually this axis is brought nearer and nearer to the healthy one until the deformity has disappeared. Of course such a correction of the deformity presupposes that simple muscular spasm is the cause of the occurrence. Extension is of comparatively little use when there is contraction of liga-

![Image](https://via.placeholder.com/150)

**Fig. 99.**—Right-angled traction in the treatment of hip-joint disease.

ments and of fibrous tissue. At the end of some weeks of weight-extension the signs for which it has been introduced will have disappeared, and the further stage in treatment may be proceeded with.

(2) Recumbent Treatment

Thomas believed that as long as a joint was immobilised it was in a suitable condition for progressive cure. It has been asserted that complete fixation of a joint is liable to lead to ankylosis. If the joint disease is early, ankylosis will certainly not occur; and if the changes in the joint are so extensive as to render ankylosis possible, it is probably the best thing which could happen with a view to later cure as a result. Therefore, when the acute symptoms of pain, spasm, etc., have disappeared, the joint is immobilised without being permitted to bear any weight. In the Edinburgh Children’s Hospital two methods for securing complete fixation are in general use—they are the long plaster bandage and the Thomas hip splint.

The Long Plaster Bandage.—In out-patient work dealing with the poorer classes of patients, this is the favourite application. It has the
advantages of cheapness, durability, comfort, and absolute fixation. Its disadvantages are the tendency to become filthy and the weight.

**Method of Application.**

—The joint is in a suitable condition for the application of the plaster when pain and spasm have been relieved and deformity corrected. The general rules for the application of plaster are followed (see page 70), and the casing is carried round the pelvis and downwards to above the ankle, or to include the foot. It is applied in a position of slight abduction and flexion at the hip-joint and slight flexion at the knee-joint. As the plaster has a considerable tendency to break opposite the hip and knee joints, these parts are specially strengthened by incorporating in the plaster narrow strips of aluminium—one in front and one behind, opposite the hip-joint, and one behind the knee-joint.

**The Thomas Hip Splint.**—This method of fixation one usually recommends in private. It has the special advantages of lightness, adaptability, and cleanliness. When weighed against the plaster splint it possesses the disadvantages of being more expensive and perhaps of being a less efficient immobiliser. The splint is made as follows: A flat piece of malleable iron, \( \frac{3}{4} \) inch wide and \( \frac{3}{16} \) of an inch thick, and long enough to extend from the lower angle of the scapula to the middle of the calf, forms the upright. It is fitted to the body of the patient, passing from the lower angle of the scapula in a perpendicular line downward over the lumbar region, across the pelvis, slightly external but close to the posterior superior spine of the ilium and the prominence of the buttock, along the course of the sciatic nerve to a point slightly external to the centre of the calf of the leg. The lumbar portion of the upright must be a plane surface, on no account must it be bent to the lumbar lordosis. It must, however, be slightly twisted upon its own axis at the junction of the upper and middle thirds, so that the anterior surface of the lower part may look slightly outwards to correspond to the contour of the
buttock and the thigh. A second and double bend is made in the upright at the point where it passes the buttock, so that the thigh part lies on a slightly higher plane than the body part, but parallel with it. To the upright, chest, thigh, and leg bands are fitted. The chest band is of hoop iron, it is 1\frac{1}{2} inches wide and \frac{1}{4} inch in thickness. It is bent into an oval to fit the shape of the chest, but a space of about 4 inches ought to exist between its anterior extremities. This space is bridged across by a strap adjustable to metal studs. The chest band is riveted to the upper extremity of the brace, so that a third of its length shall be on the side of the diseased joint and two-thirds on the other. The thigh and the leg bands are also of hoop iron; they are \frac{3}{4} inch wide and \frac{1}{4} inch thick. The thigh band is equal to two-thirds of the circumference of the thigh, and is fastened to the upright at a point 1 or 2 inches below the buttock. The calf band is equal in length to half the circumference of the calf, and it is riveted to the lower extremity of the brace. The splint is wound with thin boiler felt, and covered with smooth leather sewn together upon the outer side. In fitting the splint the long arm of the chest band is made to hug the body closely, while the short arm should be somewhat away from it; the thigh and calf bands are applied to the limb. The splint is suspended by shoulder straps attached to the transverse bar, and between the thigh and calf bands the splint is secured to the limb by turns of a domette bandage. The splint must be heavy and strong, and it is effectively applied when a furrow appears on the buttock directly over the neck of the femur. Once fitted the splint is only changed at infrequent intervals. To prevent any possibility of the child attempting to walk, a flat iron bar is fastened so as to project from the end of the splint. This bar is called "a nurse."

Complete fixation is continued for at least one year, in some cases for eighteen months. If plaster is used the case is removed and reapplied at intervals of three months during this period. At the end of the period the joint ought to be well on its way towards cure, and the conditions are favourable when there is absence of pain and muscular spasm and no tendency towards a deformity. To judge of this, the fixation apparatus is entirely removed for about three days—the child, of course, being kept in bed. With conclusion of the recumbent treatment the ambulatory treatment is begun, but before one does so one must consider another method by which fixation may be secured.

The Traction Hip Splint.—While a Thomas hip splint and the plaster bandage provide immobilisation of the part, they do not ensure any degree of traction. The traction hip splint affords a considerable amount of fixation,
and in addition it provides traction. It was originally introduced by Davis, and modified considerably by Taylor and Sayre. Its introducers intended the splint to be used as a means of ambulatory treatment, but it is often employed during the recumbent period, and it will be described now. It consists of an upright, an adjustable foot-piece, a waist-band, and leg and perineal bands. The upright is a square steel rod connecting the waist-band and the foot-piece, and it extends from the level of the anterior superior spine to a point about 3 inches beyond the sole of the foot. It may be in a straight line or it may be bent to fit the curve of the thigh and the knee. The lower end is perforated with holes for the attachment of the adjustable foot-piece, and the upper end is flattened out into a small oblong plate for attachment to the waist-band. The adjustable foot-piece is forged from a piece of steel, 11 inches long. The upper end is flattened into an oval and the projecting sides turned up; to clasp the upright, it is perforated with a row of screw holes. In the lower part it is forged ⅛ inch wide and ¼ inch thick; ⅜ inch is then turned over at the end at a sharp right angle, and a similar angle is forged 2½ inches further up to form a foot-piece. A ¼-inch hole is bored in the turned-up end, ⅛ inch from the ground, and one in the upright opposite it for the attachment of a windlass spindle. This is 3½ inches long and ⅛ inch in diameter, it is square at one end and
is held in place by a pin. It projects beyond the outside surface of the upright for \( \frac{1}{2} \) an inch. Outside, next to the upright, there is attached to it a \( \frac{1}{2} \)-inch ratchet wheel, which is controlled by a spring and stop fastened to the upright by pins. The projecting end of the spindle is made square to fit a clock key. The centre of the spindle is filed half-way through on one side and a slot cut out and in from this point to within \( \frac{1}{4} \) inch of the foot-piece to receive the webbing straps of the extension. The waist-band is of flat steel 1 inch wide. The posterior half is 1 inch longer than the anterior half, and it is bent in a more gradual curve. The band extends from the centre of the outer surface of the thigh above the trochanter to a point just over the opposite anterior superior spine. It is riveted to the upper end of the upright, and it is inclined at 20 degrees to the horizon, the posterior end being higher. Buckles are fastened to the lower edge of the waist-band for the attachment of the perineal straps—there are two in front and two behind. At the back they lie upon each side half-way between the trochanter and the posterior superior spines. In front they are sufficiently far apart not to exert any pressure upon the genitals. To the end of the posterior arm a belt is attached to complete the waist-band, it buckles to the extremity of the anterior arm.

**Leg Bands.**—There are generally three of these in older children and two in small ones. They are situated at the middle of the thigh and the upper third of the calf. They extend half round the limb and the circumference is completed by a strap.

**The Perineal Bands.**—The perineal bands are of webbing covered with Canton flannel and padded with felt. They are secured to the buckles of the waist-belt in front and behind.

**The Application of the Splint.**—Traction is made upon the leg by adhesive plaster in any of the methods already described. The lower ends of the adhesive straps terminate in tapes which project beyond the foot for attachment to the windlass of the splint. The splint is applied in the following manner: The patient lying on his back, the pelvic band is adjusted and strapped about the body. The perineal bands are drawn firmly into
place, so that pressure on the upright does not move the pelvic band from its proper position just above the trochanter. The brace is pushed upwards against the resistance of the pelvic bands, while the limb is at the same time drawn downwards and fixed by attaching the extension straps to the buckles at the end of the adhesive plasters. Traction is applied to the point of tolerance by means of the key. The splint must be worn day and night. The perineal bands may be loosened from time to time to allow for bathing the skin with alcohol and for powdering, but while this is being done manual traction should be made upon the limb until the brace has been readjusted. Considering the apparatus as a fixation splint and not as a walking brace (see later) it has distinct advantages. It is decidedly comfortable, it ensures constant and effective traction; and as long as the patient remains recumbent and the traction is continued, there is good practical fixation.

(3) Ambulatory Treatment

Ambulatory treatment must be begun gradually. The patient at first gets up for a short time, morning and evening, and that period is extended from time to time. For the successful conduction of ambulatory treatment it is essential that the hip-joint should be fixed, and that the weight-bearing function of the joint should be reduced to a minimum. The special advantage of the method lies in the fact that it is favourable to a rapid improvement in the patient's general condition, for he is now able to spend his time out of doors and have that amount of exercise which tones and invigorates his system.

Methods.—Splints, too numerous to mention, have been introduced at one time and another. It is possible to mention only the more important. It will simplify matters to describe them under three headings: (A) The plaster splint and its modifications; (B) Thomas splint and its modifications; (C) The traction splint and its modifications.

(A) The Plaster Splint and its Modifications

(1) The Long Plaster Spica with High Boot and Crutches.—The plaster case is applied in the usual manner, extending around the pelvis and along the leg as far as the foot. The boot used on the healthy foot is fitted with a patten or a high sole of such a height that when the patient stands erect the foot which is encased in plaster is swung free of the ground. Crutches are used to get about with. If one were asked to summarise the advantages of this splint one would mention its cheapness, the simplicity of its application, and the complete fixation which it affords to the joint. It has, however, disadvantages, which are very considerable. Its weight is excessive and the majority of children find it so distressing that they refuse to continue the treatment. The second disadvantage is that of discomfort; as long as the patient lies recumbent a plaster case may be exceedingly comfortable, but when the erect position is maintained for any length of time there is
a persistent drag upon the pelvic girdle, and this drag soon becomes a source of annoyance.

(2) The Short Plaster Spica.—This is sometimes called the "Lorenz" splint. It is used in the Lorenz Clinic at Vienna as the routine treatment of hip disease, except in those cases which cannot bear direct weight without pain being aroused. Here it is discussed purely as a means of ambulatory treatment. The plaster case is applied to the affected limb in such a way that it fixes the limb in an attitude of slight flexion and abduction. The plaster is carefully moulded about the pelvis and thigh; at its lower end it is cut away immediately above or immediately below the knee. Above, it rises laterally to below the iliac crests, anteriorly to just above the symphysis pubis, and posteriorly it passes across the centre of the sacrum. Crutches and a high boot upon the opposite foot are used. In mild cases the splint is preferable to the heavy long splint. It possesses the common advantages of simplicity and cheapness, and in addition it is by comparison considerably lighter. It has, however, by no means the same power of fixation, and for that reason its use is not to be recommended in any but the mildest and most advantageous cases.

(3) The Lorenz Splint with Stilt.—In the treatment of the more acute cases Lorenz recommends the use of a stilt in combination with the short spica. It is part of Lorenz's plan to allow his patients to bear weight upon the diseased joint, and it is when weight-bearing induces pain that he advises the use of his stilt. There are many who do not consider that weight-bearing ought to be permitted during the period of ambulatory treatment, and therefore would not make use of the stilt for this reason, but because it improves the process of ambulation. The stilt consists of a stirrup of steel which projects for about 3 inches beyond the sole of the foot. To the upper end of the stirrup semicircles of steel are attached, and these are incorporated in the plaster above the region of the knee. The patient walks upon the lower end of the stilt, the foot being thus carried free of the ground. The weight is transmitted along the side of the stilt to the plaster and thence to the pelvic girdle. This application has the advantage of making locomotion easier for the patient, and when the short spica is used as the fixation agent it is well to combine the stilt with it.

(4) The Short Spica with the Traction Brace.—Whitman was the first to
recommend the combination of the short spica bandage with the traction splint. He describes how he had been taught in his early training to rely largely for treatment upon the traction splint. He later became somewhat dissatisfied with this method, as he found that while it usually relieved pain and muscular spasm it did not prevent deformity if the patient was permitted to go about. The deformity most commonly produced was one of flexion and adduction, and it came on when the patient was allowed to sit up. The traction splint was further disappointing in so far that during exacerbation it did not materially relieve the pain. Under these conditions it was found that acute symptoms might be relieved and deformity prevented by the application of a close-fitting short spica bandage extending from the middle of the thorax to the knee. Over this the traction brace was applied. An apparatus is thus produced which combines fixation, traction, and stilting, a high boot being worn on the healthy foot.

(B) Thomas Splint and its Modifications

(1) Simple Thomas Splint with High Boot and Crutches.—When the simple Thomas splint is used in ambulatory treatment, weight-bearing is removed from the diseased limb by fitting a patten to the opposite foot and giving the patient crutches. In this country it is probably the most common appliance used at this period of treatment, and it is most satisfactory. When used during the ambulatory period the splint has a tendency to rotate, but this can be prevented by accurate fitting. The liability which there is to the development of the lateral distortions of abduction or adduction is counteracted by the use of opposite-sided chest bands (page 237).

(2) The Short Thomas Splint.—This is a modification of the ordinary Thomas in which the vertical portion of the splint ends at the thigh cross bar. It possesses the advantage of movement at the knee, rather a doubtful advantage, as the knee movement is only gained at the expense of diminishing the fixation of the hip. It should only be used as a convalescent splint.

(3) The Combined Thomas and Traction Splint.—Elsewhere the reasons for the introduction of the combined short spica and traction splint have been discussed. The combined Thomas and traction splint was produced to meet very similar indications. To the pelvic band of a traction splint a lateral thoracic bar is attached, reaching upwards in the axillary line to a point opposite the middle of the scapula, where it is joined to a metal band encircling the chest. Traction is secured as in an ordinary traction splint. The splint can be further improved by substituting for the perineal bands of the traction splint a ring similar to that used in a Thomas knee splint. The ring is fixed to the lateral bar of the traction splint, and it affords excellent fixation to the pelvis.
(C) The Traction Hip Splint and its Modifications

(a) The Simple Traction Splint.—The simple splint has been already described in application to recumbent treatment, and it differs in no respect when used as an ambulatory splint. When the apparatus is used as a walking brace, constant traction is not exerted, for the traction straps alternately relax and tighten as the body weight in walking alternately falls upon and leaves the brace. The critics of the brace, therefore, assert that it exerts a deleterious pumping action upon the joint. In acute cases the braced limb is made pendent by using a high sole upon the opposite foot and crutches. Treatment by the long traction brace has been called "The American Treatment of Hip Disease."

(b) The Traction Splint combined with the Short Spica has been already described (page 229).

(c) The Combined Traction and Thomas Splint has also been described (page 230).

(d) Bradford Hip Splint.—This form of apparatus has been devised for the purpose of fixing the hip by traction, and at the same time overcoming the chronic muscular spasm at the joint. It consists of two steel rods, longer than the affected limb, connected below by a flat steel bar, furnished with a small windlass attachment to produce traction, and above by a ring open in front. This ring is placed obliquely upon the rods so as to fit the buttock from the tuber ischii to above the great trochanter. To the ring near the top of the inner rod a bent steel rod is welded; it passes above the symphysis and under the perineum of the healthy side, and should be long enough so that the end does not press into the buttock when the patient is seated. The limb is steadied by circular leather straps, and traction is furnished by means of adhesive plaster straps secured to the windlass and applied to the limb. When the splint is properly applied there is excellent fixation of the hip-joint, and the limb is held well abducted. The appliance is light and inexpensive, and it requires no special skill in adjustment. Locomotion is made possible by raising the sole of the opposite boot, and if necessary crutches are added.

Phelps Hip Splint.—To this form of hip splint Phelps applied the principle of the Thomas ring. It combines fixation with traction, and the traction is a double one, being both vertical and lateral. There is a lateral stay running from the axilla to beyond the foot, and the lower end is fitted
with an adjustable foot-piece and traction straps, exactly as in the traction splint. There are two body bands, one passing round the chest and one round the pelvis. They are of steel riveted to the upright, their circumference being completed with a leather strap and buckle. Opposite the hip-joint a Thomas ring is fastened obliquely to the upright in such a way that it supports the pelvis passing from above the trochanter to beneath the tuberosity of the ischium. The leg is fastened to the upright by a semi-circular band opposite the knee and one round the ankle. At the upper third of the thigh there is a flat leather pad which presses upon the inner side of the limb, and is fastened to the upright by adjustable cords which pass round the limb to the upright; by means of this pad lateral traction is carried out. The splint is applied to the limb; vertical extension is procured by fastening adhesive plasters to the limb and securing their ends to the extension buckles; lateral extension is obtained by means of the pad and cord just mentioned. While this splint appears excellent in theory it is rather disappointing in practice. Its vertical traction is imperfect, and the lateral traction is certainly more imaginary than real. However, the upright and the Thomas ring give good fixation.

It has been urged against splints such as this, which possess an upright passing beyond the hip to the chest, that the fixation which they afford is ineffective because the movements of the trunk are transmitted to the joint. This is not true of braces which do not extend above the pelvis. In practice one finds that motion of the upper part of the trunk is absorbed as it were in the flexible lumbar region of the spine before it reaches the joint. The chief disadvantage of long splints which fix the hip and spine appears when the patient attempts to sit down; such a manoeuvre becomes impossible with any degree of comfort. To meet the difficulty a special chair is used in which there is only half a seat and that for the sound side. The splinted limb remains in the extended position, the brace resting upon the floor.

The Dane Hip Splint.—Dane's splint is a combination of the Thomas knee splint with a windlass and ratchet for extension at the base, and with the waist-band of a traction splint fastened to the top above the ring. It differs from the Thomas knee splint in having a stouter upright on the outer side. From the waist-band there is no perineal band upon the diseased side, as its place is taken by the ring. Upon the healthy side there is a perineal band usually in the shape of a chain covered with chamois leather. Dane later modified his splint by altering the waist-band. He has added to it a second posterior pelvic band, which is carried as low down as possible.
over the sacrum. A firm grasp of the pelvis is thus obtained, and movements of the hip-joint are in large measure prevented. It is an excellent splint, but it requires care in adjustment in order to prevent the formation of sores in the perineum.

The Convalescent Hip Splint.—The convalescent hip splint is a form of traction splint, which, while it keeps the patient's heel off the ground, permits him to walk upon his toes. The traction splint is easily converted into the convalescent type. The lower end is cut 3 inches from the ground, and there is welded to the lower part a piece long enough to extend 2 inches below the sole of the boot, where it extends into a bulbous tip ¾ inch in diameter. The splint should extend from the anterior superior spine to 1½ inches beyond the bottom of the heel, the foot being held at right angles. If desired the lower end of the splint can be made adjustable with screws. The bulbous tip may be covered over with a crutch rubber to prevent slipping. A modification of the splint is made by attaching the lower end to the sole of the boot.

Tubular Hip Splint.—For children under five years of age Thornton recommends a traction splint with an upright of steel tubing, because it is stiffer and lighter than a small steel rod. The upright consists of a piece of

1 Thornton, loc. sup. cit. p. 372.
Steel tubing about \( \frac{3}{4} \) inch in diameter; to its upper end a waist-band is attached as in a single traction splint; into the lower end of the upright there slides a rod, which carries a foot-piece. Rotation of the rod in the tube is prevented by fastening a pin into the rod through a slot in the tube, and vertical movement is controlled by nuts and screws. The foot-piece is not provided with a windlass but with buckles. Extension is secured with strapping in the usual way.

**The Choice of an Ambulatory Splint.**—It is difficult to recommend any one of the above-mentioned ambulatory splints. One must judge by practical experience, and it is only this which will guide one in the choice of splint for an individual case. One's routine practice is to employ a Thomas splint. If pain and spasm begin to reappear one either returns the patient to recumbency and weight extension, or one tries the substitution of a traction splint for the Thomas. The second contra-indication to the use of the Thomas splint is the tendency to a deformity in the shape of adduction, and when this threatens one recommends a Bradford abduction splint.

(4) **Convalescent Treatment**

The surgeon often experiences considerable difficulty in making up his mind when ambulatory treatment is to be stopped. In deciding
this point it must be insisted that the ambulatory treatment shall have been continued for a sufficient length of time to enable the disease to recover, presupposing that it is of the ordinary type and treated under satisfactory conditions. If there have been no symptoms of active disease for a year or more, and if muscular spasm is absent, one may test the joint by removing the splint at night to ascertain the effect of simple motion without weight-bearing. This is continued for about one month, and if at the end of that time free movement is being acquired without pain or discomfort some form of walking splint may be fitted.

WalkingSplints.—Up to this point, while the patient has been permitted to walk about, no direct weight has been borne by the joint, because care has been taken to fit the opposite boot with a patten and to provide the patient with crutches. In this, which may be called the final stage of treatment, while a certain amount of support is given to the joint, some degree of weight-bearing is permitted and movements are encouraged within certain limits. To fulfil these indications walking splints are in use.

_Taylor's Convalescent Splint._—The structure of the splint is easily understood by reference to the illustration. The lateral brace is jointed at the knee, and it is so adjusted that it is slightly longer than the leg; the heel does not touch the bottom of the shoe. The weight is therefore partly removed from the foot, and borne instead by a perineal band which is attached to the upper end of the splint.

_Convalescent Lateral Brace._—This is an excellent form of walking splint, combining lightness, simplicity, and cheapness. A lateral brace is attached above to a pelvic band and to a perineal crutch, and opposite the knee the brace is jointed. The lower end of the splint is attached as in a calliper splint to the sole of the boot.

There are other forms of walking splints, but the above mentioned are very satisfactory.

As the strain upon the joint becomes naturally increased it is necessary to watch carefully for any return of muscular spasm, pain, or increasing limitation of movement. The stage of supervision ought to be continued for at least three months in even the most favourable case. The brace is then removed at intervals and finally discarded entirely. When the brace has been discarded the patient should be trained to walk with equal steps, placing each limb as far as possible upon an equality with its fellow, and adapting the stronger to the weaker member. This precaution has an important influence in checking the tendency to deformity, and in modifying or even concealing any limp which may exist.
(5) **Treatment of Deformities**

The deformities which may occur in the course of the disease are those of flexion, abduction, adduction, or a combination of either of the two last mentioned with flexion. The deformities of eversion and inversion may be neglected, as they are so dependent upon the position of abduction or adduction. According as they occur in the early or in the later stages of the disease the deformities have various origins. Early they are the result of muscular spasm, later they depend upon contraction of the soft parts and alteration in the bony outlines. The treatment may be considered under the headings of

(A) Gradual correction.
(B) Rapid correction.
(C) Operative correction.

(A) **Gradual Correction**

There are four methods of gradual correction which fall to be discussed:

- By weight and pulley.
- By the traction splint.
- By the plaster bandage.
- By the Thomas splint.

*By Weight and Pulley.*—Some directions have been given in the application of these (page 102). After the extension plasters are applied to the limb the latter is placed in such a position that the iliac spines are on the same level and the lumbar spine rests upon the mattress. The fulfilment of these obligations will maintain the limb in a deformed position, and at first the extension is to be applied in such an axis.¹ The limb may be supported upon a pillow or upon an adjustable wooden triangle, the extension being applied over a pulley in the line of the elevated leg. As in Buck's system of extension, the foot of the bed may be raised in order to increase the friction of the body and so to counteract the traction. In young children this procedure may be insufficient, and a direct counter-extension may become necessary. This is best secured by a couple of perineal bands which pass upon each side, above and below the patient, and are attached to the top corners of the bed. In order to secure efficient traction the patient must not be allowed to sit up, therefore a swathe is applied around the body and fastened to the bed, or shoulder straps are applied. If it is necessary to fix the patient more completely, it is well to use a long lateral splint extending from the axilla to beyond the foot and attached below to a cross bar. The bed-clothes are held from the raised limb by some variety of cradle. At first the traction weight must not be great, but from day to day it is increased. After traction has been maintained for two or three days in the deformed position the axis of the limb is gradually altered until it more exactly approximates to the normal. The flexion is reduced and the adduction

¹ This detail was first pointed out by Professor Howard Marsh.
or abduction gradually corrected. The process of correction is slow, as it depends upon a stretching of the shortened soft tissue structures; the method is valueless when there is osseous ankylosis or bone deformity.

By the Traction Splint.—The application of this splint has been discussed, and it has a distinct place in the treatment of the correction of deformity. The principle of its action is similar to that of the weight and pulley in which the shrunken soft structures are gradually stretched. It possesses the advantage that its action can be maintained and yet the patient is able to go about, crutches and a high patten on the opposite foot being used. There is, however, the great disadvantage that it is difficult to so alter the long axis of the splint that it fits the deformed limb. It is, therefore, often impossible to secure traction in the proper direction.

By the Plaster Bandage.—When this method is adopted the original plaster bandage is applied to the limb in its deformed position. It is kept in position for four weeks, and during that time the rest and fixation have done much to relieve the muscular spasm which may be playing a very considerable part in the deformity. Therefore, when the first case is removed the deformity may be very considerably reduced. If some degree of malposition still exists an accurately fitting second case is applied, and when it is removed at the end of the second month it may be found that the deformity can be completely reduced.

By Thomas Splint.—In children a satisfactory correction is obtained by using the double Thomas splint. The sound limb is fixed in the extended position, while the displaced limb is supported by the other arm of the splint, straight or bent to the angle of the deformity. The splint is best suited for the correction of a flexion deformity. The common mistake has already been alluded to of shaping a Thomas splint above the buttock to fit the lumbar lordosis. A correctly made splint, in which the portions of the upright above and below the pelvis are straight and in parallel planes, exercises a continuous corrective action on a flexion deformity. A splint altered, as has been described, is useless as a corrective agent. When the flexion deformity is too great to be treated by the straight splint, the arm of the splint supporting the diseased limb is bent by wrenches to such a position that it fits the deformity. As the muscular spasm subsides the splint is straightened slightly from time to time at a point opposite the hip-joint, so as to conform to the improved position. This is done until the limb is straightened. If there is much flexion it is advisable to reduce it as far as possible by weight extension before applying a corrective Thomas splint.

The deformities of abduction and adduction are much more difficult to correct than that of flexion. If there exists any degree of abduction a wing should be attached to the splint which passes round the flank on the side opposite to the disease. The wing is made from the same-sized iron as the thigh band of the splint. It is placed at such a point that it will pass round the flank midway between the rib border and the crest of the ilium; this point is usually situated upon the vertical of the splint midway between the chest band and the buttock bend. Assuming that the right
leg is the one affected: to counteract abduction the band is fitted to the right side of the body, to counteract adduction the band is fitted to the left side. The splint is applied so that the correcting band exerts considerable pressure; from time to time this pressure is increased by altering the curve of the band. These bands are slow and uncertain methods of correction. One would prefer to speak of them as safeguards against, rather than active correctives of the deformity.

(B) Rapid Correction

It must be remembered that this method is absolutely contraindicated in the acute stages of the disease. It is found suitable in cases in which the disease has subsided, in which the deformity does not yield to recumbency and traction, and in which the deformity depends upon a shortening of the soft parts. The reduction may be carried out at one attempt or by repeated sittings. It consists in a manual or mechanical stretching of the shortened parts and the reduction of the deformity, the patient being deeply under the influence of an anaesthetic. To ensure a complete reduction it may be necessary to divide shortened flexor or adductor muscles. After the correction, or after each correction, the limb is fixed in a splint of plaster of Paris. The treatment possesses the advantage of rapidity. Its disadvantages are the tendencies which it has of being followed by tuberculous meningitis, fresh local tuberculosis, or abscess formation.

(C) Operative Correction

When the deformity is associated with a bony ankylosis in the deformed position, operative treatment in the shape of an osteotomy is the only procedure which should be carried out. Different osteotomies have been done under the names of Adams's operation, inter-trochanteric osteotomy, Barton's operation, sub-trochanteric osteotomy, and Jones's operation for correction of adduction and shortening.

Adams's Operation.—The patient being placed on the opposite side, a long, narrow-bladed knife is introduced a finger-breadth above the top of the trochanter major, and pushed onwards until it encounters the neck of the femur. The knife is passed over the neck of the femur in a direction at right angles to the axis of the neck. The route taken by the knife is practically one parallel to Poupart's ligament. The knife is left in situ and an Adams's or a Jones's saw is passed alongside the knife until the teeth of the saw are in contact with the femoral neck; the knife is then removed. The bone may be entirely divided, or the division may be incomplete and the deformity completely corrected by breaking across the remainder of the neck of the bone. Before obtaining complete rectification it may be necessary to divide the tendons of the adductor
longus, sartorius, and perhaps the rectus muscles. After rectification the limb is immobilised in a position of slight flexion and abduction.

The operation has two advantages to recommend it: (1) the amount of shortening which accompanies it is less than occurs in the other corrective operations; (2) the fragments unite without any marked degree of displacement. As there are advantages so there are distinct disadvantages. The operation being subcutaneous it is exceedingly difficult to be sure where the section is being made, more especially as the contour of the neck may be altered by disease. Another point is that often the bone is so intensely hard that a most inordinate time may be necessary to secure its division.

To overcome the disadvantages of a subcutaneous operation the division is sometimes made through a small open incision. At a point immediately above the great trochanter a vertical incision, 1 inch long, is made down to the neck of the femur. An osteotome is introduced alongside the knife, and the latter withdrawn. The edge of the osteotome is turned transversely to the neck of the femur and the bone completely divided.

The two above-mentioned operations, the common feature of which is division of the femoral neck, are suitable in cases of bony ankylosis when flexion is the deformity present.

Inter-trochanteric Osteotomy. Sayre's Operation. — A vertical incision is made from a point just above the tip of the great trochanter downwards for 6 inches along the mid line of the outer surface of the femur. From the centre of this incision a transverse cut is made directly backwards for a short distance. The outer, anterior, and posterior surfaces of the upper end of the femur are exposed by means of a periosteal elevator until the trochanter minor can be felt. A Gigli saw is passed around the femur between the major and minor trochanters and the bone divided. Sayre removed a triangular portion of bone, and rounded the upper end of the lower fragment in such a way that it fitted into a depression upon the under surface of the upper fragment. He hoped, by so doing, to secure a movable joint, but this hope is without much foundation.

The operation has the disadvantages that it is difficult to perform, and, further, that as the division of the bone is carried out above the insertion of the psoas there is a tendency to tilting of the lower fragment and the formation of an unsightly mass of callus in the centre of the groin.

Barton's Operation. Trochanteric Osteotomy.—Barton of Philadelphia was the first to correct the deformity of hip ankylosis by osteotomy, and the line of section which he recommended was through the trochanter major. The operation is not now performed. Trochanteric and inter-trochanteric osteotomy resemble cervical osteotomy in so far as they are indicated in cases of deformity due to flexion; they are not suitable as corrective measures of adduction and abduction.

Subtrochanteric Osteotomy.—Under this heading three distinct types of osteotomy have been described. They possess certain common advantages: (1) The operations are easy in performance. (2) The operation field is remote from the joint, a point of considerable importance in dealing with a tuber-
culous ankylosis. (3) As the section is made below the insertion of the psoas muscle, there is less tendency to recurrence of the deformity by the pull of the muscle.

**Transverse Linear Subtrochanteric Osteotomy. Gant’s Operation.**—At a point 2 inches below the tip of the great trochanter, an incision is made downwards over the outer surface of the femur down to the bone. An osteotome is introduced into the incision, its cutting edge being parallel to the long axis of the wound. When the bone is reached the cutting edge is turned so that it becomes transverse. The bone is divided with the osteotome and the limb immobilised in a good position.

**Oblique Linear Subtrochanteric Osteotomy (Terrier-Hannequin).**—In its preliminary steps the operation resembles Gant’s. The bone is divided with an osteotome or chisel, and the section is made obliquely from above downwards and inwards. The antero-posterior plane of section ought to be slightly oblique from in front backwards and inwards. By this manoeuvre a subsequent better apposition of fragments is obtained, and if weight extension is applied the obliquely divided surfaces may be induced to slide upon one another and so produce some degree of lengthening.

**Cuneiform Subtrochanteric Osteotomy.**—A 3-inch vertical incision is made over the external surface of the femur, the centre of the incision being situated about 2 inches below the tip of the great trochanter. The outer surface of the bone having been exposed, a wedge of bone is removed with chisel and mallet. The wedge removed is so placed that its removal corrects the deformity, whatever it may be, e.g. in a flexion deformity the base of the wedge will lie posteriorly, in an adduction deformity it will lie external. After removal of the wedge the bone is straightened, and the part dressed and immobilised in a proper position of slight abduction and flexion.

**Jones’s Operation to correct Adduction Deformity with Shortening.**—Jones overcomes the deformity of adduction and real shortening by an osteotomy and extension of the leg. A trans-trochanteric osteotomy is done. By keeping the femur in abduction with the pelvis, the elevation of the pelvis on the opposite side is affected. With an outstretched thigh in one piece with the trunk it is clear that the limb can only be adducted at the cost of elevating the pelvis on the sound side, and in this way several inches of shortening may be remedied.

(6) Treatment of Complications

**Abscess Formation.**—A considerable proportion of cases of hip-joint disease pass on to abscess formation, and it may be looked upon as an indication of an extension of the disease. Abscesses are more likely to occur in cases which are being treated with improper and incomplete fixation, and their formation ought at once to call in question the methods of immobilisation which are being employed.

**Conservative Treatment.**—In considering this treatment it must first be borne in mind that a small yet a certain proportion of hip abscesses become
shut off and ultimately entirely absorbed, if, and this is the important detail, the most scrupulous care is taken to ensure absolute fixation of the diseased joint. It is well, therefore, to delay any very active line of treatment until nature has been put at the very best advantage for a spontaneous cure.

**Aspiration and Injection.** But in a very large proportion of cases such passive methods are unsuccessful. The abscess continues to increase in size and to track to other situations, and pain becomes more persistent and severe. One's choice of treatment now lies between that of aspiration with or without injection of medicaments, and incision with evacuation of the pus. It is stated that aspiration with or without injection has given excellent results. The abscess is aspirated when it becomes superficial. The technique of aspiration has been discussed upon page 77, *et seq.*, and situations in which hip abscesses most commonly appear are detailed upon page 217. It occasionally happens that the abscess remains localised by the capsular ligament, and as the fluid is sometimes retained here under considerable tension, an abscess in this situation is one of the most painful with which one has to deal. There being little or no superficial bulging, the joint is entered by certain definite anatomical landmarks. The needle ought to be about 3½ inches long. The patient lies on his back in such a position that the leg is adducted and rotated slightly inwards. The needle is introduced at right angles to the axis of the femur at a point immediately above the tip of the great trochanter and midway between its anterior and posterior borders. The needle being pushed slowly inwards its point comes into contact with the head or neck of the femur. The limb is then strongly adducted, and the needle point being kept in contact with bone, is pushed over the head into the joint. The needle enters the joint between the head of the femur and the rim of the acetabulum.

**Incision.** There are conditions under which aspiration of the abscess becomes impossible or undesirable, and one has to fall back upon free incision. The contents of the abscess may be so thick and inspissated that their aspiration is impossible. The presence of a sequestrum lying in the confines of the abscess cavity is an indication for free incision. An abscess which has become involved with a secondary infection should only be dealt with by free incision. These are the commoner indications. As an operation the evacuation of a tuberculous abscess calls for the most rigid asepsis. The cavity is freely opened and emptied, and any loose bone or sequestra are removed. It has been said that it is unwise to remove the pyogenic membrane lining the abscess wall, as it acts as a barrier preventing infection of the soft tissues around. As the wall of a cold abscess is lined by actively developing tubercles, this advice is one of doubtful value. It is probably best to use a pledget of gauze in such a way that it removes the pyogenic membrane without seriously damaging the surrounding soft tissues. The interior of the abscess may be washed out with a stream of hot sterile saline, and when the cavity is thoroughly dried the walls are rubbed with a quantity of bismuth and iodoform paste. Then, the question arises whether the wound is to be drained or immediately closed. It is advisable to close the
wound completely, and if the operation has been carried out with proper regard to asepsis the parts heal by first intention. Drainage acts as an invitation to sepsis. A pad and firm bandage applied over the situation of the abscess tends to prevent the re-accumulation of fluid.

Sinus Formation.—The prevention of sinus formation ought to be one of the aims of one’s treatment, for the occurrence of a sinus constitutes a serious complication. When the sinuses have formed it is not advisable to at once proceed to active methods of treatment. An opportunity must be given for the development of a salutary fibrosis by which alone a cure can be effected. A sinus from which the flow of pus is diminishing, the general health being maintained, ought to be left alone. The persistence and increase of the sinus discharge may be indicative of an extension of the bone caries or of the formation of a sequestrum. The possibilities are proved or disproved by X-ray examination, and the presence of either may call for an opening up of the sinus and radical treatment of the bone. The various methods of dealing with sinuses have been discussed.

(7) Operative Treatment of Hip-Joint Disease

Endless discussion has been waged around the question of when operative treatment, excision or erasion, should be employed in the treatment of tuberculous joints. There are authorities who say that operative measures, as far as excision is concerned, are at all times unjustifiable. Bowlby,¹ for example, has given an interesting account of his experiences for the past twenty-one years at the Alexandra Hip Hospital. Nine hundred cases have been treated without a single case of excision, and of these, many of them taken from the poorer classes and many of them with advanced disease, a percentage of 96 recovered. There are surgeons who take a view almost the exact opposite of this, and recommend excision in a very large proportion of their cases. Lastly, there are men who give conservative measures every chance, but when these are unsuccessful and the indications are propitious do not hesitate to carry out a thorough excision. Something is to be said for each of these attitudes. The thorough conservatist claims certain advantages for his procedure. The deleterious effects of operation are avoided, there is a minimum of risk of dissemination of the disease, and there is a possibility that cure may be obtained with a good functional limb. There is no disguising the fact that conservation possesses distinct disadvantages. Of these the most obtrusive is the duration of time required in treatment; three to four years are probably necessary, and, while, in the well-to-do classes this may be a mere bagatelle, among the poorer classes it may constitute an obstacle which there is no getting past. In Scotland, at least, there are very few institutions in which prolonged residence for poor children is possible. The second disadvantage of thorough conservatism is the risk that in spite of every precaution the disease continues to extend.

There are few who advocate the line of treatment of immediate operation. The advantages they claim are the minimising of time and the possibility of getting rid at once of all the disease. But over against these benefits one must set the fact that they are often bought at the expense of an ankylosed hip with a varying degree of shortening and deformity.

The third line of consideration has much to recommend it. Conservative measures are thoroughly carried out, and if a cure results so much the better. There is no hesitation in recommending excision or erosion if either are indicated. One's experience has been that the last is the most rational attitude to adopt towards this question of operation. There is no element of dogmatism about it, the treatment is suited to the demands of the disease, and nature herself is given every chance to effect a cure. There are cases which illustrate to a marked degree the value of operation. A child who, before operation, has been tortured with pain and divitalised by toxaemia and suppuration steadily improves after excision is performed. Excision of the hip-joint has hitherto been associated with the idea that the operation is necessarily followed by a flail limb, this is an entirely unfounded belief; proper observance of operative technique will guarantee an ankylosed joint, which for practical purposes is often a useful one.

Indications for Operation.—What may one consider as indications for operative treatment? They may be summarised as follows: (1) The occurrence of abscess formation with a steady progression of the disease. (2) A persistent loss of health. (3) The uncontrollable occurrence of pain. (4) Imperfect home conditions, under which efficient conservative treatment is impossible. In a doubtful case invaluable information may be obtained by examining the joint while the patient is under an anaesthetic. The grating sensation of approximated diseased bone surfaces can be appreciated by this means.

Operative Possibilities.—The operative possibilities consist in complete excision of the hip-joint or in local curettage.

Methods of Excision.—In performing the operation of excision one keeps two ideals in view. These ideals are the removal as far as possible of the diseased tissue, and the possession after operation of a limb which is stable and useful. In planning the incision to be adopted these two necessities ought to be kept before one, but owing to the peculiar anatomy of the joint they are somewhat difficult to fulfil. The joint may be exposed by three possible routes—antero-lateral, external, and posterior.

Anterior Excision.—Several methods have been devised for excising the joint through an anterior incision. The best known is that of Parker, it has been strongly recommended by A. E. Barker and by Hueter.

Preliminaries.—The usual preparations for anaesthetic are followed. In the preparation of the limb before operation the purification should include the whole lower limb with the pelvis. At operation the limb of the diseased hip is encased in a sterile towel fastened with a sterile bandage; the part is thus free to be moved about in any desired direction.
Operation.—The patient lying on his back, an incision 3 to 4 inches long is made downwards and slightly inwards from a point an inch below and external to the anterior superior spine of the ilium. The upper part of the incision runs along the outer border of the sartorius muscle, the lower half of the incision is midway between the sartorius and the tensor fasciae femoris. The incision is deepened, and the sartorius and rectus femoris muscles are retracted inwards. The joint capsule is now exposed. The capsule is opened by an incision parallel to the neck of the femur.

It is not advisable to attempt to dislocate the head of the femur through the incision, in all probability any such attempt would fail. Instead, the neck of the femur is divided in situ with an osteotome or saw, and the femoral head removed. Even at this stage difficulty may be experienced in removing the head of the bone, but as it is usually rarefied and softened by tuberculous disease it is easily extracted. With curette, forceps, and curved scissors as much diseased tissue as possible is removed. The acetabulum is examined and any apparent disease is removed. When one is satisfied that the eradication of disease is as thorough as possible, the divided neck of the bone is rounded.
and trimmed, and by abducting the limb it is jammed against the floor of the acetabulum. It is maintained in this position for reasons to be presently mentioned. The remains of the capsule are united with catgut, the muscles are brought back into position and stitched, and the skin wound closed. If there is no secondary infection the wound is closed without drainage. If sinuses are present it will be necessary to provide for drainage, and this is most satisfactorily established by a stab wound passing to the back through the buttock.

After-treatment.—As this is similar in the different methods of excision it will be discussed later under a common heading. The anterior route has the advantage of not necessitating the division of any muscles, and in the post operative treatment the situation of the incision is such that the wound is easily dressed. These advantages are more than counterbalanced by the insufficiency of space which the incision affords, for while it gives good access to the upper end of the femur it does not sufficiently expose the acetabulum. The incision is useful in dealing with foci in the head and neck of the femur, but these of course are best treated by conservative means.

External Excision.—Langenbeck’s name is associated with this incision, and the details of the operation have been systematised by König. The preliminaries are similar to those already described, and the patient is placed on his sound side.

Operation.—An incision about 5 inches long is made in the axis of the limb over the centre of the trochanter; half of the incision lies above the level of the trochanter. The incision exposes the gluteus maximus above, the vastus externus below, and the area of aponeurosis which lies over the outer surface of the trochanter. The gluteus maximus is split and retracted, and the gluteus medius is exposed as it passes to its insertion along the oblique line upon the outer surface of the trochanter. The gluteus medius is pulled forwards to expose the pyriformis behind and the gluteus minimus in front. The interval between these two muscles is opened up and the capsular ligament exposed. The ligament is divided over the head and neck of the femur in the line of the original incision, and in the same direction the periosseum is split over the outer surface of the trochanter. With a broad chisel shells of cartilage are detached from the anterior and posterior surfaces of the trochanter in such a way that they open outwards as upon hinges. The separated shells of bone carry the insertions of the trochanteric muscles. With a periosteal elevator the neck of the bone is now bared and the bone divided with finger saw, Gigli saw, or broad chisel. The femoral head is removed; there is difficulty in doing so, but some additional room may be gained by pulling on the limb. In unusually difficult cases it may be necessary to chisel away the posterior superior rim of the acetabulum.
The diseased synovial tissues are removed with sharp spoon and scissors. The floor of the acetabulum is examined for disease and any suspicious bone is chiselled away. An important pocket of synovial membrane should be curetted as it runs downwards towards the lesser trochanter. Before closing the wound the upper end of the femur is rounded so that it may fit the concave acetabulum when it is placed in contact with it. The interior of the cavity is rubbed with iodoform and bismuth paste. The flaps detached from the trochanter and the various muscles are brought back and sutured in position with interrupted catgut stitches and the skin wound closed. In the absence of a secondary infection it is unnecessary to provide drainage.

This method gives good access to the joint, and it is more particularly adapted to cases in which it is necessary to remove the trochanter as well as the head and neck of the bone.

**Posterior Excision. Kocher's.**—This route has been recommended because it undoubtedly provides the best access to both the femoral head and the acetabulum. It has the further advantage of being as suitable for arthrotomy as for arthrectomy.

**Operation.**—The patient is placed in the semi-lateral position with the thigh, which is underneath, extended, and that which is above flexed.
and adducted. The incision begins some little distance below and to the outer side of the posterior superior spine of the ilium. It extends downwards to the posterior superior angle of the trochanter and along the long axis of the femur to a short distance below the trochanter. The fleshy portion of the gluteus maximus is split in the long axis of its fibres, and the aponeurotic part divided to expose the tendon of the vastus externus. Retraction of the edges of the wound exposes the insertion of the gluteus medius into the oblique line upon the trochanter, with a quantity of fatty tissue above and the tendon of the vastus externus below. The gluteus medius is detached from the great trochanter by an incision which runs parallel to its insertion from the posterior superior to the anterior inferior angle. The tendon is separated by including with it a scale of cartilage, and a knife is used in the procedure. The lower border of the separated gluteus medius is retracted upwards until the upper and anterior borders of the trochanter are exposed. The insertion of the gluteus minimus is thus reached, and if necessary it may be detached. Beneath the retracted lower border of the gluteus medius there are now exposed from above downwards: the pyriformis, the obturator internus, the gemelli, and the upper fibres of the quadratus femoris. The sciatic vessels and nerves lie so far inwards that they are not usually seen. The tendon of the pyriformis is detached and retracted upwards or downwards. The obturator internus and the gemelli are separated and retracted downwards. Retraction of the separated muscles exposes the posterior part of the capsule. The head of the femur is made to project against the capsule by flexing, adducting, and rotating the limb inwards. The capsule is incised over the projecting head by an incision which runs parallel to the fibres of the pyriformis. By rotating the limb strongly inwards the head of the bone is made to start out from the opening in the capsule; if the ligamentum teres is intact and prevents extrusion of the head, it must be divided. It now becomes necessary to divide the neck of the femur, and this is advantageously done with a broad chisel or gouge. Having removed the head and neck of the bone, the interior of the joint is examined to give one an idea of the extent and the distribution of the disease. The interior is thoroughly curetted and diseased synovial membrane removed with scissors. Should a sequestrum be present it is taken away. Small periarticular foci or abscesses are liable to be overlooked, the interior of the joint is therefore carefully searched, and anything resembling a sinus opening is enlarged and scraped. The interior of the
TUBERCULOSIS OF THE BONES AND JOINTS

The joint cavity is doused with hot sterile lotion, and after it is dried a bactericidal paste is rubbed over the interior. To fit the acetabulum the irregular upper end of the femur is rounded. It is set in the acetabulum in such a way that the limb is held well abducted. The wound is closed in different layers with interrupted sutures of catgut. A layer of stitches closes the opening in the capsule, a second row unites the gluteus medius to the pyriformis and the superior gemellus, or the pyriformis to the superior gemellus. The third layer brings together the split edges of the gluteus maximus. The skin is closed with interrupted sutures of silkworm gut. As these stitches may require to remain in position for two or three weeks, Stiles recommends that each suture should be threaded upon a piece of fine rubber tubing about \( \frac{3}{4} \) inch long, so that when the stitch is tied the tubing is left surrounding that portion of the loop which overlies the skin.

**After-treatment.**—It is essential in the after-treatment to secure retention of the limb in the abducted position. The methods here described may be employed after any type of excision, and therefore these remarks have a general application. After excision of the hip it is expected that ankylosis will occur: to obtain this it is well to have broad osseous surfaces in contact, and if the upper end of the femur is well apposed to the acetabulum and the limb carried in a position of abduction, the conditions are ideal. Further,

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there is the advantage that when ankylosis is complete, the part being abducted, the limbs are easily brought parallel by dropping the pelvis upon the abducted side, and locomotion afterwards is well carried out. If the limb is kept in the straight position after excision, it will be found difficult to retain the upper end of the femur in the acetabulum, because the limb has lost the mechanical fixation which it had from the angular relation of the neck to the shaft. If, under such conditions, the patient was to attempt to bear any degree of weight upon the limb the end of the femur would become displaced from the acetabulum and would pass upwards and outwards on to the ilium. These mechanical principles have been investigated by Stiles, and he has applied them in the after-treatment of his cases.

After-treatment by the Abduction Splint. — Every precaution must be taken to maintain the hip in the abducted position during the entire period of the after-treatment. For this purpose the writer (Mr. Stiles) uses a simple but very effective splint. . . . It is really a modification of the double long splint (box splint) introduced many years ago by Hamilton for treating fractures of the lower extremity in children. The cross-pieces, instead of being placed at the very end of the splint, as in Hamilton's, unite the two portions posteriorly a little above the heels. The splint is padded with wool, and covered with jaconet waterproof. . . . To convert this simple splint into an abduction splint, two modifications are necessary. The first is that the portion corresponding to the diseased side is sawn across opposite the hip, and the two parts united by a common hinge screwed on to the outer side of the splint. The other alteration is that the two halves of the splint are separate from each other, each with its own cross-piece. The cross-pieces are made long enough for their free extremities to overlap when the affected limb is abducted to the desired degree. To maintain the abduction, all that is necessary is to fix together the cross portions at the point where they overlap with a common screw clamp. The upper portions of the splint are of course secured to the chest by a broad binder. Throughout the subsequent dressing care must be taken to keep the limb in the exact position it occupied while in the splint, otherwise there will be a great risk of the trochanter becoming displaced from the acetabulum.¹

After the stitches have been removed, and the wound is firmly healed, the limb is encased in a plaster splint which passes round the pelvis and along the limb as far as the ankle-joint. The leg is maintained in the abducted position, the knee is slightly flexed, and to overcome the tendency which there is for the plaster to crack opposite the hip and knee these parts are strengthened by incorporating in the plaster narrow strips of aluminium. At the end of three months the original case is removed and a fresh one substituted, this second case remains in position for three months. At the end of six months from the operation the plaster is dispensed with; a patten is fixed to the opposite boot and the child allowed to go about with crutches, no weight being borne upon the affected limb.

After-treatment by Extension. — There are those who claim that no splint is necessary after operation. They believe that the muscular tension around is sufficient to keep the limb in position. If there is a tendency to upward

¹ Stiles, loc. sup. cit. vol. ii. p. 117.
displacement of the femur, the tendency is counteracted by applying weight
extension in the long axis of the limb. When the wound is healed the child
is fastened upon a double Thomas splint, and in this it is kept until there
is sufficient fixation at the joint. Afterwards, the child is allowed to go
about, at first using crutches with a patten, afterwards discarding the crutches
and retaining the patten to counteract the shortening.

When one considers the relative value of these two methods of after-
treatment, one has no hesitation in recommending the former. In the days
which immediately succeed operation, when there is often intense pain on
movement, a firmly applied and comfortable splint affords a great sense of
relief. The splint further facilitates the dressing, there is practically no
risk of displacement of the femoral head from the acetabulum, and there
is a greater possibility of a satisfactory ankylosis occurring.

Local Curetting Operations.—If there is an isolated focus of
tuberculous disease in the upper end of the femur it is quite feasible to cut
down upon it and locally remove it. It is unlikely that a local synovectomy
could be performed on account of the difficulty in gaining free access
to the deeply situated joint.

Huntington¹ has introduced a special variety of curetting operation.
He believes that in most cases of hip-joint disease, whether tuberculous or
of acute infectious origin, the primary focus is situated in the neck or head
of the femur. Guided by X-ray examination he trephines the outer surface
of the great trochanter near its base, and through the opening thus made he
tunnels the neck of the bone until the disease is reached; it may be necessary
to pierce the epiphyseal cartilage and to enter the head. The idea of the
operation is to remove the diseased tissue before it has extended far enough
to infect the synovial membrane. The after treatment is similar to that
employed after excision of the joint, but, of course, one does not expect the
joint to become ankylosed.

Operations of Arthroplasty in Ankylosis of the Hip-Joint

When the hip-joint is ankylosed in a deformed position, steps, as
already described, are taken to correct the deformity. It has been further
suggested that in addition to counteracting the displacement, an attempt
should be made to restore some degree of movement to the fixed joint. To
such a type of operation the term arthroplasty is applied. The procedure
briefly consists in introducing a soft tissue material between the ends of
the bones, in the hope that as the result of the continual movement by
the opposing bone surfaces, a structure which bears a resemblance to
synovial membrane may be evolved. The idea originated from Lange-
mak’s² work on the origin of bursae. Two types of operation will be
described: in one, muscle is used as the interosseal separation, in the other
fascia and fat.

¹ Huntington, Surgery, Gynecology, and Obstetrics, ii. 406.
Nelaton's Operations with the Introduction of Muscle between the Cut Surfaces of the Bone.—An incision 6 inches long is made along the anterior border of the great trochanter, it begins about 1 inch below the anterior superior spine of the ilium. The muscular interspace between the tensor fasciae femoris and the sartorius is opened up to expose the rectus femoris and more deeply the ilio-psoas. The two last-named muscles are retracted inwards to expose the anterior surface of the articular capsule. The capsule is split from the anterior inferior iliac spine to the trochanter, care being taken to retain the ilio-femoral ligament as complete as possible. The anterior surface of the neck of the femur is exposed with the junction of ankylosis between thigh bone and acetabulum. Using a broad osteotome the neck of the femur is divided close to the pelvis, and the site of the acetabulum is made concave and smooth by means of gouge and rongeur. The divided neck is rounded off to fit the acetabulum. A layer of muscle is now interposed between the new articulating surfaces, the muscle being obtained by dividing the rectus femoris 4 inches below its origin and fixing the upper end in the new acetabular cavity with a few catgut sutures. The femur is set in position and kept in place until the wound heals. Exercises are begun early and gradually. If there is much inversion of the thigh it may be impossible to employ an anterior incision, under such conditions an external incision is used, and the muscle flap is obtained from one of the gluteal muscles.

Murphy's Operation 1 with the Introduction of Fascia and Fat between the Ends of the Bones.—A V-shaped incision is used. The trochanter occupies the centre of the V, the open end of which measures 5 inches. Vertically the incision extends from a point 4 inches above to a point 2 inches below the trochanter. The flap thus outlined is dissected upwards; it consists of skin, superficial fascia, and fascia lata. The outer surface of the trochanter major is cleared, a Gigli saw is passed round its base and the trochanter divided at its attachment to the femur. The separated trochanter, carrying the muscles which are inserted into it, is retracted upwards. The remains of the articular capsule are incised and separated from the edge of the acetabulum. The ankylosis between the femur and the pelvis is separated, and in doing so the bone is cut away from the acetabulum so that a rounded surface is left upon the femoral head, while the cotyloid cavity is of considerable depth. From the deep surface of the original flap the fascia lata is separated, being left attached above. It is made to line the acetabulum, and it is fixed in position with a few interrupted catgut sutures. As only the base of the fascial flap is required for this purpose, the apical portion is used to cover over the head of the femur. Murphy insists upon the importance of covering every portion of the opposed bone with the fascial covering. The head of the femur is manipulated into the deepened acetabulum, and the separated trochanter is brought back and wired in position. The skin wound having been closed the limb is kept in extension until the parts are healed, movements are then commenced.

1 Murphy, Journ. Amer. Med. Assoc., May 20, 27, June 3, 1905.
After Results of Excision of the Hip.—During the years 1901–1911 there have been 59 excisions of the hip performed in the Edinburgh Sick Children's Hospital. These operations, which were performed by Mr. Stiles, have been embodied in a recent paper.\(^1\) The average age at the time of operation was 5\(\frac{1}{2}\) years; 33 were below 6 years and 26 between 6 years and 12. Eighteen months was the average duration of the disease before operation was carried out. In the immediate post-operative results, that is to say in the period before the child was discharged from hospital, there were only two deaths, both the result of tuberculous meningitis. Within six months after operation 9 cases had succumbed to general tuberculosis, and within eighteen months another child had succumbed from the same cause. Therefore, eighteen months after operation there was a total mortality of 12,\(^2\) all due to a dissemination of the disease. As regards the usefulness of the limb, observations were made upon 40 cases, the post-operative period varying in time from ten years to eighteen months. In 19 instances, that is to say in 50 per cent of the investigated cases, the results of the excision could be classified as good. The general health was excellent, the hip ankylosed, no sinuses, the scars completely decolorised, and a very moderate deformity of shortening and flexion. The degree of shortening averaged 1\(\frac{3}{4}\) inches, an amount easily corrected by heightening the sole of the boot. In 3 cases, there was such an extensive recurrence of the disease that it was found necessary to perform disarticulation of the hip. Five cases returned with slight recurrence of the disease necessitating and cured by further operation.

It may be stated then, in brief, that the post-operative results of hip excision are wonderfully good when it is remembered that the operation is performed when the disease is well advanced and often as a life-saving measure. The secret of success is that when the operation is performed, it must be carried out thoroughly, an incomplete operation is worse than useless as it stimulates and aggravates the disease which is left. The disadvantages usually quoted are those of ankylosis and shortening. Ankylosis, when it is unilateral, is no great encumbrance, it certainly interferes very little with progression. Shortening is, of course, a more formidable drawback, but as long as it is not excessive it can be compensated.

Operative Dislocation of the Hip.—In the natural cure of hip-joint disease, one sometimes finds that the head is pushed out of the acetabulum, and the fact that the diseased surfaces are not now in apposition, appears to improve the prospect of eventual cure. Bradford and Lovett suggested that this process might be imitated in operating practice, and in 3 cases of advanced disease it was practised. The femoral head is exposed as in excision, and the carious surfaces curetted and wiped with alcohol. The head is dislocated on to the dorsum ilii, and after drainage has been secured and the wound closed the limb is fixed in a position of flexion and adduction. When cure is complete the adduction of the ankylosed hip can be treated by a correcting osteotomy. In three cases operated on by the originator, one died six months


\(^{2}\) Only forty cases traced.
later of waxy disease, in the second the ultimate result could not be ascer-
tained, the third recovered completely, and ten years later was strong and
well with a serviceable limb which, though flexed and adducted, could easily
be restored to proper position by an osteotomy.

**Amputation.**—The question of amputation or disarticulation of the
diseased limb remains for consideration. The operation is indicated in
those cases in which (1) the disease is steadily progressive; (2) there are
numerous sinuses and extensive superficial ulceration; (3) the disease is
extensively involving the pelvic bones; (4) the general health is seriously
affected, and the prolonged suppuration is giving rise to amyloid disease.
It is important that the operation should not be delayed too long. The
most absolute economy must be exercised in permitting the loss of blood,
as these cases are often reduced to the last extremity by the ravages of the
original disease.

The difficulty of the operation lies in the method of controlling the
femoral artery. The limb may be elevated and stripped of blood, and the
artery controlled by an elastic band or tourniquet. This band passes behind
the thigh, between the tuber ischii and the anus; in front it passes over the
vessels where it exerts pressure through the medium of a roller bandage
placed beneath it. The ends of the tourniquet are drawn tightly upwards
and outwards to a point above the centre of the iliac crest. They are held
in place by an assistant, and the bleeding from both femoral and internal
iliac sources is controlled.

Haemorrhage may be dealt with by means of Wyeth's pins. The thigh is
transfixed with these from side to side above the incision, and pressure is
exerted by passing stout rubber tubing around the ends of the skewers in
front of and behind the thigh.

Lastly, the bleeding may be minimised by ligaturing the femoral vessels
preliminary to removing the limb. In the presence of sinuses, flaps should
be planned which avoid these. It is also of importance to take care that the
wound lies if possible upon the outer side of the limb, and so removed from
the danger of an anal infection.

When the pelvis is diseased, it may be necessary to remove large portions
of the ilium, the ischium, and pubis. This should be done as completely
as possible to lessen the chance of a recurrence of the disease.

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TUBERCULOUS DISEASE OF THE KNEE-JOINT

Etiology

Tuberculosis of the knee is essentially a disease of early life, although it is less strictly confined to childhood than disease of the hip and spine. As in tubercle affecting other joints there is often the history of injury preceding the development of the disease, and from the exposed position of the knee it, of course, is specially liable to various kinds of injuries. There is also very often the previous history of one of the exanthemata. The disease occurs almost equally in the two sexes. The other etiological factors are similar to those discussed in other joints.

Pathology

Anatomy of the Joint.—The knee is the largest joint in the body. The strength and numbers of its ligaments make it one of the strongest also. A distinctive feature of the joint is the presence in its interior of ligaments (crucial) and cartilages (semi-lunar). The synovial membrane forms a large surface. Its upper limit extends about three finger-breadths above the upper border of the patella; laterally it covers the anterior third of the outer surface of each condyle, posteriorly there is no extension upwards above the condyles. The lower limit extends anteriorly and laterally as far as the upper border of the tibia; posteriorly it dips downwards for a short distance behind the popliteal notch of the tibia to form a cul-de-sac. The membrane lines the capsule, the deep aspect of the infrapatellar pad of fat, and both surfaces of the semi-lunar cartilages. It forms an almost complete investment for the crucial ligaments and the tendon of the popliteus. The upper synovial reflexion extends on to the metaphysis of the femur in front; laterally and posteriorly it does not extend beyond the epiphysis. The majority of the vessels communicating between the synovial tissues and the bone enter posteriorly and therefore enter the epiphysis. Below, both synovial reflexion and blood-vessels lie in relation to the epiphysis.
Pathological Anatomy.—The first question which arises in pathology is that of whether the disease is primarily osseous or primarily synovial. Some have stated that in childhood the disease is primarily an epiphysitis commencing in the head of the tibia or the lower end of the femur and rarely in the patella or fibula. The experience of others has been that the disease starts more frequently in the synovial membrane than in the bone, and with this view the author agrees.

When a secondary osseous focus occurs, it is more common to find it in the lower end of the femur than in the tibia or patella, and, speaking more exactly, the epiphysis of the femur is more commonly affected than the metaphysis. The explanation of the location is dependent upon the arrangement of the overlying synovial membrane, more especially the reflexion of the membrane and the circus vasculosus. The vessels which pass from the synovial membrane into the femur lie almost entirely upon the posterior surface, a few pierce the lateral parts and a few enter in front. The upper reflexion of the synovial membrane posteriorly does not extend above the epiphyseal cartilage, it lies entirely in relation to the epiphysis. Therefore, with these facts before one, it is easy to understand why tuberculous lesions at the lower end of the femur, secondary to synovial disease, are epiphyseal and so rarely metaphyseal. If the anatomical reflexion of the synovial membrane extends to the metaphysis the bone lesion is in all probability a metaphyseal one. The more intimate pathology dealing with the changes in the synovial membrane and other constituents of the joint are similar to those described in the general section (page 35).

Symptoms and Physical Signs

It is very frequently noted by the parents or the patient that the symptoms came on some little time after an injury had been sustained by the joint. The effects of the injury may almost imperceptibly pass into the features of the disease, or there may be an apparent complete recovery from the injury, followed after a period by the signs of the more serious condition.

Summary of Clinical Features.—The affection begins with a limp and some limitation of movement in the affected knee. At intervals pain is complained of, and as the disease progresses the pain becomes more constant and severe. There is swelling in the neighbourhood of the joint, and the swelling is rendered more prominent by an atrophy of the muscles of the thigh and leg. The degree of movement becomes progressively less, and the joint is distorted into a position of flexion with displacement backwards of the leg upon the thigh. In the last stages periarticular abscesses form, and by bursting externally constitute sinuses. The infection of the underlying bone is evidenced by osseous thickening and deformity. Such is an outline of the sequence of the disease; the more important features may now be discussed in detail.

Pain.—The pain of the affection is, as a rule, not severe. Its onset may
be very insidious; for example a joint which appears quite as strong as formerly, tires more easily, or at the end of a long walk or day's work there may be a distinct limp. Pain is exacerbated by movements of the limb and jars and by weight-bearing. Night-cries are much less common than in hip-joint disease; their presence would indicate considerable advancement of the disease. There are cases in which pain is entirely absent. Pathologically this peculiarity appears to correspond with a hydrops of the joint, and the forcible separation of the articular surfaces. Local tenderness may be present in one or other of the adjacent bones; it denotes a periostitis secondary to an intraosseal focus.

Muscular Rigidity.—Muscular rigidity is a feature of this, as it is of other tuberculous joint diseases, but it is less prominent than in the hip-joint. In the early stages it may be so slight that its detection is difficult. It may be evidenced only by a limitation of the extreme degrees of movement, flexion very often not being quite so complete as it ought to be. The muscular fixation is the explanation of the lameness which is so characteristic of the disease, the limp being the result of a fixation of the hamstrings and some degree of persistent flexion.
Deformity. — The positions of deformity arise from the greater power the flexors possess in contrast to the extensors, and therefore the position is one of gradually increasing flexion. As the disease continues and the ligaments and periarticular structures become stretched, the flexion is accompanied by an external rotation of the tibia upon the femur and a backward displacement of the leg upon the thigh. These deformities often offer very grave obstacles to the satisfactory treatment of the disease.

Swelling. — The appearance of the knee becomes early altered by an indistinctness of outline which is apparent to both sight and touch. In its beginnings the swelling is found to delimit with considerable exactness the distribution of the synovial reflexion. It is evidenced by a filling up of the natural hollows around the suprapatellar ligament and the ligamentum patellae and

![Image](Fig. 126. — The swelling of the left knee is the result of tuberculous disease confined to the synovial membrane. The outline of the swelling follows the distribution of the synovial membrane.)

![Image](Fig. 127. — Tuberculous disease of the knee-joint with the accumulation of fluid in the joint. The swelling is a general distention of the synovial sac.)

a thickening upon the lateral surface of the condyles of the femur and the tuberosities of the tibia. Posteriorly the depth of the joint from the surface generally obscures the swelling, although it may be apparent as cyst-like tumours in the popliteal space. The synovial thickening sometimes pushes the patella forwards and so makes it appear unusually prominent. In this relation Tubby has drawn attention to an important detail. When the healthy patella is handled and pushed back against the femur there is produced the patellar click. No such sensation can be elicited if the patella is resting upon a pad of thickened synovial membrane. When the joint
is distended with fluid, the click can be produced as long as the membrane is not thickened. This distinction may constitute an important point in differential diagnosis. When fluid collects within the joint, the swelling increases in amount, but its character alters. It is now a general distension of the synovial sac, fusiform in shape, and tapering above and below. Secondary to a focus in the interior the outline of the neighbouring bones becomes altered. There is thickness and irregularity from a reactionary deposit of new sub-periosteal bone. In the late stages of the disease the character of the swelling becomes further changed by the development of periarticular abscesses.

Muscular Atrophy.—Atrophy of the muscles both of the thigh and of the calf is present, and in acute cases it reaches a marked degree. The wasting gives an exaggerated importance to the swelling of the diseased joint.

Changes in Appearance of the Joint.—In addition to the swelling, the skin over the joint soon loses its natural healthy hue. It becomes pale and anaemic with an oedematous sodden appearance. The surface veins stand out in blue lines, giving the part a marbled appearance, and as the soft tissue changes advance, the veins in the centre become stretched and empty while those around the periphery increase in size and prominence. When pus has formed within the joint the skin becomes reddened in several places. The abscesses burst through the skin and sinuses develop.

Alterations in Length of the Limb.—The destruction of the articular surface and the rarefaction of the underlying bones lead in nearly every case of any seriousness to a diminution in the length of the limb. Under one condition it is possible to imagine an increase in the leg measurements, and that is a stimulation of the epiphysis secondary to the presence of tuberculous disease either in the bone or in the joint adjacent.
Method and Results of Examination.—A detailed history of the illness and its symptoms is taken. The examination opens with a careful general scrutiny, enlarged glands are noted, perhaps the presence of osseous tuberculosis elsewhere. The general appearance is observed and commented on. Giving detailed attention to the diseased limb inspection will yield information on the facts of skin changes, swelling, deformity, and muscular atrophy. Examination by palpation will add to the store of knowledge in respect of increased temperature of the part, thickening of the neighbouring bones, enlargement of the synovial membrane, the mobility or fixation of the patella upon the underlying femur, and the presence of fluid in the joint. Measurements, both longitudinal and circular, are made. The longitudinal measurements must include the complete length of the limb, as measured from the anterior superior spine or trochanter to the internal malleolus, and also the measurements of the individual bones of the leg, the femur and the tibia. The femur is measured upon its outer side from the top of the great trochanter to the lower edge of the external condyle, the knee being kept slightly flexed. The tibial measurement is estimated from the articular edge above the internal tuberosity to the tip of the internal malleolus. Measurements are made of the circumference of the limb in these localities, the centre of the thigh, the centre of the calf, and the diseased joint. For future reference any degree of deformity present is carefully noted; for example, the degree of flexion is recorded by laying the limb upon its side and outlining on paper the displacement which exists. The degree of movement present in flexion and extension is tested, care being taken to avoid any unnecessary production of pain. The investigation is completed by an X-ray examination of the joint with its associated bones.

Diagnosis

Actual Diagnosis.—There is usually no difficulty in arriving at the correct diagnosis. Assistance will be gained from the family history and perhaps the presence of tuberculous disease elsewhere. The actual account of the onset of the disease is usually very suggestive. The exact diagnosis is made from the facts gained by inspection and palpation of the diseased joint. When fluid is present, and there is still some dubiety as to the exact nature of the condition, it is justifiable to withdraw a syringeful of fluid from the knee under strict aseptic precautions, and with it to inoculate an animal. A positive result will remove all doubt, a negative result does not of necessity mean that the condition is non-tuberculous. It is necessary to mention Von Pirquet’s test as an aid in diagnosis. In the differential diagnosis certain conditions require to be excluded.

Differential Diagnosis.—Syphilitic Synovitis.—Perhaps the condition most commonly confused with tuberculous disease is syphilitic synovitis. One distinguishes the latter by the bilateral effusion into the knees, the absence of pain, and the small amount of functional disturbance. Clutton remarks that he has never seen both knee-joints filled with fluid, causing no
pain, while the other joints remain unaffected, except in cases of hereditary syphilis. If one finds that the synovitis is associated with other syphilitic stigmata, and that it yields to anti-syphilitic treatment, there should be no difficulty in arriving at a diagnosis.

Infection and Gonorrheal Arthritis.—These may sometimes be confused with a tuberculous condition. If serious doubt should arise it may be dispelled by the examination of fluid withdrawn from the knee.

Trauma.—Contusions and sprain may be followed by pain, tenderness, and effusion, but under rest and fixation the symptoms of acute synovitis speedily disappear.

Rheumatism.—An unjustifiable confusion sometimes arises between tuberculosis and rheumatism. Rheumatism of a single joint in childhood is practically never seen without the positive signs of fever, heat, sudden swelling, sweating, and cardiac lesions.

Hemorrhage into the Joint.—In "bleeders" an effusion may occur into the joint, and the synovial membrane acquires an oedematous thickened appearance. In nearly every instance the complication follows a slight injury, and the exact nature is made clear by a careful study of the general history.

Arthritis Deformans and Hysterical Joints.—In children these are sufficiently rare to be almost negligible in diagnosis.

Prognosis

The prognosis depends largely on early recognition and efficient treatment. If the case comes under appropriate care sufficiently early one can usually guarantee a complete cure. In certain of these cases the movement of the joint will be perfect in every respect; in the majority, while there is healing of the actual disease, the movements may be limited through varying degrees. The longer the period before treatment is undertaken the graver does the prognosis become. If the articular surfaces are involved cure will almost certainly necessitate an ankylosis. The outlook becomes infinitely more serious when suppuration and sinus formation appears. Unless amputation is performed suppuration cases rarely reach middle life. When death occurs it is due to prolonged suppuration, waxy disease, or general tuberculosis.

Treatment

A. General Treatment.—What has been said in regard to the treatment of hip disease may be repeated in speaking of disease of the knee-joint. Sunshine, fresh air, and an outdoor life are invaluable, and as ambulatory treatment may be begun early there is no reason why these general benefits should not be fully taken advantage of.

B. Local Conservative Treatment.—As in dealing with tuberculosis

of the hip, conservative treatment indicates fixation and protection, and the various methods of securing these will now be enumerated.

Weight Extension.—In early cases, accompanied as they so often are by flexion, deformity, and considerable pain, it is well to begin the treatment by fixation and weight extension. The child is confined to bed. The extension is applied to the limb up to the knee, and care is taken that the extension is carried out in the proper axis of the limb, or in the line of any deformity which may be present. When the position of the limb is a straight one, sufficient counter-extension is obtained by raising the foot of the bed upon blocks or pillars. If there is deformity in the form of flexion, the knee is supported in this position by a splint, while counter-extension is secured by a leather band which passes round the thigh above the knee and is connected with weight extension. The employment of this treatment for some weeks is sufficient to relieve the pain and to correct any early flexion deformity which is present. With the relief of symptoms one enters upon a course of fixation treatment.

Fixation Treatment.—Plaster of Paris.—Perhaps there is no material so satisfactory as this; it provides the most absolute fixation and protection and its application is simple and rapid. It is contra-indicated when the knee is flexed, and in the presence of abscess or sinus formation. Its use is indicated when the knee is straight and deformity is reduced. It has a special value in children of tender years who are too young to use crutches. The general details of plaster application have been discussed elsewhere. The bandage is applied from the upper part of the thigh down to and including the foot. If there is a suspicion of mobility the plaster should include the hip-joint. A casing extending from the middle of the thigh to the middle of the leg is insufficient. The fixation of the part leads to muscular atrophy, and as the diameter of the limb diminishes the plaster slips downwards until quite a considerable range of movement may be permitted at the knee. It is well to have the knee fixed in a position of slight flexion, in case ankylosis should occur during the period of resolution, and to prevent a tendency to genu recurvatum. As the splint frequently breaks behind the knee it should be strengthened in this situation by strips of aluminium. The first splint is kept in position for three months, at the end of that time the patient returns and the casing is removed. The joint is examined and radiographed, and if the conditions are favourable a second splint is applied for three more months. Six months from the date of the commencement of treatment may be considered appropriate for the commencement of the ambulatory stage. During the period of treatment by plaster it is advisable to keep the patient off his feet. The difficulty in ensuring this is common knowledge, and if it is found impossible to prevent the patient from getting up, he must be provided with a patten upon the opposite boot and a pair of crutches. Upon no account should he be permitted to bear weight on the affected limb.

Ambulatory Treatment.—From the position of the knee it is possible in the sequence of treatment to ensure fixation of the part and yet to avoid
the deleterious effects which would arise from pressure upon the joint. Certain well-known splints are employed in this connection.

**Thomas Knee Splint.**—This consists of two lateral uprights which support the limb upon either side, terminating below in a cross-bar which serves as a stilt, and above in a ring which fits the upper extremity of the thigh and supports the body weight. The uprights are made of round steel wires of No. 2, 3, or 4 gauge. They are secured to the ring above and the bar below by brazing. The ring is of an ovoid shape, flattened in front, expanded behind, and wider on the inner than on the outer side. The uprights are brazed to it at a lateral and antero-posterior inclination—135 and 145 degrees respectively. There are definite reasons for the irregular shape of the ring.
TUBERCULOUS DISEASE OF THE KNEE-JOINT

and its inclination. Its anterior surface is flat because the surface of the groin is flat; it is expanded behind to fit the thickness of the buttock; the antero-posterior inclination allows the ring to rest with comfort beneath the tuberosity of the ischium; the lateral inclination is necessitated by the greater length of the outer bar which rises above the level of the great trochanter. The ring of the splint is made larger than the thigh to permit of padding, the padding is thickest on the posterior and inner surfaces where the greatest weight is borne. To serve as posterior supports for the thigh and leg a single or two separate pieces of soft leather are stretched across the splint from side to side. A strap is attached to either side of the foot-piece, to provide for traction in the limb and to increase the fixation of the splint.

Method of Adjustment.—The limb is passed through the ring so that the extremity lies between the uprights upon the posterior leather supports. Adhesive plasters are applied to each side of the limb, each plaster terminating below in buckles. The splint is pushed firmly against the perineum, and it is held in position by buckling the straps of the foot cross-bar to the ends of the extension tapes. By means of these straps as much extension is carried out as may be necessary. The splint is further secured by turns of a bandage around the knee, and sometimes above the ankle. Many splints are fitted with a shoulder strap, which, fastened to the ring in front and behind, passes over the opposite shoulder. The sole of the boot upon the healthy limb is raised, and the patient uses crutches. In this variety of splint the foot is entirely off the ground, and as the joint continues to improve a further stage in the treatment may be reached by the employment of the Calliper splint.

The Calliper Splint.—This splint possesses the advantage that instead of walking upon a stilt ring the patient walks on the sole of the boot. The splint differs from the Thomas splint at its lower end. In the Calliper splint the two lateral bars are cut off at their lower end and turned inwards at a right angle. They are inserted into a steel tube which passes through the heel of the boot. The lateral bars are made slightly longer than the leg, so that the patient's heel is lifted nearly an inch from the inside of the sole when walking. The jar of impact with the ground is thus diminished. When the heel strikes against the back of the boot it sometimes excoriates,
in which case a triangular piece of leather should be put in the back of the shoe for the heel to play on, and it is sometimes necessary to slit the back seam just above the counter for a short distance. The limb may be kept in position by a knee-cap or by wide thigh and calf leather lacings. The splint is kept in position until sufficient time has elapsed for a natural cure. If there have been no active symptoms of disease for several months, the splint is tentatively removed at night and worn during the day. Later the splint is removed entirely, or a light supporting brace jointed at the knee is worn.

Summary of Conservative Treatment.—When the case is first seen, if there is anything about it of the nature of the acute in the shape of pain and flexion deformity, the joint is treated by fixation with weight extension. A very few weeks of this treatment is sufficient to relieve the symptoms to such an extent that it becomes possible to enter upon the second stage of treatment, namely complete fixation by means of a plaster of Paris case. During a period of six months two separate cases are applied. With the conclusion of the treatment by plaster, the ambulatory stage is entered on, and to secure fixation during this period a Thomas knee splint is the most suitable apparatus to employ. The period during which it will be necessary to continue wearing the knee splint varies according to the clinical condition of the diseased joint. Certainly the splint must be worn until all traces of the disease have disappeared. The concluding stages of the treatment are carried out with a Calliper splint. Such is the routine which one attempts to follow in actual practice.

In addition to the treatment of fixation and protection which has been described, there are various local measures which can be adopted, and which have already described in the general section upon the treatment of tuberculous joints (page 103). Among the methods which may be mentioned are the injection of a sterile emulsion of iodoform in glycerin (10 per cent) into the joint cavity in amounts of 5 to 10 cc. at intervals of three to four weeks, Bier’s congestive treatment, the application of allyl sulphide ointment, and counter irritation of the skin by means of a cautery.
Lannelongue's Sclerogenic Injections. — The natural cure of tuberculous disease is by the imprisoning of the focus in a capsule of dense fibrous tissue. Lannelongue has attempted to forestall or at least to stimulate nature by injecting into a joint an irritant which will induce the formation of scar tissue, and thus indirectly overcome the disease. The method is as follows: A 10 per cent solution of chloride of zinc is prepared, and with a fine hypodermic needle from 8 to 10 minims of the solution are injected at various points around the diseased area. The injections are made into healthy tissue immediately adjoining the disease. Excellent results have been obtained by this method.

The Correction of Deformity. — The deformities which may exist are those of flexion, external rotation, and backward displacement of the tibia upon the femur. The causes of each are different. The flexion deformity is in its early stages the result of a reflex contraction of the hamstrings, and later of an actual structural shortening and contracture. External rotation is mainly due to an exaggerated action of the biceps. The backward displacement is an indication that the ligaments, more especially the crucial, have become infected, softened, and stretched. The weight of the limb with the contracting posterior muscles is responsible for the commencing backward dislocation. Considering, therefore, the various etiologies the treatment of the different deformities must vary.

Correction by Traction. — As muscular contraction is the earliest cause of flexion deformity it may be corrected by simple weight traction. The leg must be supported so that no direct leverage is exerted upon the seat of the disease (see page 101).

Correction by Plaster Bandage. — The plaster bandage has much the same action as weight extension in reducing deformity when the deformity is the result of simple muscular contraction. A close-fitting plaster bandage is applied from the groin down to and including the foot; no attempt is made in any way to correct the deformity. At the end of a week the plaster is removed, when it will be found that the muscular spasm has diminished, and the deformity may now be considerably reduced. In persistent cases several applications of the bandage may be necessary.

Immediate Reduction under Anaesthesia and the Application of the Plaster Bandage. — Under anaesthesia the more resistant deformities may be reduced by traction and leverage. When the deformity is corrected a plaster case is applied to keep the limb in position. This method has the advantage of speed to recommend it. It is advised to break down adhesions by flexing the limb, and then by forcible extension to straighten it. There are certain drawbacks, however. In reducing the deformity care must be taken to avoid using too much force. The epiphysis of children becomes rarefied in tuberculous disease and easily displaced. Further, the deformity has a strong tendency to recur when treated by such an immediate reduction.

Reduction by the Billroth Splint. — In obstinate cases the Billroth splint as modified by Stillman may be employed. The prominences of the lower limb are well and carefully padded, especially over the outer surface of the
condyles of the femur, and the popliteal region over the upper border of the tibia. A plaster bandage is applied from the groin to the toes, being made especially strong in the popliteal region, and in the plaster on either side of the knee there are incorporated expanded tin splints to which curved and slotted steel bars are attached. When the bandage has hardened, it is divided into two parts by a circular cut above the knee, and the slotted splints being connected, the bolts in the slots are adjusted in such a way as to form a hinged splint, the centre of movement being slightly above and in front of the knee joint. If the limb be extended slightly the action of the lateral hinges is such as gradually to force the tibia away from the femur. This opens up the posterior part of the circular incision, and the part is held open by the insertion of a cork wedge. From day to day larger wedges are introduced, and the deformity gradually corrected until the limb is straight. When the correction is complete a new plaster bandage is applied and kept in position for some weeks.

**Correction by the Thomas Knee Splint.**—The Thomas splint may be used as a corrective of deformity in two ways. By employing simple traction it overcomes the flexion deformity which is the result of simple muscular contraction. At a later period, when there may be true contracture and shortening, the splint can be made to exert a correcting action by forcing the knee towards the splint with the aid of a firmly applied elastic or domette bandage; as the bandage slackens it is reapplied.

**Forcible Correction by the Genuclast.**—Certain mechanical devices or genuclasts have been employed to correct long standing deformities, more especially when the displacements are associated with a subluxation backwards of the tibia. Lateral steel bars, attached below to a handle in a catapult shape, are placed upon each side of the leg. Pressure can be exerted posteriorly over the head of the tibia by a plate attached indirectly to the lateral bars and furnished with an adjustable screw. Counter extension is exerted over the lower end of the femur and the lower end of the tibia by means of strong linen bands. Pressure forward on the head of the tibia is exerted by turning the screw handle. The calf muscles protect the artery and nerve from injurious pressure, and gradually the deformity is overcome. The instrument is one of considerable power and care must be used in its manipulation.

**Correction by Operation.**—When bone ankylosis is present the flexion deformity is overcome by operation. Operative measures consist in a linear osteotomy or the removal of a wedge of bone—a cuneiform osteotomy. In children a linear osteotomy of the femur is to be preferred, as it does not in any way interfere with the growing parts of the bone, and yet answers well in straightening the limb.

**Linear Osteotomy.**—On either the inner or the outer side of the rectus tendon a longitudinal incision is made, the centre of the incision being a finger-breadth above the upper portion of the external condyle. A MacEwan's osteotome is inserted into the incision and the bone divided. It may be found that contraction of the hamstrings renders correction
impossible. Should this be so, one must have no hesitation in dividing the shortened muscles. It sometimes happens that division of the femur is insufficient; the tibia is then divided below the anterior tubercle. J. W. Perkins recommends an osteotomy carried out some distance above the joint, and in support of his recommendation he quotes the following arguments:

(a) There is entire avoidance of injury to the epiphyseal line.
(b) There is avoidance of injury to or undue stretching of the great vessels and nerves of the popliteal space.

As the operation includes the removal from the femur of a rhomboid of bone there is a considerable amount of shortening. The operation has nothing to recommend it over linear osteotomy.

*Cuneiform* Osteotomy of the Ankylosed Knee.—It is presumed that the femur, tibia, and patella are fused into one bony mass. The front of the knee is exposed by a large U-shaped flap having its base directed upwards. With a saw or a very broad chisel a segment of bone is excised. The upper cut through the bone should be nearly at a right angle to the axis of the femur, the lower cut nearly at a right angle to the axis of the tibia. It is not advisable to carry the apex of the wedge as far back as the ligaments of the joint, by doing so there is a danger of wounding the popliteal artery, and when the deformity is corrected an awkward projection remains at the posterior part. The wedge should therefore be planned so that the apex lies about half an inch in front of the posterior bony surface. The wedge is removed and the remaining bridge of bone broken down by firm flexion of the knee. If the remaining bone offers a reduction to proper apposition it should be chiselled carefully away. By this procedure all chance of injuring the popliteal artery is avoided. The osseous surfaces may be approximated by means of nails inserted obliquely through the head of the tibia into the femur (see later, p. 274). The limb is fastened on a posterior splint.

**Treatment of Abscesses and Sinuses.**—The treatment of abscesses and sinuses is similar to that recommended in disease of the hip-joint. Abscesses are generally superficial and are easily recognised and treated. The sinuses are usually short and direct; they do not dissect tortuously among muscles as hip sinuses so often do.

**Operative Treatment of Knee-joint Disease**

**Operations for Tuberculous Disease of the Knee-joint.**—The operative measures which may be called for are those of excision, synovectomy, and amputation.

**Excision.**—Excision necessarily means the removal of the entire synovial surface, the ablation of the articular ends of the bones, and the exposure of healthy bone surfaces beneath. A successful and complete operation is almost necessarily followed by an ankylosed joint.

**Indications.**—The operation is indicated in cases in which conservative
treatment has failed to arrest the disease, in which originally the disease is too extensive to render conservative treatment justifiable, or in which the general health is beginning to fail. It is said that the operation should not be performed in young children, because of necessity it interferes with the epiphyseal cartilages, and therefore with the growth of the limb. It should rather, perhaps, be stated that in young children, if there is a likelihood of operation becoming necessary, such ought not to be delayed too long. It ought to be performed at such a period that the articular surfaces may be removed without interfering with the epiphyseal cartilages. Any method of exposing the joint is good if it fulfils the following requirements: free access to the joint, the easy removal of all diseased tissues, with the minimum destruction of healthy structures, the possession after operation of a strong, useful limb with an ankylosed knee, and as little shortening as possible.

Incisions.—A large number of incisions have been planned to expose the joint. Volkmann recommends a transverse incision passing across the front of the joint from condyle to condyle over the centre of the patella. The patella is divided to expose the interior of the joint. Miller advocated a similar incision, his operation including not a division but a complete removal of the patella. Diakonow uses an incision which passes vertically over the centre of the joint. He splits the patella from above downwards in the middle, and separates the insertion of the patellar ligament from each side together with a scale of cartilage or bone. An excellent manner of exposing the joint is by a transverse curved incision, convex downwards as far as the tubercle of the tibia, the horns of the incision being over the condyles and opposite the centre of the patella. With this incision Textor's name is associated. Cheyne and Burghard recommend an H-shaped incision. The vertical incisions should reach from the upper limit of the suprapatellar pouch well on to the anterior surface of the tibia, and should be from 1 inch
to 1½ inches away from the edges of the patella.\(^1\) The verticals are united by a transverse incision passing over the centre of the patella. Kocher\(^2\) formerly advocated a Textor's curved incision, but he has now replaced it by an external J-shaped one. The incision which begins over the vastus externus, a hand-breadth above the upper border of the patella, extends at first vertically downwards a finger-breadth external to it, and then curves slightly inwards to end at the anterior border of the tibia just below its tuberosity. Kocher claims for this incision an excellent access to the joint and a minimum of disturbance in the strength of the part.

**Operation.**—Beyond the differences in the original incision, the stages of the operation are practically the same in each instance. Many operators recommend the use of a tourniquet, but while this has the advantage of rendering the operation field clear, it is apt to be followed after operation by a most troublesome and persistent oozing.

As a standard the operation will be described as it is carried out with a curved Textor incision. The incision is carried down to the deep fascia all round, and the large U-shaped flap so outlined is raised carrying with it the patella. To permit of raising the patella its ligament must be divided about the centre, or the insertion of the ligament must be chiselled off with the tubercle of the tibia.

When the patellar flap is thus raised the capsule of the joint is opened on each side as far as the posterior limit of the incision. The knee is bent and the interior of the joint partly exposed to view. It may not be necessary to divide either the internal or the external lateral ligaments, but in the event of such a step becoming essential the ligaments are separated subperiosteally from their attachments to the femoral condyles.

With the joint fully flexed the crucial ligaments are brought into view, and they are divided about their centre. A careful survey is now made of the interior of the joint, and the exact extent of the disease ascertained. Having satisfied one’s self on this point, the removal of the synovial membrane is proceeded with. A knife and scissors are conveniently used in the dissection. The separation is begun in front and carried deeper. In front and below, the infrapatellar pad of fat and its synovial membrane are removed. In front and above, the synovial membrane is dissected away from either side of and above the patella, and from the suprapatellar and sub-crural pouches.

Laterally the membrane is dissected off the surfaces of the femoral condyles and the tuberosities of the tibia, especially from the internal tuberosity of the tibia, where there is a distinct sacculation from the main synovial cavity. Before the synovial tissue can be satisfactorily removed from the posterior part of the joint more room must be obtained. The crucial ligaments are carefully dissected from their attachment to the inter-condylar notch of the femur. The semi-lunar cartilages may be removed from the head of the tibia, or they may be kept in position to be taken away later with the articular cartilage.

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Each articular surface is removed with a saw. The amount must be sufficient to include the whole disease-bearing area. The bone is divided in a plane parallel to the articular surface. It may be sawn in such a way as to leave opposing flat surfaces, or by using a strong fret saw the raw surfaces may be so shaped as to fit one another with less liability to displacement. The lower end of the femur is left slightly convex, and the upper end of the tibia is sawn somewhat concave in order to receive the lower end of the femur. In dividing the bone it is an advantage to slip over and behind the articular surface a sterilised triangular handkerchief or bandage; by it one has more control over the end of the bone, and it is possible to pull the bone well forward, and so to avoid the risk of injuring the posterior structures. There may be such extensive disease of the underlying bone that the removal of the articular surface is insufficient. Isolated foci are scraped out with a sharp spoon, and the interior of the cavity curetted. If the disease is sufficiently extensive to involve an entire condyle or tuberosity, Stiles recommends that the affected condyle or tuberosity be sawn through beyond the seat of the disease at a deeper level than its fellow. The opposite bone is dealt with in a similar but converse manner. The result of this manoeuvre is to produce two Z-shaped sawn surfaces which must be so fashioned that when the limb is brought into good position they dovetail accurately the one into the other. In other cases an oblique section is made from before backwards, or from side to side according to the position of the focus. The slice of bone removed is thus wedge-shaped, with the disease towards the base of the wedge. The extremity of the opposing bone is also sawn obliquely, and care must be taken that the surface which is left is in a plane exactly parallel to the first. When it has been necessary to saw the bones obliquely, they should be nailed into position to prevent the risk of a gliding movement between the two surfaces. If the patella is to be left, its articular surface is removed, and a corresponding flat surface is made for its reception upon the outer part of the trochlear surface of the femur.

With the removal of the articular surfaces free access can be obtained to the back of the joint, and the synovial membrane from this part is carefully dissected away. Tuberculous debris lying around the tendon of the popliteus muscle is liable to be overlooked, the tendon therefore ought to be exposed and examined. Bleeding is carefully arrested, as it is most essential to be able to close the wound without drainage. The limb is put into proper position, and the osseous surfaces being brought together it is seen whether the line of section has been properly made or not. If there is any unusual divergence a correcting scale of bone must be removed. To secure good approximation of the bones until fixation has become firm, Stiles recommends that the opposed surfaces be fixed by long steel nails which are driven one on each side upwards through the head of the tibia into the femur. They are left in position for about three weeks. At the end of that time they are easily taken out, and there is sufficient union of the opposed surfaces to prevent a deformity occurring. In closing the wound, if the patella has

not been removed, the divided ligamentum patellae is reunited, or the separated tuberosity is stitched back to the tibia. The remains of the capsule are brought together with interrupted catgut sutures, also the opening above the knee in the vastus externus. The skin wound is closed with sutures of silkworm gut or with Michel’s clips.

After Treatment.—After the operation it is sometimes an advantage to secure the limb in a vertical excision splint (Fig. 138). This is a modification of Liston’s long splint, in which a short vertical bar is attached opposite the hip-joint, extending upwards for a slightly greater length than the limb. The limb is flexed at the hip to a right angle and bandaged to the vertical. This splint has the advantages of minimising bleeding and of lessening the liability of post-operative displacement of the excised surfaces. It has one disadvantage — its use seems to cause a considerable degree of pain, probably by the continual apposition under pressure of the two raw surfaces. It is sufficient to keep the limb in the vertical splint for forty-eight hours. At the end of that period the limb is brought straight and secured to a lateral splint with a piece passing behind to support the parts. Stiles recommends the use of a MacEwan’s knock-knee splint for this purpose.

When the wound is firmly healed the limb is fitted with a plaster case extending from groin to ankle. The case is kept on with interval changes for six months. At the end of that period the patient is allowed to go about with crutches, and finally to bear full weight upon the limb.

Synovectomy.—For this operation the terms synovectomy, erasion, and arthrectomy have been employed. The word arthrectomy ought to be applied to a true excision, synovectomy essentially means a removal of all the disease-bearing synovial membrane. Should it become necessary to carry synovectomy further, and to gouge out diseased foci from the underlying bones, no special name should be applied to the procedure, as it partakes of the nature of both synovectomy and excision.

G. A. Wright,¹ who first advocated the operation, recommended it in children in preference to excision, because he claimed that it was accompanied by a less degree of shortening, and that its performance was less likely to be followed by ankylosis. The advocate is correct when he claimed that

the operation is associated with a minor degree of shortening. That it is likely to be followed by a movable joint is a false hope; a satisfactory and therefore necessarily a complete operation is almost certain to be followed by some degree of ankylosis.

What one might designate as a case typically suitable for this operation, would be one in which the disease was entirely limited to the synovial membrane, and more especially to a localised area at the front of the joint, in which the articular cartilage and underlying bones were intact and in which there were no sinuses or abscesses. When these facts are all taken into consideration it would appear that there are really very few conditions under which the operation would be called for. A case sufficiently early to be suitable would probably do equally well under a conservative régime. When the operation is performed it has such a tendency to be followed by a fibrous ankylosis that one is better advised to carry the procedure further, and by removing the articular surfaces perform an excision, and so give the child a stiff but at least a strong limb.

In performing the operation the joint is opened by one of the incisions described under excision. A Volkmann’s straight transverse or a Textor’s curved transverse are excellent. With forceps, knife, and scissors curved on the flat, a free removal is made of the synovial membrane. To obtain complete exposure it will be necessary to divide the crucial ligaments. The membrane is dissected away from the popliteal surface with great care. If it is possible the divided crucial ligaments are reunited with catgut sutures. The wound is closed without drainage.

The after treatment of the case is at first similar to that of excision. If an attempt is to be made to secure a movable joint, massage and exercises must be begun within a reasonable time, at least within three weeks after the operation.

The Results of Excision of the Knee.—Mr. Stiles reports in his paper that during the past ten years 63 excisions of the knee have been performed, and 30 of these cases have been traced. In regard to the immediate post-operative results there was healing by first intention in 53 cases, while in 9 cases the wound broke down or recurrence set in within one month after operation. Of the 30 cases which had been traced and examined, and which, therefore, might be considered as constituting examples of the late results of operation, it was found that in 29 instances there was complete bony ankylosis, and in 1 a slight degree of movement. The position in 27 cases was one of slight flexion, it averaged 10 degrees. In one instance the leg was perfectly straight, and in 2 there was a tendency to genu recurvatum. Three cases showed a slight degree of genu valgum.

Considering the question of shortening, in one case there was no difference in length between the limbs, and it would appear that the operation had stimulates the growth of the neighbouring epiphyses. In nine cases the shortening amounted to less than 1 inch, in twelve to between 1 and 2 inches, in three it reached 3 to 4 inches, and in two it amounted to 5½ inches.

In those instances in which the amount of shortening exceeded 3 inches, a secondary cuneiform resection had been performed, and therefore these cases cannot be considered as true instances of excision. In regard to the amount of inconvenience produced by the greater degrees of shortening, Mr. Stiles says that the patient experiences little or no inconvenience from an amount of shortening which does not exceed 2 inches.

Amputation was subsequently performed in twelve cases. One month after operation there was a total mortality of 4—one from tuberculous meningitis, two from general tuberculosis, and one from measles.

Operations for para-articular Tuberculosis. — Original deposits of tubercle in the epiphyseal or metaphyseal regions at the lower end of the femur or the upper end of the tibia are usually early associated with invasion of the joint. It is, however, possible for the disease to be for a short time confined to the bone, and in such cases it is advisable to remove the diseased focus by an extra-articular route in order to eliminate the possibility of a later joint infection. The position of the disease is accurately localised by X-ray examination, preferably by a stereoscopic photograph. The lesion is exposed and thoroughly evacuated. The operation is eminently satisfactory, if by it one is able to prevent a later infection of the joint cavity.

Amputation. — With our improved knowledge of treatment by general means, and the advances which have been made in conservative and operative technique, the necessity for amputation has greatly diminished.

Indications. — This dernier ressort is called for in those cases in which local attempts at removal of the disease have failed, in which the part is riddled with abscesses and sinuses, in which there is a diffuse osteomyelitis extending from the joint along the bones, and in which the general health of the patient is beginning to be seriously affected. Further it is to be recommended in early childhood when the epiphyseal cartilage is extensively diseased, and natural cure would necessarily be associated with great shortening and a useless limb. The amputation practised is usually one through the middle of the thigh. The danger must be avoided of attempting to secure a long stump at the risk of recurrence of the disease.

Arthroplasty. — An ankylosed knee is by no means a severe handicap, provided that the ankylosis is sufficiently rigid. None the less, attempts have been made to restore movement to a stiffened knee, and it is necessary to make some record of these attempts. Before any operation of this nature is tried it is most essential to satisfy one's self that the original disease is entirely cured. Latent tubercle lying in the interior of the bone may easily be lighted up by such manipulation.

Murphy's Operation. — Murphy practises an operation very similar to that which he employs in cases of hip ankylosis, the essential feature of which is the introduction of a connective tissue flap between the separated osseous surfaces in the hope that a new synovial cavity may be formed. Briefly, the operation is as follows:

Bleeding is controlled by a tourniquet. A long external incision is made from a point 6 inches above to a point 3 inches below the knee-joint.
The incision is comparatively superficial except over the joint, the remains of which it opens. A vertical 4-inch incision is made over the inner side of the joint. Through these incisions the lateral ligaments are divided and removed. The ankylosis is now reduced, the patella is lifted from the femur with a chisel, and the femur is separated from the tibia with chisel or saw. The lower end of the femur is trimmed to a convex shape, the upper end of the tibia to one correspondingly concave. From the outer surface of the vastus externus a flap of muscle and fascia with the base downwards is detached. The flap must be so planned that it extends laterally across the joint, and antero-posteriorly covers over the entire raw osseous surface. The flap is fastened in position with interrupted catgut sutures. A smaller flap is similarly interposed between the patella and the femur. The after treatment consists in keeping the limb rigid and extended for one week. At the end of that time massage and movements are begun.

**Joint Transplantation.**—In 1908 Lexer described two cases in which he had overcome an ankylosis by transplanting the entire knee-joint. In one case the ankylosis had occurred in a flexed position as the result of tuberculous disease, in the other instance acute suppuration was responsible. The operation is carried out by exposing the remains of the joint through an anterior curved incision. The soft parts are separated laterally from the neighbourhood of the joint, and the synostosis is excised. With the limb extended there now exists between the femur and tibia a space of about 1½ inches in extent. Into this gap a healthy knee-joint, from a freshly amputated limb, is introduced and accurately fitted. The implant is fixed in position by means of wire sutures or nails. The skin flap is brought into position, and the continuity of the ligamentum patellae restored. In Lexer’s cases healing by first intention occurred in both instances. The present result is said to be one of slight movement, and no pain on walking or standing.

**Ankylosis of Patella to Femur.**—Cases have been described in which local disease has produced fixation of the patella to the femur, the rest of the joint being healthy. Such a fixation necessarily means complete immobility. It is possible to correct such a complication by separating the patella from the femur and interposing between the surfaces a flap of muscle. The region is exposed by a longitudinal incision on the inner side of the patella, the muscular flap is obtained from the vastus internus.

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**PATHOLOGY**


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Diagnosis


Treatment


Operative Treatment of Knee-Joint Disease


ETIOLOGY

It is generally stated that tuberculous disease of the ankle-joint ranks third in the order of occurrence, taking in the sequence next place to disease of the knee-joint.

The illustrative statistics most frequently quoted are those of Whitman. In five consecutive years 1788 cases of tuberculous disease of the joints of the lower extremity were treated at the outdoor department of the Hospital for Ruptured and Crippled. In 54.1 per cent of these the hip-joint was affected, in 36.2 per cent the knee-joint, and in but 9.7 per cent the ankle-joint. Statistics obtained over a period of ten years from the Edinburgh Sick Children's Hospital show somewhat different results. Considering tuberculous joints of all varieties the ankle was found to constitute a proportion of 15.5 per cent. This difference is probably to be explained by the fact that while Whitman's results were obtained from cases of all ages, the Edinburgh figures are drawn entirely from children less than twelve years old. In comparison with the occurrence of tuberculous joint disease in other situations ankle disease is more common in childhood than in later life. It is more common in boys than in girls in the proportion almost of 2 to 1. The increased occurrence of injury in the male sex has been made responsible for the greater proportion in boys.

PATHOLOGY

Anatomy of the Joint.—The bones which enter into the formation of the ankle-joint are the lower ends of the tibia and fibula and the astragalus. The tibia and fibula, aided by the transverse inferior tibio-fibular ligament, form a three-sided socket within which the astragalus is accommodated. The joint is completely invested by ligaments, and, with the exception of the anterior, they are of considerable strength. Synovial membrane lines the capsular ligament, and the joint cavity communicates directly with the inferior tibio-fibular joint. The movements of which the joint is capable are those of dorsi-flexion and extension; it is extremely doubtful whether any degree of lateral movement is possible.

Pathological Anatomy.—The actual pathology differs in no respect from that which has been described in other situations. Under this heading one must discuss the exact location of the disease, and this question is complicated by the proximity of the ankle-joint to the tarsal bones and synovial

1 Whitman, loc. cit., p. 440.
sacs. Hahn has published an investigation of the situation of the disease as illustrated by a series of 309 cases. Of these, 51 per cent had apparently originated in the bone, the remainder were primarily synovial. The situation of the osseous lesion varied within wide limits. The primary focus was in the internal malleolus in 11 instances, in the external in 7, and in 5 both tibia and fibula were affected. In 116 cases the disease had begun in the astragalus, in 16 instances in the os calcis, and in 5 both astragalus and os calcis were diseased. During the past ten years 29 cases were operated on in the Edinburgh Sick Children's Hospital. The disease was primarily synovial in 6 cases, while in 23 it was both synovial and osseous. The astragalus was involved in 15 cases, the os calcis in 5, the tibia and fibula in 2, and the scaphoid in 1. It was more especially observed that when the astragalus was diseased, the focus was originally localised to the neck of the bone. Statistics therefore appear to indicate that the neck of the astragalus is the situation of choice in which the disease begins. This distinctness and peculiarity of origin is to be explained upon anatomical grounds. If the popliteal artery of a limb is injected with a solution of lampblack, and the bones afterwards cut and examined, it will be found that a considerable quantity of the injection becomes deposited in the interior of the neck of the astragalus. The deposit is usually sufficient to produce a distinct blackened area in this portion of the bone. The injection has collected in this situation, because the part is an exceedingly vascular one. Its vessels originate from those around the synovial reflection, and they extend into the interior of the bone, at the attachment of the anterior ligament to the neck. As one finds anatomically, so one finds clinically, tuberculous disease of the ankle-joint is mainly osseous in origin, and its origin is more especially localised to the neck of the astragalus. From the original deposit in the neck of the astragalus the disease may extend in various directions. It may pass directly to the surface in front of or behind the anterior ligament of the joint. If in front of the anterior ligament, it forms an extra-articular cold abscess upon the dorsum of the foot; if posterior to the ligament, it invades the ankle-joint directly. Its other possible direction is backwards into the body of the astragalus, from which it secondarily usually invades the joint. Sometimes it makes its way forwards into the astragalo-scaphoid joint, and eventually into the various bones of the tarsus. The surrounding tendons are in such close proximity to the ankle-joint that they soon become infected, and the disease spreads upwards and downwards along the sheaths.

Symptoms and Physical Signs

Limp.—Perhaps the earliest symptom of ankle-joint disease is a slight limp. At first it is noticed only after unusual exertion, but it becomes more persistent until it is permanently established. In its beginnings the limp

PLATE XLIV.—ADVANCED TUBERCULOUS DISEASE OF THE ANKLE-JOINT.

Section of the foot shows that the disease originated in the neck of the astragalus.
appears to be due to some hesitation in the free flexion of the ankle-joint. Fully developed, it is quite obviously the result of a fixed deformity in the position of equino-valgus.

Pain.—Pain is complained of very soon after the patient becomes lame. The pain is indicated as occurring on the front of the joint and around both malleoli. In the earliest stages of the disease it may be induced by plantar flexion of the foot and putting the anterior ligament of the joint upon the stretch, tension being then exerted on the diseased area in the neck of the astragalus. Pain is afterwards exaggerated by all movements, and it is intensified by direct pressure upon the os calcis.

Position.—There is much that is characteristic in the position of the foot. In early disease the ankle is held slightly dorsi-flexed in order to relax the anterior ligament, and so to minimise the irritation of the disease at the neck of the astragalus. In the more fully developed condition the position is one of plantar flexion or of equino valgus. The equinus posture is adopted to reduce the chance of weight bearing by the os calcis, and is partly the result of the action of gravity. The valgus attitude, often so characteristic, is somewhat difficult to explain. It may be induced by the continual use of the limb in the passive attitude, but it has been suggested that the intention is to relax the peroneus longus, because from the sling-like arrangement of this muscle its contraction exerts a force in the long axis of the limb, which is largely borne by the ankle-joint.

Gait.—The patient walks with the gait peculiar to that of a stiff ankle-joint. In the later stages the toes are held pointing, and in walking, weight is borne upon them.

Swelling.—Swelling makes its appearance early, or rather it is early appreciated on account of the close relationship of the joint to the surface. It is first noticed at the front of the joint as a uniform fulness beneath the extensor tendons. As the infection becomes general throughout the joint there is swelling around the outlines of the malleoli. From the situation and distribution of the swelling one is able to form an idea of the origin of the disease and the course which it is taking. A synovial tuberculosis confined to the ankle-joint is evidenced by swelling around the malleoli. Astragaloid disease, while closely simulating ankle-joint disease, gives rise to a swelling at a lower level and confined to the front of the foot.

Palpation of the ankle-joint will confirm much that inspection has taught one. An increase of local temperature may be noted. The outline of the synovial thickening is palpated, and its peculiar boggy character appreciated. Free fluid may be demonstrated within the joint, though it is much less common in this situation than it is in the knee. The bones are carefully palpated and compared with those of the opposite side; it may be possible to appreciate a thickening which indicates disease of the underlying bone.

The movements at the ankle-joint are tested. It must be remembered that dorsi-flexion and plantar-flexion are the only movements of which the ankle-joint is capable. Inversion and eversion, abduction and adduction, take place at the mid-tarsal joint. Therefore, in the examination of the
disease the ankle-joint movements are limited or abolished, while the mid-tarsal ones are not interfered with unless the disease has extensively involved the tarsus.

Accompanying the limitation of movement there is a related muscular spasm. In neglected cases peri-articular abscesses become evident, and the seat of election in which they appear is around the internal or the external malleolus. These sites are chosen because the infection makes its way to the surface in the ligamentously weak spaces which occur in front of or behind the lateral ligaments. Sinuses frequently follow the appearance of abscesses. They usually lead directly into the joint. If they are located at some distance from the joint, they have probably developed from an underlying tendon disease.

**X-Ray Examination.**—It is essential that a radiogram be taken. From the peculiar anatomy of the ankle-joint and foot a single negative is often insufficient; it is well therefore to be provided with two, one antero-posterior and one lateral. By an X-ray examination one is able to come to a conclusion regarding the exact situation and extent of the disease. Attention has elsewhere been drawn to the rarefying changes which occur in an otherwise healthy bone, when it is in the neighbourhood of a tuberculous bone or joint; this point is well illustrated in the ankle-joint and tarsus. In an X-ray photograph of a tuberculous ankle, the bones of the tarsus may appear as empty shells, so great is the internal rarefaction.

**Diagnosis**

There is little chance of mistaking a tuberculous ankle for any other condition. A chronic disease, confined to a single joint, occurring in a child and accompanied by muscular spasm and deformity, is almost certainly tuberculous in origin. The diagnosis is more difficult in adults, but with that we have nothing to do.

**Actual Diagnosis**

The actual diagnosis is made by observing:

1. **Swelling.**—An early evidence of the disease is a fulness upon the front and lateral aspects of the joint. The swelling gives a characteristic spindle-shaped appearance to the joint, and it is accompanied by muscular wasting.

2. **Gait and Position of Foot.**—The patient walks lame. It is important to observe the sequence of alterations in position from dorsi-flexion to plantar-flexion and to equino-valgus.

3. **Pain and Tenderness with Muscular Rigidity.**

**Differential Diagnosis**

In considering the differential diagnosis there are in children only two conditions which could be mistaken for tuberculous disease of the ankle-joint—these are a chronic traumatic synovitis and tuberculosis of the tarsus. In chronic traumatic synovitis there is an absence of the elastic boggy swelling which is peculiar to tuberculous disease, there is much less pain,
PLATE XLV. TUBERCULOUS DISEASE OF THE ANKLE-JOINT.

There is a focus of disease in the neck of the astragalus.
and little or no local tenderness. If the foot is uniformly swollen and sinuses are present it may be difficult to decide whether the disease is affecting the ankle-joint or the tarsus. Usually a distinction may be made by the position of the swelling and by the alteration in special movements. When the ankle-joint is diseased plantar-flexion and dorsi-flexion are interfered with; when the tarsal joints are affected, inversion and eversion are probably limited.

**Prognosis**

There are a few special points to be drawn attention to. If the disease is treated early the prospect of ultimate recovery is exceedingly good. Invasion of the tarsal bones greatly increases the gravity of the prognosis. It is well to remember that a cure of a tuberculous ankle is sometimes followed by a troublesome flat foot, the result of weakening of the overlying ligaments.

**Treatment**

**General Treatment.**—It is unnecessary to repeat what has already been fully dealt with. General treatment is as important as it is in any other form of tuberculosis. As a rule, the application of suitable splints allows the child to retain almost the activity of full health, and, therefore, there can be no excuse for the neglect of proper hygienic surroundings.

**Local Treatment.**—The same principles apply to the ankle as to other joints. Fixation, rest, and protection are the essential lines of treatment, and they may be reinforced by such means as injections, passive congestion, and tuberculin.

**Methods of Fixation.**—*Extension.*—On account of the peculiar outline of the ankle-joint it is difficult to apply any form of satisfactory extension. It may be accomplished by fastening fan-shaped extension plasters to each side of the joint passing across the ankle-joint in front and behind. That portion of each strap which corresponds to the handle of the fan is fastened in the usual way to a stirrup and weights. In applying extension by this method the danger to be guarded against is a dragging downwards of the toes and the acquisition of an equinus deformity. Extension would be called for in the presence of persistent pain and muscular spasm.

*Plaster of Paris.*—The ankle-joint is especially well adapted to treatment by plaster of Paris. The toes are left exposed, and the case is carried up the leg as far as the garter line. Care must be taken to see that the foot is at right angles to the leg while the plaster is being applied. It is sometimes recommended that windows be cut out over each malleolus, to avoid the risk of pressure sores and to provide suitable observation of the joint. One uses the plaster case almost as a routine method. If the disease is acute and accompanied by pain the plaster is applied and the patient kept in bed. The urgency of the symptoms soon disappears, and the patient is allowed up, using crutches and a patten upon the opposite foot.

If the symptoms are not acute ambulation is permitted from the
beginning. The patient is strictly warned against bearing any weight on the foot, and if there is any likelihood of these instructions being disregarded a Thomas knee splint is applied in addition to the plaster case. In the presence of sinuses, windows are cut from the plaster to permit of the dressing.

Jones Crab Splint.—In the event of plaster of Paris being either unsuitable or non-available, the crab splint may be employed. It consists of a piece of sheet iron hollowed to fit the upper two-thirds of the posterior surface of the leg. To this is riveted a flat bar of iron \( \frac{3}{8} \times \frac{3}{16} \) inch or such size as will hold the part firmly, and it is bent to follow approximately the outline of the back of the ankle and heel to the middle of the sole of the foot. At the point where it passes round the bend of the heel there is riveted a cross piece of iron reaching two-thirds around the ankle, of such thickness as can be bent by the hand, and at the end of the main bar is riveted another piece of like metal long enough nearly to encircle the foot at that point. The whole may be japanned and applied over a thin layer of cotton, or it may be covered with leather without padding and applied next to the skin. The splint is bent to grasp the foot as accurately as possible, and held in place by a strip of adhesive plaster and a roller bandage.\(^1\)

The duration of the period of complete fixation will extend over at least twelve months. If, at the end of that time, there are still evidences of disease in the shape of pain or muscular rigidity the fixation treatment must be continued. If the signs are propitious the second stage of treatment is begun. The essential feature of it is that while movements can be carried out at the joint no weight is permitted to be borne by the part. These requirements are fulfilled by the use of a Thomas knee splint. The ankle-joint is freed from all fixation, the Thomas splint is applied, and with the limb dependent within it, movement of the ankle-joint is begun without any weight-bearing being permitted.

It is usually necessary to continue the use of the Thomas knee splint for a period of six months. It is then discarded and the foot is gradually allowed to resume its normal range of movement. The course of treatment

\(^1\) Contribution to Orthopedic Surgery, Jones and Ridlon, p. 214.
extending over two years, which is here outlined, may require to be extended in the event of the symptoms not improving sufficiently.

The adjuncts of Bier’s treatment and tuberculin treatment require no further discussion. The former is eminently suitable for ankle-joint tuberculosis. Injection of the joint by one of the already mentioned medicaments is recommended, more especially by Calot. The needle is entered in the front of the joint at the external tibio-tarsal angle. Krause punctures the tissue vertically immediately below one or other malleolus, and then directs the needle point upwards.

**The Correction of Deformity.** — Neglected cases of the disease acquire a deformity of equinus sometimes complicated with a valgus position. Under anaesthesia the deformity is corrected, and a splint is applied to maintain the proper position. If the malposition is of long standing, it may be necessary to divide the tendon achilles before the deformity can be corrected.

**Operative Treatment.** — *Indications.* — The conditions under which operation becomes necessary are similar to those discussed in other joints. Briefly they include progression of the disease in spite of treatment, the formation of abscesses and sinuses, extensive involvement of the tarsus or of the leg bones, and failing of the general health.

**Varieties of Operation.** — Out of a number of methods which have been introduced for exposure and excision of the ankle-joint those essentially differing in detail will be described. They are the operations associated with the names of Kocher, König, and Ochsner.

**Kocher’s Operation.** — The feature of the operation is a dislocation of the foot inwards and a resulting free exposure of the ankle-joint. A long J-shaped incision is used. It extends along the posterior border of the fibula for about 2 inches, curves forwards beneath the tip of the external malleolus, and passes slightly on to the dorsum of the foot to end at the edge of the peroneus tertius tendon. With division of the skin and superficial fascia the external saphenous vein and nerve are exposed and preserved. The sheaths of the peroneus longus and brevis tendons come into view. They are opened upwards and downwards along the full extent of the wound, and the tendons are divided with the knife a short distance in front of the external malleolus. Through each cut end a silk suture is passed and secured with artery forceps; if different types of forceps are used for each tendon the subsequent recognition and approximation are facilitated.

The periosteum is separated from the outer and under aspect of the external malleolus, and the flap of soft tissues is retracted strongly inwards.

1 Calot, *Orthopädie indispensable*, p. 540.
With the retraction of the reflected tissues the outer part of the anterior ligament of the joint comes into view. The interior of the ankle-joint will almost certainly have been opened at the outer edge of the anterior ligament where it joins the anterior fasciculus of the external lateral ligament, and this aids the division of the anterior ligament with scissors across the front of the joint, as far inwards as the anterior edge of the internal malleolus. The three bands of the external lateral ligament are divided near the tip and on the inner aspect of the external malleolus. The portion of the anterior ligament which is attached to the lower end of the tibia is separated upwards from the bone together with the periosteum. A similar separation of tendon sheath and periosteum is carried out from the posterior surface of the fibula. The foot is now dislocated inwards exposing the complete articular surface. Should the dislocation be incomplete it is rendered more complete by detaching the posterior and transverse ligaments from the back of the tibia. A study of the interior of the joint will decide the necessary extent of further interference; if the disease is confined to the ankle-joint it may be sufficient to remove the articular surfaces of tibia, fibula, and astragalus. If the astragalus and astragalo-calcanean joint are diseased it becomes necessary to remove the whole astragalus.

To remove the astragalus its head should first be freed. This is done by dividing the outer attachment of the lower division of the anterior annular ligament, and detaching the origin and posterior part of the extensor brevis digitorum. The peroneus tertius and extensor tendons are retracted well upwards and inwards. The posterior and outer part of the astragalo-scaphoid capsule is now exposed, and by dividing it in the coronal plane the head of the astragalus is laid bare. A sharp hook is inserted into the astragalus, and while the bone is dragged upwards, a knife is introduced beneath it so as to divide the strong interosseous ligament between it and the os calcis. To completely free the astragalus, all that is needed is to detach it from the internal lateral (deltoid) ligament. To do this the foot is forcibly inverted so that a strong, sharp hook may be inserted into the inner surface of the astragalus, which is dragged downwards and outwards, while the internal lateral ligament is divided close to the bone, or separated at its attachment with a strong sharp rugine. By keeping close to the bone the tendons at the inner ankle, especially the tibialis posticus, and the posterior tibial vessels and nerves escape injury.1

When the astragalus has been removed, the upper surface of the os calcis is examined and freed thoroughly from all trace of disease. The foot is now returned to its proper position. If the astragalus has been retained, care is taken to see that its pared upper surface fits accurately into the new tibio-fibular surface. Should it have been necessary to remove the astragalus, the upper surface of the os calcis is suitably modelled, the sustentaculum tali removed, and the external malleolus shortened. Mr. Stiles has recommended that to keep the bones accurately and firmly in position until the process of healing is established, a long square steel nail should be driven from the sole of the foot through the os calcis, the remains of astragalus (if not completely removed), and into the tibia for an inch or two. The remains

of the separated ligaments are united, the divided peroneal tendons are resutured, their sheaths repaired, and the skin edges closed.

Konig’s Operation.—Only the special features of this operation will be dealt with. It is most valuable in cases of extensive disease, which has extended beyond the ankle-joint and involved the tarsal bones. An incision is made along the antero-internal aspect of the joint, beginning 2 inches above the ankle-joint and ending at the prominence of the scaphoid; the incision lies over the neck and inner side of the astragalus. A similar incision is made on the outer side of the ankle, along the anterior surface and margin of the fibula, and ending at the astragalo-scaphoid joint. The whole bridge of tissue between the two cuts is lifted up from the underlying bones. If the foot is dorsi-flexed a good view can be had of the front of the joint. Before the posterior part of the joint can be thoroughly cleaned the astragalus must be removed. The succeeding steps of the operation are similar to those already described. The value of the method lies in the fact that through the original incisions, not only the ankle-joint but the astragalo-scaphoid and the calcaneo-cuboid joints, with their respective bones, can be examined and treated.

Ochsner’s Operation.—Ochsner’s method possesses the advantage of affording exceedingly good access to the joint, but the benefit is counteracted by the mutilation which is necessary in obtaining it. An incision is carried across the front of the ankle-joint from malleolus to malleolus. The extensor tendons are divided, and for purposes of identification later each is secured with a silk suture and a pair of forceps of distinctive pattern. The joint is opened by a transverse incision, and the sole of the foot is forced back upon the calf of the leg. In this manner the entire joint is opened up, and all disease can be removed. When this has been accomplished the foot is replaced in position. The tendons are carefully sutured and their sheaths restored. The skin wound is then closed.

After-treatment of Excision of the Ankle.—A simple dressing is kept on the part until the nail has been removed and its puncture wound healed, the foot is then placed in plaster of Paris. The plaster case is kept in position for about three months. There is an important detail regarding the boots which these cases wear afterwards. After the operation, more especially when the astragalus has been removed, there is a tendency for a flat foot to occur, this can be partly prevented by raising the sole and heel of the boot upon the inner side to the extent of about 1⁄2 an inch. It is sometimes an advantage to have a light plate of steel fastened to the sole and passing up the inner side of the boot.

The Results of Excision of the Ankle-joint. — It has been said that the results of excision of the ankle-joint are not as a rule satisfactory. There is little or no ground for this assertion. A properly performed excision gives exceedingly good results both as regards cure of the disease and restoration of function. The following is a summary of Mr. Stiles’s results. In all,

1 Ochsner, Clinical Surgery, p. 727.
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29 cases were operated on and 25 were afterwards accounted for. The actual extent of the operation varied considerably. In 6 cases only was a simple excision performed, i.e. removal of the articular surfaces. In 15 cases it was necessary to remove the astragalus, in 5 the os calcis, in 2 considerable portions of the lower end of tibia and fibula, and in 1 the scaphoid. There were no deaths as an immediate result of the operation. Within one year there were three deaths, one from broncho-pneumonia, one from tuberculous meningitis, and one from general tuberculosis. Subsequent amputation was performed in 6 cases, owing to recurrence of the disease. The local conditions were eminently satisfactory, in only one instance was there a sinus, the other cases showed wounds firmly healed. Ankylosis was present in all the cases except two, and these two showed no degree of flailty.

As regards the position of the foot, it was in every case in such a position that the patient was able to walk well. Any deformities present were slight. One case had a tendency to varus, in four instances the foot had taken up a slight position of valgus; there was one example of a moderate degree of calcaneus. If one realises that in all cases the disease calling for excision was extensive, these results must be classed as exceedingly good, when considered from the point of view of a thoroughly serviceable foot.

The shortening, as a result of the excision, averaged about 3 inch, and in no case was it necessary to make a uniform thickening of the sole of the boot. In the examples of valgus deformity the sole was raised upon the inner side.

Amputation in Ankle-joint Disease.—In performing amputation for extensive disease of the ankle-joint, one must be guided very largely by the extent of the disease and the position of any sinuses which may be present. It is not advisable to employ a method which necessitates the retaining of any of the osseous portion of the foot. There are conditions under which it may be justifiable to employ a Syme or a Mackenzie amputation, but the foot must be very carefully examined in order to be sure that there is no possibility of the skin flap being infected with tubercle. In the majority of cases it is advisable to perform an amputation in the lower third of the leg.

TUBERCULOUS DISEASE OF THE TARSUS

Etiology

Tuberculous disease may occur in any bone or in any joint of the tarsus. The astragalus, from its proximity to the ankle-joint, is the most common bone to be affected, and in point of frequency it is followed by the os calcis. Of the various joints the mid-tarsal is the most often diseased. It is rare for the tarsal joints to become primarily infected, the disease is usually an extension from a neighbouring tarsal bone or from the ankle-joint. The bones may be primarily infected quite apart from disease in any other
situation, and attention has elsewhere been drawn to what apparently is
the essential feature in the localisation. The occurrence of a primary
disease appears to depend upon a primary tuberculous endarteritis of the
nutrient vessel supplying the interior of the bone, a secondary degeneration
of the marrow within the bone, and a subsequent infection of the bone with
the actual tuberculous material.

Pathology

Anatomy of Joint.—The tarsus consists of seven bones—the astragalus,
os calcis, scaphoid, three cuneiforms, and the cuboid. The cuneiforms
articulate with the three inner metatarsals and the cuboid with the two outer.
Between the individual bones there are six distinct synovial membranes.
Between the astragalus and the os calcis there are two distinct synovial sacs,
an anterior and a posterior, subdivided by the interosseous ligament. The
anterior division communicates with the joint between the astragalus and
scaphoid. There are synovial membranes which may be designated, cal-
caneo-cuboid, cubo-metatarsal, cuneo-metatarsal, and anterior-tarsal, the
names are sufficient explanation of their positions. The anterior tarsal
joint is the largest and the most important, it passes between the scaphoid
cuboid, cuneiforms, and the bases of the second and third metatarsals.

Pathology.—When the joints are infected the pathological changes are
similar to those described under the headings of other situations, and the same
may be said of the bones. Tuberculous disease in the tarsal bones usually
extends rapidly, because the interior is predisposed to infection by the marrow
changes. The astragalus and the os calcis are the bones most commonly
affected, the astragalus on account of its proximity to the ankle-joint and the
os calcis on account of its epiphyseal line, and the strain which it undergoes
in supporting the body weight. The rule that tuberculous disease appears
in those parts which are most liable to pressure, holds good in application
to the other tarsal bones. It is more especially the inner portion of the
tarsus, the articulation of the scaphoid and cuneiforms, and the astragalo-
scaphoid joint, which become diseased.

Clinical Features

The clinical features are very similar to those of ankle-joint disease,
and, therefore, only distinguishing features will be mentioned.

Pain.—Pain is an early symptom, but it is not so marked as when the
ankle is involved. This is to be expected, because the ankle is much more
liable to extensive individual movements than the multiplicity of small
joints in the tarsus. Disease entirely confined to the interior of a tarsal bone
may be unaccompanied by pain.

Limp and Position.—The character of the limp and the position of the
foot at rest are very similar to those of the higher disease.

Swelling.—The swelling is distinctive, it occurs at a level below that of
the ankle-joint, and during the early stages of the disease it is confined to
the dorsum of the foot.

_Movements._—Alteration in the movements of the foot are important.
If the disease is in any degree extensive the movements of abduction and
adduction, inversion and eversion, are limited or abolished. An X-ray
examination of the part will decide the exact localisation of the disease and
its extent.

**Diagnosis**

The question of diagnosis really circulates around the point, whether
the disease is in the ankle-joint or in the tarsus. The situation of the
swelling and the alteration in the various movements are the points upon
which a distinction is usually made. The information afforded by X-ray
examination will clear up any remaining doubt.

**Treatment**

The conservative methods of treatment are exactly similar to those
employed in disease of the ankle-joint, but operative measures remain to be
discussed. The operative measures which may become necessary are as
follows:

1. Operation for disease of the tarso-metatarsal joints.
2. Complete anterior tarsectomy.
3. Operation for disease of the os calcis.
4. Operation for disease of the astragalus.
5. Posterior tarsectomy.

**Operation for Disease of the Tarso-metatarsal Joints._—Satis-
factory operation in this region is difficult on account of the multiplicity
and intercommunication of the various joints. At the tarso-metatarsal
articulation there are three synovial sacs, between the first metatarsal and
the internal cuneiform, between the second and third metatarsals, and the
middle and external cuneiforms, communicating with the joint between
scaphoid and cuneiforms, and between the fourth and fifth metatarsals and
the cuboid. These three joints are exposed and their articular surfaces
removed through different incisions. The internal joint, between internal
cuneiform and first metatarsal is entered by an incision, which runs along the
inner side of the long extensor tendon. The tendon is retracted outwards,
and the tibialis anticus separated from its insertion into the internal cunei-
form. The base of the metatarsal and the articular surface of the internal
cuneiform are chiselled across and the intervening part removed, after
dividing the anterior attachment of the peroneus longus. The joint between
the two outer metatarsals and the cuboid is exposed by an incision which runs
from the peroneal tubercle forwards to beyond the tip of the fifth metatarsal
bone. The tendons of the peroneus brevis and tertius are separated from their insertions, and the sheath of the peroneus longus is opened and the tendon retracted. The necessary portion of the fourth and fifth metatarsals and the cuboid are removed. The middle joint is reached by an incision, which runs along the centre of the dorsum of the foot. The tendons of the extensor longus and brevis are separated in the interval between the second and third metatarsals. The metatarsal and tarsal arteries are divided between ligatures. The surfaces of metatarsals and cuneiforms are removed, the attachment of the tibialis posticus being separated, but it must be remembered that the synovial sac passes backwards between middle and internal cuneiforms to communicate with the joint between scaphoid and cuneiforms.

After-treatment.—After the wound is healed the foot is encased in plaster of Paris, and treated similarly to an excised ankle.

Complete Anterior Tarsectomy.—When the disease has become too extensive to permit of a local removal, the operation of anterior tarsectomy is performed. Two long dorso-lateral incisions are used. The inner extends from the posterior third of the first metatarsal backwards to the inner aspect of the head of the astragalus. The incision goes down to the bone except at its posterior extremity where it crosses the astragalo-scaphoid joint. The outer incision extends from the posterior third of the fifth metatarsal to the upper surface of the os calcis in front of the external malleolus. The dissection of the inner incision necessitates the division of the attachment of the tibialis anticus to the first metatarsal and internal cuneiform, and the separation of these bones above and below. At the outer side the tendon of the peroneus tertius is separated from its insertion into the base of the fifth metatarsal, the tendons of the peroneus longus and brevis are separated and drawn backwards, and the upper and under surfaces of the cuboid and outer metatarsals are separated. The separation is carried across the dorsum of the foot, and the dorsalis pedis artery ligatured as it enters the first interspace. The soft tissues are separated from the plantar aspect of the foot, and the insertions of the tibialis posticus divided. The difficulty of separating the tissues from this concave surface is lessened by snipping off
the base of the fifth metatarsal bone. The necessary amount of bone is removed by using a key-hole saw, in front it is carried through the bases of the metatarsals; behind, through the scaphoid and cuboid or the astragalus and os calcis. The wound is drained by passing a couple of large rubber tubes side by side through the wound. The after-treatment consists in keeping the foot at right angles to the leg, and this is most satisfactorily done by applying a stirrup splint to the sole and lateral aspects of the limb. The operation is necessarily followed by considerable antero-posterior shortening.

**Operation for Tuberculous Disease of Os Calcis.**—The bone is exposed with the least amount of damage by a horseshoe-shaped incision, which runs round the border of the heel from the base of the fifth metatarsal on the outer side to below the internal malleolus on the inner side. The soft tissues are turned down in a flap, carrying with them a layer of cartilage from the under surface of the os calcis. This exposes the central osseous tissue, and with a gouge and sharp spoon any diseased tissue is removed. The cartilaginous shell is left intact, and its interior is filled with some variety of bone plug, or with simple blood clot. The soft tissues are stitched back in position. When the wound is firmly healed and the stitches removed, the foot is encased in plaster of Paris for about three months. Full use of the part is then permitted.

**Operation for Tuberculous Disease of the Astragalus.**—The steps for removal of this bone have been described in the operation for excision of the ankle, it is occasionally necessary, however, to remove the single entire bone. This is done by an incision, which begins a hand-breadth above the ankle, at the anterior surface of the fibula, and extends downwards to the outer edge of the peroneus tertius, and ends opposite the tuberosity at the base of the fifth metatarsal bone. The incision opens the ankle and the astra-galo-scaphoid joints. The other steps of the operation are similar to those described in excision of the ankle-joint.

**Posterior Tarsectomy.**—This operation has been recommended by Kocher when disease involves the os calcis and astragalus. A long curved incision is made upon the outer surface of the foot, it begins 3 inches above the ankle-joint at the outer edge of the tendo achillis, it runs vertically downwards and turns forwards behind the external malleolus to end opposite
the tuberosity at the base of the fifth metatarsal. The peroneal tendons are separated and pulled forward. The bones are removed sub-periosteally if possible. The external malleolus is retained in order to prevent forward dislocation of the peroneal tendons. The operation is not suitably employed in children. As the leg passes downwards into the defect, there is, of necessity, very considerable after shortening.

Mikulicz's Osteoplastic Resection.—This operation is employed as a substitute for amputation, when the disease has extensively involved the posterior tarsus and is associated with infection of the soft parts above the heel. An incision is made across the sole of the foot from the tuberosity of the scaphoid to the base of the fifth metatarsal bone. A second transverse incision is made across the back of the ankle between the bases of the two malleoli. The extremities of the incisions are joined by vertical incision passing down the outer and inner sides of the leg and foot. Both bones of the leg are divided immediately above the ankle-joint. The soft tissues are divided from the tarsus downwards to beyond the disease and at the distal level, wherever it may be, the bones are divided. The cut surface of tarsus or metatarsus is now approximated to the ends of the leg bones, the long axis of the metatarsals being in line with that of the leg. The wound is closed, and the parts are kept in position by a posterior strip of aluminium bent to a right angle opposite the metatarso-phalangeal joint, in order to keep the phalanges hyperextended. When the wounds are healed the part is put in plaster until there is firm osseous ankylosis. After the operation, as the limb is lengthened, a thick sole must be applied to the boot of the opposite side. A specially designed boot must be worn on the affected limb.

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TUBERCULOSIS OF THE BONES AND JOINTS


Tuberculous Disease of the Long Bones of the Hand and Foot

Tuberculosis of the long bones of the hand and foot have certain characteristics which combine to give the condition a special interest. While it does not belong exclusively to infancy, it is exceptional to find the condition occurring in adult life. The commonest period of incidence is during the first five years of life. Lexer has offered what he believes to be the explanation of the peculiar age period. His view is as follows: During childhood the epiphyses are ununited and the bones are growing. This steady growth is accompanied by a considerable degree of vascularity in the bones, and the nutrient vessels are of larger calibre than the actual size of the bone would appear to demand. As age increases and the epiphyses become united, the demand for blood is lessened, and the size of the nutrient vessels diminishes. Lexer believes that the larger size of the vessels in childhood is responsible for the greater occurrence of disease at that period. It is interesting to note that the disease is usually multiple, and not only multiple but often symmetrical. It is common to find it associated with tuberculous lesions of the skin, glands, or other bones, it is distinctly unusual to have it appearing in conjunction with joint disease.

Pathology

From the characteristic fusiform thickening which the diseased bone acquires, the term "spina ventosa" has been derived. The source of the term "spina ventosa" is a curious one. The term "spina" expresses the idea of an ache comparable to that produced by a thorn or spine prick; "ventosa" denotes the rounded uniform outline of the diseased bone (Vincent).

The primary change in the pathology is an alteration in the main nutrient vessel supplying the bone. The vessel becomes infected with a tuberculous endarteritis. There is thickening of the wall and gradual obliteration of the lumen, and, as a result of the interference with the blood supply, the red marrow disappears from the interior of the bone to become replaced by a fibro-myxomatous tissue. In addition to the myxomatous degeneration of the marrow, the bone lamellae tend to become rarefied and absorbed. When a bone becomes in this way predisposed, an actual infection with tubercle may result; the resistance of the marrow is destroyed, and the vessel lumen is so narrowed and altered that arrest of circulating tuberculous material readily occurs. Certain bones are more commonly

1 Lexer, Untersuchungen über Knochenarterien, 1904, Lexer, Tuliga, and Turk.
attacked than others, and this condition bears some resemblance to arteriosclerosis, in so far as it usually affects the vessel at the point when the bifurcation occurs.

If tuberculous material becomes definitely lodged in the interior of the bone, the pathology becomes that of an infiltrating tuberculosis. The interior of the bone becomes filled with tuberculous granulation tissue, many of the bone lamellae are absorbed and those which are left become converted into sequestra. As the disease spreads in the interior, the periosteum becomes thickened by the deposit of successive layers of new bone, apparently with a view to preventing eruption of the disease and infection of the surrounding soft parts. If the disease should extend beyond the limits of the bone, it produces a superficial cold abscess. It is very exceptional for the disease to involve a neighbouring joint.

The characteristic fusiform appearance of the bone is of course derived from the deposit of new sub-periosteal bone and not from any true expansion of the shaft.

The disease is more frequent in the hand than in the foot, and the metacarpal bones and phalanges are affected with equal frequency. In the foot the metatarsal bones are more often involved than the phalanges. It is interesting to note that the metatarsal bone of the great toe is the one most frequently affected; it has an important rôle in supporting the foot, and the result of the strain is evidenced by the liability of its nutrient artery to suffer from tuberculous endarteritis.

**Symptoms and Physical Signs**

The uniform thickening of the bone is usually the first sign to arouse attention, the enlargement may be accompanied by attacks of dull aching pain. The overlying skin is at first healthy, but as the swelling increases it becomes thin, glossy, and purple in colour. It eventually gives way, and tuberculous pus or granulation tissue escapes. The surface eruption of the disease is in the case of the phalanges always upon the lateral aspect of the bones, in the case of the metacarpals and metatarsals upon the dorsal aspect of the hand or foot. The superficial sinus leads into soft carious bone. It is common to find sequestra of quite considerable size.
PLATE XLVI.

a. Tuberculous dactylitis affecting the proximal phalanx of the finger: the interior of the phalanx is occupied by tuberculous granulation tissue.  b. Tuberculous dactylitis of a phalanx.
Before the period of ulceration, the swelling may gradually recede and a spontaneous cure result. After the disease perforates the skin the discharge of débris and sequestra continues for some time, and in favourable cases ultimately ceases, the cicatrix becoming adherent to the bone. In the severer cases cure is only obtained at the expense of deformity in the shape of a shortening of the finger or toe in its long axis. Sometimes the shortening is accompanied by a lateral deviation or even by a rotation. Rarely the osseous disease produces an irritation in the neighbourhood of the epiphyseal cartilage, and an exaggerated increase in length of the corresponding bone is produced. An X-ray examination will show the presence of central tuberculous disease with cyst-like cavity formation and a deposit of new subperiosteal bone. One occasionally finds secondary tuberculous disease of the epitrochlear glands.

**Diagnosis**

**Syphilitic Dactylitis.**—It may be difficult to differentiate between tuberculous and specific dactylitis. In the latter instance a central gummatous formation or a syphilitic periostitis may give an appearance to the bone which closely simulates tuberculous disease. Syphilis can be excluded by the X-ray appearances. Syphilis shows either a true erosion of the bone by a central gumma, or dense thick periosteal bone with a dense interior. Syphilis can also be excluded by the evidences of congenital syphilis in other parts of the body and by the results of anti-syphilitic treatment.
Tumour Formation.—Central tumour formation, usually an enchondroma, is associated with a fusiform enlargement of the bone. An X-ray photograph at once demonstrates the nature of the condition, for, in this instance, the compact bone is stretched over the central tumour into a thin shell-like layer.

Prognosis

These are among the more hopeful forms of tuberculosis, they readily undergo spontaneous cure. The accompaniment of epitrochlear, axillary or groin glandular disease increases the gravity of the ultimate outlook. So also does a multiplicity of the disease. It is well to warn the patient that an ultimate cure may be obtained at the expense of a deformed and shortened finger or toe.

Treatment

Conservative Means.—It is easy to secure entire rest of the hand. A most efficient and serviceable plan is to use a flat piece of aluminium as a splint, it is neatly covered with boracic lint, adjusted to the palmar surface of the hand, and securely fixed in position with strips of adhesive plaster.
LONG BONES OF HAND AND FOOT

The part is powdered with talc and French chalk, and strips of lint are laid between the fingers to prevent excoriation. This method possesses many obvious advantages. Other appliances have been recommended, such as plaster of Paris and various types of mechanical splints. The hand is carried in the splint for at least twelve months.

When the foot is to be dealt with, nothing can be better than a splint made of plaster of Paris, it extends from the middle of the leg either up to or including the toes, according to the situation of the disease. If there are objections to a plaster case, Jones's crab splint may be used, but it does not control the toes. Lately, one has been using celluloid splints modelled upon a cast of the foot; apart from the difficulty in construction, they are excellent.

During the period of fixation the patient must not bear any weight upon the foot, if he decides to go about, it must be with the aid of a Thomas knee splint. At the termination of the period of fixation, when the local splint, whatever it may be, is removed, the use of the knee splint is persevered in for some months until there is no possibility of recurrence of the disease.

Operative Treatment. — There are two possibilities to be considered under this heading, they are sub-periosteal resection or curetting of the diseased bone and amputation.

Sub-periosteal Resection. Indications. — There may be said to be two indications necessitating local removal of the bone, cold abscess formation and sinus formation. Cold abscess formation does not in itself justify the operation, but, if, after repeated aspiration and proper conservative treatment, the abscess recurs, and if the overlying skin is becoming thin and devitalised it is advisable to step in and remove the disease. Persistent sinus formation probably indicates the presence of a sequestrum.

Operation. — A complete sub-periosteal resection may be done, or the interior of the bone may be thoroughly scraped out. The second operation is preferable to the first, because in resecting such small bones as those of the hands and feet it is impossible to avoid serious damage to the epiphysis.

Metatarsals and Metacarpals. — To expose the metatarsals or metacarpals a straight incision is made over the dorsum of the hand or foot along the line of the diseased bone. The extensor tendons are drawn aside. The periosteum is divided along the dorsum of the bone, and separated all round with the interosseous muscles. If complete resection is to be attempted the bone is divided at the junction of the shaft with the epiphyseal cartilage, the divided extremity of the shaft is hooked up and the periosteum separated from the bone proximally, as far beyond the disease as is necessary. The bone is divided with bone-forceps, if possible, without opening into the joint. The peri-

![Fig. 150.—Incisions for excision of the metacarpals and the phalanges.](image-url)
osteum is brought back into position and sutured, and the soft parts are united. If curetting is proposed in preference to resection the bone is opened with a gouge on its dorsal surface, or if a sinus is present this is widened. The interior of the bone is thoroughly curetted, the cavity is rubbed with an antiseptic paste, and the soft parts brought together.

Special mention must be made of the operation for disease of the first metacarpal bone. The incision to expose the bone is made along the radial side of the tendon of the extensor primi-internodii pollicis. The periosteum is divided between the origin of the abductor brevis pollicis and the abductor indicis (first dorsal interosseous); the periosteum is separated from the bone. The bone is divided near the epiphysis at its proximal end. Any adherent periosteum is separated, and the neck of the bone cut across at its distal extremity.

After-treatment.—The hand and wrist are kept quiet for a considerable time upon an anterior aluminium splint such as has been described. In the case of the foot, as soon as the wounds are healed, the part is encased in plaster of Paris for about six months.

Phalanges.—The phalanges of the hand are exposed through lateral incisions, which run on each side between the extensor tendon and the digital vessels and nerves. The periosteum is separated from the dorsal and from the palmar surfaces. The distal end of the bone is divided at the neck, and the shaft separated upwards towards its proximal extremity, it is then wrenched from its epiphysis. In dealing with disease of the first phalanx of the great toe a single lateral incision upon the inner side of the extensor tendon is preferable to a double incision. After removal of the bone the periosteum is united to the tendinous expansion at the side of the extensor tendon with cat-gut sutures.

After-treatment.—The after-treatment is similar to that employed in disease of the metacarpals and metatarsals. The fingers are fastened to an anterior splint, preferably with extension, to prevent shortening. In the foot it is impossible to apply extension, and the part is encased in plaster of Paris.

Amputation.—Amputation is usually reserved for disease of the phalanges of the toes. The mutilation is concealed, and conservative treatment is unsatisfactory on account of the difficulty in keeping the parts at rest. Every effort should be made to avoid amputation of the fingers.

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TUBERCULOUS DISEASE OF THE SHOULDER-JOINT

Etiology

Tuberculous disease of the shoulder-joint is rare in childhood. Among the cases of tuberculous joints treated at the Edinburgh Children’s Hospital during the past ten years, the occurrence of tuberculosis of the shoulder has been 5 per cent. It is said that the right shoulder-joint is more commonly affected than the left. One thing is certainly evident, this form of tuberculous disease is frequently accompanied by tuberculosis in other regions.

Pathology

Anatomy of Joint.—In order properly to understand the distribution and pathology of the disease it is essential that certain points in the anatomy of the joint be made clear. The shoulder-joint in itself is a shallow and simple joint, but it has three prolongations which increase its complexity—one corresponding with the long head of the biceps, one with the tendon of the subscapularis, and a third with the tendon of the infraspinatus. The distribution of infection and the position of superficial abscess formation is largely determined by the position of these diverticula.

Pathological Anatomy.—It is usually stated that the primary focus of disease is an osseous one, and that the joint is infected secondarily. Gangolphe ¹ has lately published investigations of 32 cases. Osseous disease was present in 29 instances, and in nearly every case the epiphysis was the site of the disease. The tuberculous process in the bone may be an infiltrating or an encysted type. Volkmann ² has described an atrophic non-suppurating variety to which he has applied the term caries sicca and which he considers is almost entirely confined to this locality. It is characterised by the formation within the joint of a quantity of granulation tissue which is peculiarly dry and fibrous in type. The cancellous tissue in the head of the humerus is replaced by fibro-myxomatous tissue and the bone lamellae become wasted and rarefied. The joint ligaments share in the general fibrous metaplasia and they begin to contract. As they contract they gradually pull the head of the humerus closer against the wall of the glenoid fossa. The increased pressure upon the diseased bone leads to an atrophy, and ultimately to a complete disappearance of the humeral head. This is the sequence of events which Volkmann described.

¹ Gangolphe, Arthrites tuberculeuses (1906), p. 9.
König has detailed another variety of tuberculous disease of the shoulder, which he considers is practically confined to this region. It has been given the name caries carnosa. The tuberculous granulation tissue in the joint is vascular and proliferating, and the inter-lamellar spaces of the bone are filled with fleshy-like granulation tissue, which microscopically is shown to be a vascular granulation tissue with tubercles intermingled; the framework of the bone is considerably rarefied. It has been suggested, and there is considerable ground for the supposition, that caries sicca and caries carnosa are but stages in the same variety of tuberculosis. Caries sicca follows caries carnosa by reason of a fibrous metaplasia in the vascular granulation tissue.

**Symptoms and Physical Signs**

**Symptoms.**—The symptomatology of shoulder-joint tuberculosis is peculiar for the astonishing insidiousness with which the disease comes on. There are several factors responsible for this: (1) The joint is not to any extent a weight-bearing one, and, therefore, there is not the same tendency to exaggeration of symptoms which one finds in the joints of the lower extremity. (2) The scapula has great power of mobility upon the thorax.

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1 König, *Die specielle Tuberkulose der Knochen und Gelenken*, 1896.
and any slight degree of fixation at the shoulder-joint may be disguised by this secondary movement. The symptoms of the disease may be summarised as those of pain, tenderness, restriction of movement, and muscular atrophy.

**Pain.**—Pain is usually the first symptom to appear or at least to be noticed by the sufferer. It is frequently traced to the origin of a fall or blow upon the shoulder. At first the pain is only elicited when the joint is moved; in a fully established case it is almost constantly present. It is characteristic that it is complained of at night when the patient lies upon the affected shoulder, and so brings the articular surfaces into contact. The pain is complained of at the front of the joint and at the insertion of the deltoid. It is of a dull, aching character, and it may be referred to the elbow and forearm.

**Tenderness.**—Tenderness is complained of upon all sides of the joint; it is elicited by pressure to the outer side of the coracoid process, on the greater tuberosity, and at the posterior margin of the deltoid.

**Rigidity.**—There is distinct limitation of the movements of the joint, especially those accompanied by rotation and abduction. Care must be taken not to mistake scapular movements for movements at the shoulder-joint. The patient cannot lift the arm from the side beyond a short distance, and there is considerable pain when he attempts to place the hand behind his back or behind his head; yet he can without discomfort lay his hand upon the opposite shoulder, or push his arm forwards.

**Wasting and Position.**—Rapid atrophy of the shoulder muscles takes place, and as the wasting of the deltoid increases, the tuberosities of the humerus become more distinct and palpable. The limb takes up faulty positions which may well find a parallel to those observed in hip-joint disease. At an early period, the position of the limb is one of slight abduction; later on, as fluid begins to accumulate in the joint, the arm is placed in a position of abduction, flexion, and some internal rotation. The shoulder tip is depressed. At a still more advanced period the arm is held across the wall of the chest in an extreme position of adduction. The shoulder being raised there is an impression of apparent shortening. Palpation of the joint will demonstrate a local increase of temperature, perhaps an increase of fluid in the joint, and occasionally an actual enlargement of the bones forming the joint.

**Abscesses.**—Peri-articular abscesses develop around the joint. They make their way along the synovial prolongations with the subscapularis and infraspinatus, and appear in the axilla, or they are guided by the long head of the biceps and appear on the front of the joint; sometimes they pass directly through weak places in the capsule above and below the subscapularis. The part above is really in contact with the long head of the biceps, and by this latter structure the pus is guided. Should the capsule be perforated below the subscapularis, the pus makes its way beneath the deltoid muscle and points in front of or behind its insertion. The examination concludes with an X-ray photograph taken in an antero-posterior direction.
Special Clinical Features of Caries Sicca.—If one is to classify caries sicca as a separate variety of tuberculous shoulder, it is essential to allude to certain clinical features which are apparently characteristic of the disease. There are two things which most forcibly strike one: there is no swelling, or if there has been any it rapidly subsides, and there is no abscess formation. The muscular wasting is the most striking characteristic. The shoulder has the appearance of a subcoracoid dislocation, the deltoid is so wasted that the shoulder-joint seems unoccupied, it is possible even to see beneath the coraco-acromial arch. The arm is held close to the side of the chest, and any attempt at movement is accompanied by great pain. Ultimately there is complete fibrous ankylosis of the joint in this adducted position, and probably a true shortening of the bone in its long axis.

Diagnosis

The actual diagnosis is made by the insidious onset of symptoms, and the physical quartette of pain, tenderness, rigidity, and atrophy. The differential diagnosis will necessitate the exclusion of subdeltoid bursitis. In bursitis it is the movement of abduction which chiefly elicits pain, in tuberculosis all movements are painful. The muscular wasting in tuberculosis is infinitely greater than that which may occur in bursitis. In cases associated with marked wasting of the deltoid muscle, the shoulder has an appearance suggestive of a subcoracoid dislocation, and if the disease has been ushered in with a history of traumatism a mistake is apt to be made and the case treated as a true dislocation.

Prognosis

With complete cure of the disease the best that can be hoped for is partial or complete ankylosis of the joint, but the compensating movement of the scapula is so good that little inconvenience may arise from even a complete ankylosis. The most favourable position for ankylosis is one of moderate abduction. When the prognosis is considered from the point of view of expectation of life, it should be understood that tuberculous affections of the shoulder are more serious than a similar disease in other joints, and the explanation of this is that a considerable proportion of them are followed by tuberculous disease of the lung upon the affected side. The death rate is higher than in disease of the joints of the lower extremity.

Treatment

Conservative Treatment.—The joint should be fixed in such a position that in the event of ankylosis occurring the maximum amount of use in the part will be available. The most advantageous position is one of abduction to half a right angle with a slight degree of flexion.

There is a variety of methods for fixing the joint. In children we have
found a modification of Middledorpf's splint most useful. A strip of aluminium 1\(\frac{1}{2}\) to 2 inches broad is padded with boracic lint. It is moulded in such a way that it passes along the inner side of the upper arm from the elbow into the axilla and down the side wall of the chest for about 6 inches. The bend is fitted to the proper degree of abduction. The splint is fastened to the arm and to the chest wall with several strips of adhesive plaster. Jones and Ridlon recommend the use of a halter which suspends the forearm to the neck at a right angle. A supplementary band of adhesive strapping or bandage is passed from the elbow round the body, and the region of the shoulder is supported by imbricated bands of sticking-plaster which cross the outer part of the shoulder and over the shoulder girdle. Plaster of Paris has been recommended for use in this region, but it is exceedingly difficult to adjust it to the proper degree of comfort and yet properly to fix the arm. It is never necessary to employ extension, the weight of the arm in the vertical position is sufficient; in fact, additional extension often aggravates the pain. Conservative treatment must be persevered in for at least twelve months; the period is of course shorter than in weight-bearing joints.

**Operative Treatment.**—**Indications.**—There are those who say that the possibility of lung infection following shoulder disease is so real that complete excision should be performed as early as possible. And it is further urged that conservative treatment persevered in will probably result in ankylosis, while an early excision often means a movable joint. These are two very potent reasons in favour of early excision. The great majority are agreed that operation should not be delayed, when conservative treatment is failing to afford relief, when abscess formation has appeared, and when sinuses are present.

**Type of Operation.**—The joint may be exposed by an anterior or by a posterior route. When the disease is situated chiefly in the upper end of the humerus the anterior method is preferable. When, however, the disease is chiefly synovial or involving the glenoid cavity the posterior route should be chosen.

**Anterior Excision.**—After preparation of the part the patient is placed in such a position that the affected shoulder projects beyond the edge of the table. The arm to the middle of the upper arm is wrapped in a sterilised towel. These preliminaries are necessary to permit of movement of the arm in any direction during operation. The incision begins on the clavicle above the coracoid process, and it passes obliquely downwards and outwards along the anterior border of the deltoid muscle. As the incision is deepened the cephalic vein is exposed, running in the interval between the deltoid and the pectoralis major. The muscles are separated, the deltoid is pulled outwards, and the pectoral, with the vein, is pulled inwards. To assist in retraction of the deltoid its anterior border is divided just below its attachment to the clavicle. In the retracted interval there are now exposed from above downwards, the pectoralis minor, the coraco-brachialis with the short head of the biceps, the anterior surface of the neck of the humerus, and the tendon of the pectoralis major. Pressing one's finger on the humerus at the outer
TUBERCULOUS DISEASE OF SHOULDER-JOINT

edge of the coraco-brachialis and biceps, one feels the bicipital groove of the humerus, it contains the long head of the biceps lying in its sheath. The sheath is slit up and the biceps tendon retracted inwards. The arm is now rotated outwards, and the tendon of the subscapularis exposed as it passes to the lesser tuberosity; the tendon is detached with the periosteum and the inner edge of the capsule. The arm is rotated inwards, and from the greater tuberosity the supraspinatus, infraspinatus, and teres minor, with the periosteum and the outer edge of the capsule, are detached. In every instance the separation is made parallel to the bicipital groove. The incision which exposed the long head of the biceps opened the shoulder-joint, and it is extended slightly upwards to the edge of the glenoid cavity. By carrying the arm downwards into a vertical position over the edge of the table the head of the humerus is made to project from the joint. The disease is thoroughly eradicated, and the necessary amount of bone removed. On account of the extent of the disease it may be necessary to expose the humerus lower down. To do this the incision is enlarged. Care must be taken to avoid the anterior and posterior circumflex arteries and the circumflex nerve; the former may be ligatured, the latter must be kept intact. The section of the head is made obliquely, and as far as possible parallel to the anatomical neck. The cut surface must be made as smooth and rounded as possible, and it is recommended to cover the raw surface with a flap of soft parts, or with thin sheet rubber, gold-foil, or membrane. The end of the bone is returned within the capsule and the wound is closed. The separated muscles are restored to the respective tuberosities and sutured in place with catgut. The long head of the biceps is replaced in the bicipital groove, and the sheath sutured over it. A drainage tube may be inserted into the joint cavity and brought out by a stab puncture behind establishing a through drainage.

After-treatment.—In applying the dressing a pad should be placed in the axilla to prevent the upper end of the humerus being displaced inwards. The upper arm is fixed to the chest with a bandage, and the forearm is carried in a sling. Care must be taken that the axillary pad does not exert too much pressure on the large blood-vessels. The joint is kept immobilised for about three weeks after the operation, in order that the muscles which have been detached may be firmly rejoined. Passive movements are then begun and gradually increased. For two months the forearm and elbow should be supported with a sling, as the weight of the unsupported arm tends to stretch and relax the healing structures. If much bone has been removed in the
course of the operation, the part should be immobilised for four weeks before movements are begun.

Posterior Excision.—The patient is put in a prone or a semi-prone position with the affected shoulder raised and projecting over the edge of the table. The other preliminaries are similar to those described in the anterior operation. The skin incision begins at the acromio-clavicular joint, it passes along the upper border of the acromion to the root of the process, and from thence downwards in a curved direction to end about 1 inch above the posterior fold of the axilla. The incision opens the acromio-clavicular joint, it divides the fibres of the trapezius as they are inserted along the upper border of the spine of the scapula, and lower down it exposes the fibres of the deltoid muscle. A finger is passed beneath the edge of the deltoid muscle, and its deep surface is separated from the teres minor and the infraspinatus. The posterior fibres of the deltoid muscle are divided. The upper border of the infraspinatus is separated from the lower border of the spine and the root of the acromion process. The lower border of the supraspinatus is detached from the upper border of the spine. A finger can now be passed underneath the acromion process from behind forwards. The scapular origin of the deltoid is separated with the periosteum, or the acromion process is chiselled obliquely through at its base, this latter is more suitable in children. A deltoid flap, with or without the acromion process, is turned outwards to expose the head of the humerus covered with the insertion of the external rotators, the supraspinatus, infraspinatus, and teres minor. In front of the external rotators the capsular ligament is exposed, and if the arm is externally rotated the bicipital groove, with the long head of the biceps, appears more anterior. An incision is now made over the head of the humerus in the coronal direction; it begins at the insertion of the capsular ligament into the humerus, it extends through the capsule parallel to the anterior border of the supraspinatus, and it exposes the tendon of the long head of the biceps as far as the edge of the glenoid cavity. The insertion of the external rotators is separated from the greater tuberosity, and the muscles are pulled backwards. The tendon of the biceps is held forwards. The head of the humerus and the glenoid cavity are exposed, and if more room is required the subscapularis is separated upwards and inwards from the lesser tuberosity. By adducting the arm and pushing the elbow upwards the head is displaced through the opening in the capsule. When the disease has been thoroughly removed the parts are restored. The external rotators are sutured in position, also the subscapularis if it has been detached. The deltoid is stitched back to the spine, or, if the acromion has been divided, the bone surfaces are wired. The posterior fibres of the deltoid are united.

The after-treatment is similar to that employed in the anterior excision.

BIBLIOGRAPHY


TUBERCULOUS DISEASE OF THE ELBOW-JOINT

Etiology

We have found that the elbow ranks common among tuberculous joints in the degree of occurrence. It is correctly stated, but hitherto without explanation, that girls are more commonly affected than boys. The first ten years of life is the most usual period for the disease to develop, and in that period slightly more than half of the cases occur during the first five years.

Pathology

Anatomy of the Joint.—The joint is formed by the articulation of the humerus above with the ulna and radius below. The lower epiphysis of the humerus is made up of the articular surface of the bone and the two centres of ossification which form it—the outer or capitellar and the inner or trochlear. Ossification begins in the capitellar during the second year of life; it does not begin in the trochlear until the eleventh year. Therefore, during the first two years of life the lower epiphysis of the humerus is entirely cartilaginous. The upper epiphysis of the ulna does not form more than the tip of the olecranon, and it remains cartilaginous until the tenth year. The upper epiphysis of the radius is a rounded disc upon the end of the bone, ossifying about the sixth year. The synovial membrane extends upwards upon the humerus for some distance beyond the epiphyseal cartilage; vessels, therefore, entering the bone from the synovial reflexion pass into the metaphysis of the bone. The synovial membrane is not reflexed to any extent upon the ulna, but the neck of the radius is surrounded by a ditch-like prolongation to which the term "recessus sacciformis" has been applied.

Pathological Anatomy.—Situation of the Disease.—The disease may begin in the synovial membrane or in the bones forming the joint. Probably about 25 per cent are primarily synovial. Of the various bones the humerus is most frequently diseased, and the ulna is more liable to infection than the radius. The disease in the humerus is primarily situated in the metaphysis, and if the epiphysis should be diseased the infection is secondary to the metaphyseal disease or to disease in the joint. In the ulna the focus appears in the region of the lesser sigmoid cavity, and in the radius about the neck. These various situations of disease are determined by the position in which vessels from the synovial reflexion enter the bone. The more detailed pathology of membrane and bone is similar to that already described (see page 35).
a. Disease of the synovial membrane in the "recessus sacciformis" around the neck of the radius.

b. Tuberculous synovial membrane in the olecranon and coronoid fossae of the humerus.

c. Tuberculous synovial disease around the lower end of the humerus.

d. Tuberculous synovial membrane surrounding the upper end of the radius.

e. Tuberculous disease of the synovial membrane around the lower end of the humerus; the disease is beginning to invade the interior of the bone.
Symptoms and Physical Signs

 Symptoms.—The leading features in the disease are those of pain, tenderness, swelling, stiffness, deformity, and muscular wasting.

 Pain.—Pain is usually an early feature of the disease, it is localised to the joint, and it is increased by movements of the joint. In late stages of the disease, when there is a considerable degree of soft tissue involvement, a neuritis of the ulnar nerve may be responsible for tingling and numbness along the inner side of the forearm.

 Tenderness.—There is local tenderness to pressure, especially over the seat of the disease. The first situation to show tenderness is the space upon each side of the olecranon. The local temperature is often raised.

 Swelling.—The swelling comes on gradually. If it is the result of a synovial thickening it first becomes evident in that region in which the synovial membrane is most superficial, namely, around the olecranon and in the space between the head of the radius and the external condyle of the humerus. The swollen regions have the characteristic doughy and elastic feeling; at any moment the swelling may be increased by an effusion into the joint. As the disease progresses the swelling ceases to be limited by the distribution of the synovial membrane, and it becomes more general. The soft parts around become involved, and the joint acquires the characteristic spindle shape. It is often possible to appreciate a thickening of the bone, for example the lower part of the shaft of the humerus.

 Stiffness.—Probably the most important physical sign is the restriction of movement in the joint. It is the result of the characteristic muscular spasm which becomes evident when the limit of painless motion is reached. At first only the extremes of flexion and extension are interfered with, but the movements gradually become less until the joint is fixed in a position midway between flexion and extension, with the forearm midway between pronation and supination. In an osseous lesion pronation and supination remain perfect for some time after flexion and extension are limited; in synovial disease all movements are equally interfered with.

 Deformity.—The characteristic deformities of the disease are those of a fusiform swelling with the elbow held at about a right angle, and the forearm midway between pronation and supination.

 Fig. 153.—Advanced disease of the elbow-joint and lower end of humerus.
Atrophy.—There is a marked atrophy of the muscles of the upper arm. Those of the forearm are not so markedly affected, as they are kept in condition by the movements of the wrist-joint. The examination must include the taking of an X-ray photograph; this should be done in two directions, antero-posterior and lateral. By this manoeuvre the exact situation of the disease is demonstrated, and if operative interference is indicated the proper type of operation is more easily chosen. If the disease is allowed to progress without appropriate treatment, the disease makes its way to the surface, peri-articular abscesses develop, the skin becomes involved, and the surroundings of the joint are riddled with sinuses.

Diagnosis

The actual diagnosis is made by attention to the characteristic grouping of symptoms and physical signs. Differential diagnosis necessitates the exclusion of—

(1) Specific Metaphysitis.—The metaphysis of the humerus is often affected with this disease. It is distinguished from tuberculous disease by the fact that it is usually multiple, and that there are other unmistakable evidences of specific disease.

(2) Post-traumatic Stiffness.—Injuries to the elbow-joint are often bandaged into a position of full flexion and kept so for some weeks; there necessarily results for some time a considerable degree of stiffness, and a mistake may be made in ascribing the limitation of movement to tuberculous disease.

Prognosis

If the case is treated at an early stage the prognosis is good, and a joint with a fair degree of movement may be assured. Should ankylosis occur with the arm in a suitable position, there is wonderfully little inconvenience. If operative treatment has become necessary and excision is done, there is a possibility of the joint becoming flail. The prognosis as regards life has none of the gravity which one associates with disease of the shoulder-joint.

Treatment

Conservative.—Fixation Treatment.—Here, as elsewhere, the conservative treatment consists in placing the joint at rest in such a position that should ankylosis occur the patient will suffer the least possible inconvenience. The ideal position is one of flexion to a little less than a right angle with the forearm midway between pronation and supination.

The Halter Sling.—The arm is bent to the proper degree of flexion. It is kept in this position by a broad bandage, which is sufficiently long to pass round the wrist once or twice and thence round the neck. The knots at the wrist and neck are sealed to ensure that the bandage is not disturbed. No other means of fixation is necessary. It adds to the comfort of the joint.

1 Jones and Ridlon, Contribution to Orthopaedic Surgery, p. 241.
PLATE L.—ADVANCED TUBERCULOUS DISEASE OF THE ELBOW-JOINT.

The articular surface of the ulna is practically destroyed.
TUBERCULOUS DISEASE OF ELBOW-JOINT

patient to have that portion of the bandage which passes round the back of the neck threaded upon a piece of rubber tubing; the bandage is attached below to a leather wristlet. The arm is carried next to the body with all the garments above it. In the event of its being impossible to bend the arm to the proper degree of flexion, a modification of the halter is used. If the wrist cannot be brought to the neck, the neck is brought to the hand, and in this position the halter is adjusted. Very soon the discomfort of the position induces the patient to bend the elbow sufficiently to permit of straightening the head. The manoeuvre is repeated until the proper degree of flexion is obtained.

*Plaster of Paris.*—This is sometimes used as a splint. It secures excellent fixation, but discomfort is often complained of. If it is impossible to flex the arm sufficiently at the first application, the plaster should be applied in two portions, one to the upper arm and one to the forearm. Opposite the elbow a space of nearly 3 inches is left. The space is bridged in front by a strip of aluminium 1 inch wide, the ends of the strip are incorporated in the plaster above and below. If the wrist cannot be brought to the neck, the neck is brought to the hand, and in this position the halter is adjusted. Very soon the discomfort of the position induces the patient to bend the elbow sufficiently to permit of straightening the head. The manoeuvre is repeated until the proper degree of flexion is obtained.

*Fig. 154.*—The halter sling for use in tuberculous disease of the elbow-joint.

*After-treatment.*—The fixation splint should be kept in position until such a time as the disease is thoroughly and entirely cured, necessitating a period of not less than eighteen months. At the end of that time, if ankylosis has occurred, it is not advisable to take steps to procure some movement in the joint. If the cessation of active treatment has left a joint with a certain degree of movement, the patient is allowed gradually to use the joint, at first slight and simple active movements, and then more thorough movements entailing some degree of weight-lifting.

*Additional Means of Conservative Treatment.*—The elbow is well suited for treatment by Bier’s congestion bandage. The application is made at the middle of the upper arm. The details of the treatment have been already discussed. Medicated injections into the joint are recommended. The most suitable point for injection is immediately above the head of the radius, the forearm being held midway between pronation and supination, and the elbow flexed to a right angle.

*Operative Treatment.*—*Excision of the Elbow-joint.*—*Indications.*—The conditions which call for operation are similar to those described under
the headings of other situations. Briefly they are the presence of a bone focus, especially one which is tending to extend along the centre of the shaft of the humerus; the progression of the disease in spite of conservative treatment; the development of peri-articular abscesses; and the presence of sinuses leading into the joint.

The Operation.—There are two methods of excision which are in common use—excision by Langenbeck's posterior vertical median incision, and excision by the lateral J-shaped incision of Kocher.

Posterior Excision.—The operator standing on the affected side, the arm is held across the table in a position of partial flexion by an assistant. An incision is made in the middle line behind from 2 inches above to 2 inches below the joint. It penetrates to the bone throughout, it passes through the triceps on to the posterior surface of the humerus, it opens the posterior part of the joint, and it exposes the olecranon and the subcutaneous surface of the ulna. With the knife and periosteal elevator the periosteum, the triceps, and the anconeus are separated off the inner and the outer sides of the olecranon. The separation is carried up the inner part of the lower end of the humerus, and pronators and flexors are separated, with the internal lateral ligament and the periosteum, from the antero-lateral aspect of the condyle; the lower end of the origin of the triceps is separated from the posterior surface of the humerus. In this stage of the dissection there is a risk of injuring the ulnar nerve, as it lies in the groove between the olecranon and the internal condyle. It is preserved by raising it and retracting it inwards with the rest of the soft structures.

The outer half of the elbow-joint is cleared, the anconeus and the triceps have already been separated from the outer side of the olecranon. The ligaments covering the posterior part of the head of the radius are exposed with the articular ligament and the supinator brevis at successive levels. A small part of the supinator brevis should be separated subperiosteally from the neck of the radius and retracted outwards. The outer part of the humerus is cleared from the attachment of the anconeus, and the origins of the extensors and the external lateral ligament are divided. There is thus effected a complete decortication of the posterior and lateral surfaces of the bones forming the elbow. The elbow is now flexed, and the posterior ligament having been divided, the interior of the joint is exposed. By flexing the joint acutely the lower end of the humerus is projected from the wound and the soft parts (anterior ligament and brachialis anticus) are separated sufficiently from its anterior surface. If no disease is apparent in the humerus, the bone is divided on a level with the upper part of the epicondyles. If a focus is present the division should be made above the disease, and in the event of this being impossible the focus should be exposed by the division and thoroughly curetted out from the cut surface.

Attention is directed to the radius and ulna, the orbicular ligament is retained if possible, but the neck of the radius divided well below the head. The attachments of the anterior ligament and the brachialis anticus to the coronoid process of the ulna are separated subperiosteally, and the articular
surface of the ulna removed to expose a concave surface. The division of all the bones is preferably made with a narrow ribbon butcher’s saw, and the section is carried from before backwards to avoid possible injury to the vessels.

After removal of the articular surfaces all diseased synovial membrane is systematically cleared. Attention is paid to the posterior ligament and the pouch beneath the triceps, to the surface of the orbicular ligament and the recessus sacciformis, and finally to the anterior ligament with its membrane. Iodoform and bismuth paste is well rubbed into the interior of the joint. The soft parts are restored as far as possible into their proper position. The muscles detached from the lateral aspects of the humerus are sutured back with the periosteum if possible. The split edges of the triceps are brought together, and the separated attachments of the triceps and anconeus are brought over the remains of the olecranon. The supinator brevis is sutured either behind the neck or over the cut surface of the radius. In the absence of mixed infection drainage is unnecessary.

Kocher’s Excision.—Kocher claims as an advantage for his operation that the joint is thoroughly exposed with a minimum of interference to the nerve supply of the muscles. Only the special points of the operation will be dealt with. Beginning at a point 2 inches above the joint, the incision is carried down along the back of the external supra-condyloid ridge over the radio-humeral joint and the head of the radius, and along the outer margin of the anconeus between that muscle and the extensor carpi ulnaris to the ridge of the ulna 2 inches below the tip of the olecranon. At the upper end of the incision the outer edge of the humerus is exposed by separating the supinator longus and the extensor carpi radialis longior in front from the triceps behind. Below the level of the joint the ulna is exposed by separating between the extensor carpi ulnaris and the anconeus. A flap is then turned inwards, consisting of the triceps, a scale of cartilage from the olecranon carrying the insertion of the triceps, and the anconeus. The ulnar nerve is separated inwards with the flap, the nerve supply to the anconeus entering the deep surface of the muscle is preserved. With the exposure of the posterior surface of the joint the steps of the operation are similar to those already described.

When the diseased tissues have been removed the soft parts are restored to position. The posterior detached flap is brought back and sutured to the external intermuscular septum and the muscles arising from it (supinator longus and the extensor carpi radialis longior) above the outer edge of the triceps tendon. Below, the outer margin of the anconeus is united to the common origin of the extensors and to the inner surface of the extensor carpi ulnaris.

After-treatment.—When the dressing is applied the arm is fastened
to the side of the chest in a position of extension and moderate supination. The arm is kept in this position until the wound is firmly healed, a period usually of two or three weeks. At the end of that time and for the next two weeks the arm is kept fully flexed and fully extended for alternate periods of twenty-four hours. In obtaining the first flexion it will probably be necessary to administer a general anaesthetic. Four or five weeks after the operation the arm is carried in a sling, and the patient allowed to bring it into gradual use. Massage is useful in reducing the post-operative stiffness.

Results of Excision of the Elbow-joint.—Mr. Stiles has reported the results of excision in 54 instances. Each case was an example of advanced disease, which had failed to improve under proper conservative treatment. In 28 cases there was abscess formation, and 10 cases were complicated by sinuses. Of the 54 excisions, 34 were traced at the end of a period of ten years from the date of the first operation. There was no immediate mortality from the operation, but 6 cases died subsequently, each as the result of general tuberculosis. In 8 instances there was a recurrence of the disease, trivial in all cases save one, which required amputation. Of the functional results it could be said that in 10 cases the ultimate result was distinctly good. In 6 instances the arm was ankylosed in a position which permitted the patient to carry out the functions of the part. In 7 cases the joint was somewhat flail, and while active movements were satisfactorily executed, the power of weight-lifting was naturally limited. The average amount of shortening was $\frac{1}{2}$ inches, the maximum was $\frac{2}{3}$ inches, and the minimum $\frac{1}{2}$ inch.

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TUBERCULOUS DISEASE OF THE WRIST-JOINT

Etiology

One's experience has been that tuberculous disease of the wrist-joint is distinctly rare in children, and in the statistics of a large number of joints it has been found to occur in a proportion of 2 per cent. The right wrist is more commonly affected than the left, a circumstance which is explained by the greater liability to injury and the greater degree of strain borne by that side.

Pathology

Anatomy of the Joint.—The characteristics of the joint are the multiplicity of the carpal bones and the corresponding intricacy of the synovial cavities. Between the lower articulation of radius and ulna there is a synovial cavity to which the term recessus sacciformis inferior has been applied. The lower end of the radius and the triangular fibro-cartilage at the lower end of the ulna articulate with the scaphoid, semi-lunar, and cuneiform bones. And at the articulation there is an extensive synovial space. There is a small synovial sac uniting the pisiform bone to the underlying cuneiform. Between the rows of carpal bones there is the elaborate transverse carpal joint, which sends synovial pouches between the individual bones. Finally, there are two carpo-metacarpal joints, a single one between the trapezium and the first metacarpal bone, and a complicated one between the trapezoid, os magnum, and unciform, and the four inner metacarpals. At birth the carpus is entirely cartilaginous. The os magnum and the unciform are the first bones to become ossified.

Pathological Anatomy.—The possible origin of the disease in the wrist-joint may be synovial or osseous, and by far the greater proportion originate in a bone lesion. The common situations are the lower end of the radius and certain of the carpal bones; the metacarpal bases are rarely affected. Of the individual carpal bones the os magnum is the most frequently diseased, probably on account of the fact that it is the first to become ossified. The disease does not long remain localised by the osseous tissue, it soon bursts its way through the thin limiting shell and infects the joint around. From the pressure of the different bones, a diseased carpal bone soon gives way, and as it does so there is a dissemination of diseased material into the joints on all sides of it. Therefore, wrist disease originating in a carpal bone is likely to be more extensive than an infection secondary to a focus in the radius or metacarpal.

There is nothing peculiar about the pathology in either bone or synovial
membrane. As the disease extends, it soon comes into contact with the synovial membrane of the tendon sheaths, usually on the flexor aspect. The sheath lining undergoes a degeneration exactly similar to the tuberculous change which occurs in synovial membrane. The tendon itself becomes infiltrated and destroyed, and the sheath is distended with a viscid fluid containing melon-seed bodies moulded from lymph deposited on the surface of the tendon. In neglected cases peri-articular abscesses and sinuses develop.

Clinical Features

Pain.—Pain is a leading feature. At first it is localised to the original site of the disease, it then becomes more general and gives the feeling of an increasing tightness around the wrist. It is accentuated by pressure and by any movement of which the wrist-joint is capable. If the lower end of the radius is diseased, pain is said to be produced by pressing the lower ends of radius and ulna together.

Swelling.—The superficial position of the joint renders the early detection of a swelling probable. Originally it appears in the hollow upon each lateral aspect of the joint, and later it extends in a bracelet-like manner all round the joint. The tendon sheaths are displaced and rendered more prominent, and if they become invaded by the disease the characteristic dumb-bell shaped swelling of the compound palmar ganglion is produced. The swelling of a fully developed case of wrist-joint disease is characteristically fusiform in outline. Entire absence of swelling, other symptoms being present, points to a purely osseous lesion.

Deformity.—The hand is sometimes held straight in the axis of the forearm, more commonly it is held flexed to an angle of about 120 degrees.

Limitation of Movement.—All the movements of the joint become limited, and if the condition is left untreated, movement is entirely lost and the hand is held in the flexed position. Accompanying the limited power of movement there is a characteristic spasm of the long muscles passing over the wrist-joint.
Muscular Atrophy.—The wasting is most marked in the forearm; the short muscles of the hand long remain well nourished.

Abscesses.—If abscesses develop they usually appear on the dorsum of the wrist and hand.

**Diagnosis**

There is nothing to be said in diagnosis apart from the points which have been discussed in other situations.

**Prognosis**

The prognosis as regards function in cases treated early should be good. In a certain proportion the disease is complicated by pulmonary tubercle, and in these the prognosis is bad.

**Treatment**

Conservative.—Complete fixation is the main principle in the conservative treatment of the disease. To this essential, auxiliary methods may be added in the shape of Bier's congestion and injection.

**Fixation Treatment.**—The wrist is an easy joint to control. It must be fixed in a position of moderate dorsi-flexion, as this attitude permits the flexor muscles to close the fingers easily if the joint becomes fixed by disease. Aluminium makes an excellent splint; it is padded with boracic lint; it extends from beyond the fingers to the upper part of the forearm, and opposite the wrist it is moulded to fit the position of dorsi-flexion. Between the digits pieces of powdered cotton-wool are laid, and the splint is fastened to the arm and hand with strips of adhesive plaster; the fingers are kept bent. It is important to ensure that the thumb is included. A covering bandage is applied to keep the part clean. A light plaster bandage may be used. The forearm and fingers are covered with boracic lint, and a plaster bandage is applied from the finger-tips to the elbow, the hand being kept in the proper position of slight dorsi-flexion. Silicate of potassium or celluloid splints may be used in preference to plaster of Paris.

**Jones Splint.**—Robert Jones has employed a simple form of adjustable splint, which will be understood by reference to Fig. 158.

![Fig. 158.—Jones's splint for the treatment of tuberculous wrist disease. Note the dorsi-flexed position of the hand.](image-url)

**After-treatment.**—Complete fixation is continued until there is satis-
factory evidence of the disease being thoroughly healed; a period of at least eighteen months is necessary. The splint must be removed gradually; at first it is so far shortened that movements of the phalanges and then of the metacarpo-phalangeal joints are permitted, complete movement of the thumb is allowed, and finally the splint is removed. Comfort is derived by using a stiff leather wristlet for some time after the fixation splint has been given up.

Operative Treatment.—Excision. Ollier's Operation.—The author recommends Ollier's operation because it is accompanied by a minimum of disturbance of the overlying tendons and soft parts. Upon the back of the hand two landmarks are delimited, namely, the inter-styloid line and the base of the second metacarpal bone. Beginning at the middle of the dorsal aspect of the second metacarpal bone, an incision is made along the radial side of the extensor indicis upwards and inwards. When the incision reaches the level of the inter-styloid line it changes its direction and runs parallel to the axis of the forearm for about 1½ inches. On the ulnar side of the wrist a second straight incision is made from a point ¾ of an inch below the base of the fifth metacarpal bone. This incision lies to the inner side of the extensor carpi-ulnaris, and it penetrates directly to the bone. By the outer incision the tendon of the extensor indicis is exposed lying in its sheath. Without opening the sheath both are retracted inwards. The insertion of the extensor carpi-radialis brevior is exposed, and the periosteum to its inner side having been incised, the periosteum with the insertion of the muscle is separated outwards. The periosteal incision is carried upwards, dividing the capsule of the joint and the posterior annular ligament between the extensor indicis and the extensor pollicis longus. The posterior surface of the carpus is now exposed through two incisions, and through either of them the ligamentous structures are separated from the bones. If the separation is properly carried out the various tendinous insertions are preserved. The semi-lunar bone should first be removed, as it lies exposed by the outer incision. The cuneiform is then dissected out, and room obtained to deal with the unciform, the hook of which is chipped off with bone forceps, while the body of the bone is removed. The pisiform bone is left in situ and so is the trapezium, unless, of course, it happens to be diseased. After removal of the carpal bones the lower ends of the radius and ulna with the triangular cartilage, if diseased, are removed. If possible, the carpal ends of the metacarpal bones are not interfered with. Before closing the wound sublimated iodoform bismuth paste is rubbed into the raw surfaces. If drainage is necessary it is secured by pulling a rubber drain through from one incision to another.

After-treatment.—It is important in the after-treatment to ensure that the hand is maintained in the dorsi-flexed position with the thumb and fingers free. For this purpose a bent aluminium anterior splint is used; or a Lister's splint, which is an anterior wooden splint thickened opposite the metacarpals by means of a cork pad, is employed. The splint is kept
in position until the parts are thoroughly consolidated. After the wound is healed the fingers are carefully massaged.

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SACRO-ILIAC DISEASE

Etiology

Sacro-iliac disease is uncommon at all periods of life, and during childhood its occurrence is distinctly rare. Van Hook,\(^1\) out of a total of 72 cases of sacro-iliac disease, found it occurring in children in only 6 instances. The explanation of this age incidence, so different from tuberculous disease elsewhere, is said to be as follows: the disease appears to be predisposed to by a series of multiple traumatisms, and in children it is unlikely that these are sustained. It is often noticed that the young patients who do fall victims to the disease are children who are addicted to violent forms of sport and exercise.

Pathology

Anatomy of the Joint.—The joint is formed by the contiguous auricular surfaces of the sacrum and the ilium, and it constitutes a diarthrodial joint. The joint cavity is surrounded by strong ligaments which constitute the joint capsule. The anterior ligament is thin, while the posterior ligaments, two in number, are strong. The latter are largely responsible for suspending the sacrum and the weight of the superimposed trunk from the innominate bones. The joint is lined by a rudimentary and imperfect synovial membrane.

Pathology.—The disease may occur on either side of the body; it is exceedingly rare for it to appear upon both sides simultaneously. It has been described as originally occurring in the bone and in the synovial membrane; owing to the very imperfect development of the synovial membrane the second possibility is unlikely. The osseous disease may appear in the articular surface of the ilium or in the lateral mass of the sacrum. The sacrum is the more common position, and the disease often extends into this situation from the lower lumbar vertebrae. From the osseous disease the synovial membrane becomes infected, and the disease may extend across the joint to attach the articulating surface of the iliac bone. There is nothing characteristic in the detailed pathology of the disease, either in bone or joint, beyond the fact that the tendency to cold abscess formation is more prominent than is usually the case. The pus may make its way in various directions. It may pass backwards and become superficial, but owing to the strength and arrangement of the posterior ligaments this route is not commonly chosen. More frequently it forces its way through the thin anterior ligament, and becomes intrapelvic. The intrapelvic abscess may extend outwards into or behind the sheath of the psoas appearing with the

\(^1\) *Ann. of Surgery*, vol. viii. p. 401.
muscle in the groin, it may extend still further out beneath the iliacus and become superficial internal to the anterior superior iliac spine, or it may pass directly downwards and appear on the buttock through the sacro-sciatic notch and in the ischio-rectal fossa.

Clinical Features

Pain.—Pain is usually the first symptom to appear. It is situated over the affected joint, and it radiates down the back of the thigh and upwards towards the lumbar region. The actual symptom of pain is often ushered in by indefinite complaints of weakness and discomfort in the lower part of the back and sacrum, and a sensation as though the body was giving way. Pain is increased by standing, stooping, and walking, by defaecation, and by pressing the iliac bones together. It is considerably relieved when the patient lies down. As the disease progresses the pain becomes more constant and severe.

Limp, Attitude, and Gait.—The lameness is probably first noticed at the close of a heavy day’s work. The gait is characteristic, the patient takes short hesitating steps, and he may drag the affected leg. The attitude is distinctive. The pelvis is tilted upwards upon the diseased side, and the great burden of support is accordingly thrown on the sound side. There is a compensating scoliosis in the dorso-lumbar spine with the convexity towards the sound side.

Changes in the Limbs.—The gluteal muscles on the affected side become considerably atrophied. Apparent shortening of the affected limb is noted on account of the tilting upwards of the pelvis.

Swelling.—Swelling may be apparent over the joint behind. Very frequently rectal examination will demonstrate a swelling on the anterior aspect of the joint.

Abscess Formation.—Fluctuation may be detected posteriorly over the sacro-iliac joint; it may be detected by rectal examination while intrapelvic, or the intrapelvic abscess may be recognised in its various superficial situations, psoas, iliac, or sciatic. Palpation shows that the local temperature over the joint is raised.

Diagnosis

The actual diagnosis is made by the position of the pain and of the early swelling, by the radiation of the pain, and by the elicitation of the pain on bilateral pressure. In differential diagnosis there are four conditions liable to be mistaken for sacro-iliac disease—these are lumbago, sciatica, hip disease, and Pott’s disease.

Lumbago is recognised by the bilateral character of the pain and the situation of the occurrence.

Sciatica is confined in its distribution to the sciatic nerve. Sacro-iliac disease radiates upwards as well as downwards; moreover, sciatica is exceedingly uncommon in children.
Hip disease can be excluded by careful examination, and the demonstration of muscular rigidity in the hip-joint.

Lumbar Pott's disease may be exceedingly difficult to exclude. An X-ray will help, and also the fact that lateral pressure on the iliac spines elicits local pain in sacro-iliac disease.

Prognosis

The prognosis in children is said to be more favourable than in adults. The gravity of the prognosis is increased by abscess formation, especially if in treatment a mixed infection is set up. The affection is extremely chronic, and the necessary treatment is prolonged.

Treatment

General.—The patient should be put under such conditions that he gets the greatest possible benefit from improved general treatment.

Conservative.—Recumbent Treatment.—During the acute and the progressive stages of the disease, complete rest in bed is essential. The patient is fixed in a double Hamilton or Bryant splint, or in a bed frame. Comfort is derived by affording the patient the benefit of weight extension. Jones and Ridlon recommend a modified double Thomas splint; the vertical stems of the splint pass to the outer side of the posterior superior iliac spines, and about the middle they are connected by a broad leather sling which extends from the coccyx to the mid-lumbar region. Recumbent treatment is continued until all acute symptoms have disappeared, and as long as there is any risk of abscess formation occurring.

Ambulatory Treatment.—In going about, the patient wears a patten upon the sole of the boot of the healthy side. It is advisable that the boot sole on the diseased side be weighted with lead, as in this way a moderate and continuous extension is secured. It is necessary to afford some support to the diseased region and to the spine. A simple broad lacing band of leather or jean may be sufficient; it extends from 2 inches below the tip of the great trochanter to an inch or more above the crest of the ilium. The continuous pressure of the band does not induce pain as does intermittent pressure with the hands. Plaster of Paris has been used with benefit. It passes as a broad band round the pelvis, and takes a fixed point by passing round the upper end of one or both thighs. A double Thomas hip splint, altered as already described, is recommended, crutches and a high boot being used. Its use is probably unnecessary in the ambulatory stage.

Operative Treatment.—Indications.—Operation is recommended in early cases showing by X-ray the presence of a local osseous focus, also in cases which are passing on to abscess formation.

Operation.—The patient is placed prone, the pelvis being raised by an anterior pad. A vertical semi-lunar incision is made, convex inwards and

internal to the affected joint. The flap is separated outwards. The fibres of the gluteus maximus and gluteus medius with the great sacro-sciatic ligament and periosteum are separated from the posterior surface of the sacrum and the surface of the ilium and retracted outwards. The lower part of the erector spinae is separated and pulled inwards. The posterior surface of the joint is exposed, covered by strong posterior ligaments. Better access is got by removing the posterior superior and inferior spines of the ilium. Disease in the ilium or sacrum is removed with gouge and sharp spoon; it may be necessary to remove the whole articular surface. If an intrapelvic abscess is present it is emptied and any diverticula which may exist are drained with counter openings.

After-treatment.—The patient is of course kept at rest. Until the wound is healed the child is kept lying upon the side supported with sand pillows; when the wound is healed the supine position is maintained.

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TUBERCULOUS DISEASE OF THE SKULL BONES

Etiology

Children are liable to suffer from tuberculous disease of the skull bones. Its development is usually secondary to tuberculous disease in other parts of the body. As in other situations, injury would appear to play its part in the original development of the disease, and cases have come under one's notice in which a haematoma later became converted into a tuberculous abscess.

Pathology

With the exception of mastoid disease, which is really not a true form of original bone tubercle, the frontal bone is the most common situation of the disease. The infection is blood-borne, and it develops as a typical tuberculous osteomyelitis in the diploe of the bone. As caseation and pus formation occur the disease spreads to beneath the pericranium, and there it forms a localised cold abscess. It is exceptional for the infection to extend deeply and to form an extra-dural collection, although the author has observed a case in which the infection had extended from the deep surface of the skull bone through the membranes of the brain and involved the cerebral tissue. The disease extends rapidly throughout the bone. The small area of cancellous space and the density of the compact bone upon each side renders the formation of extensive sequestra likely.

Clinical Features

There are usually very few clinical features. Pain may be persistently complained of at the site of the disease, and it may be noticed that the pain considerably lessens when the surface abscess appears, apparently as the result of the lowered tension within the bone. In the absence of pain, swelling is the feature noticed; it is a subpericranial collection of pus, and
while, at first, its position indicates the situation of the osseous disease, it gradually extends beneath the pericranium over the surface of the bone. As long as it remains beneath the pericranium its distribution is limited by the line of the sutures. If treatment of the condition is neglected the abscess pierces the pericranium, becomes superficial, and ultimately forms a sinus to the surface. A mixed infection may thus gain admission, and when it does the disease makes more rapid progress, and there is extensive sequestrum formation. In the event of the disease involving the intracranial tissues the features of cerebral compression appear.

Prognosis

A guarded and somewhat unfavourable prognosis should be given. The disease is an indication of a wide dissemination of the infection, and sooner or later it is complicated by development of the process in other situations—the meninges.

Treatment

In the early stages of the disease operation offers the best chance of cure, and therefore it is not advisable to waste time by such conservative measures as aspiration of the abscess. The operation consists in making a horseshoe-shaped incision a little beyond the upper three-fourths of the limit of the swelling. The incision penetrates to the bone, and a flap including soft tissues and pericranium are dissected off the bone. The walls of the abscess are exposed on the deep surface of the flap and on the bone; these are thoroughly scraped with a sharp spoon. A disc of bone is removed from the diseased area with a trephine, and with rongeur forceps the surrounding skull is cut away until the healthy bone is reached. Great care should be taken to avoid injuring the dura. When the diseased bone has been thoroughly removed and all tuberculous tissue scraped off the surface of the dura, the skin flap is sutured back into position.

After-treatment.—No local form of after-treatment is necessary, but every attention should be paid to an improvement of the patient’s general condition.

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TUBERCULOUS DISEASE OF THE LOWER JAW

Etiology

Tuberculous disease of the lower jaw is more common than is perhaps imagined. It occurs very often at that period of life when the second dentition is making its appearance. It frequently attacks the children of phthisical patients, and for this reason the human bacillus is said to be the common type of organism present.

Pathology

Stockmann has shown that phosphorous necrosis of the jaw has an underlying element of tuberculous disease, and that the infection of the latter disease probably occurs through the medium of a decayed tooth. But the type of tuberculous jaw which one meets with in children owes its infection to another source. The organisms are carried into the jaw by the blood stream. They may settle in the ramus of the jaw where there are no teeth, but more frequently they are deposited in the body of the jaw, in relation to the fine blood-vessels entering the roots of the teeth. As the disease develops a quantity of tuberculous granulation tissue develops around the root and the tooth becomes loose. The disease extends further into the jaw and invades the cancellous bone of the interior. The periosteum, both inside and outside, becomes thickened from an irritative deposit of new bone. In extensive disease a cold abscess may form upon the outer surface of the bone. Owing to the comparative thinness of the ramus it is more likely to occur in this situation than in the body of the bone.
PLATE LI.—TUBERCULOUS DISEASE OF THE LOWER JAW.

a. Tuberculous disease of the body of the lower jaw. b. Tuberculous disease of the body of the jaw and spreading into the ramus. c. The lower jaw with the tooth in situ. The disease has originated at the root of the tooth, and it has begun to spread over the surface of the jaw. d. Tuberculous disease originating at the root of a tooth.
Clinical Features

Pain.—Children affected with this disease complain of pain in the jaw. To some extent it is limited, but pain is also complained of which shoots along the distribution of the inferior dental nerve.

Loose Teeth.—Loosening of the teeth is a characteristic feature. The infiltration of the disease within the tooth socket is responsible. Sometimes the tooth may be pulled out from the jaw without any pain. It is further noticeable that the cavity from which the tooth is withdrawn does not bleed.

Swelling.—The thickening of the jaw is the result of the deposit of new subperiosteal bone, and the deposit is secondary to the irritative process in the interior of the bone. It should be noticed that the thickening is present upon both surfaces of the jaw, in contradistinction to a simple periostitis which is often limited to the outer table of the bone.

Abscess Formation.—The bony swelling may be suddenly accentuated by the development of a cold abscess. The abscess may make its way to the surface through the skin or through the mucous membrane into the mouth. When the abscess opens into the mouth the gravity of the disease is greatly increased by the tendency which there is to the development of laryngeal, bronchial, or mesenteric tubercle.

Glandular Enlargement.—It is common to find the submaxillary and submental lymphatic glands infected with tubercle secondary to disease of the jaw.

Diagnosis

There may be considerable difficulty in coming to a certain diagnosis. A general anaesthetic may require to be given to ensure a thorough examination of the part. Importance will, of course, be attached to the presence of tubercle in other situations. There are two conditions which are apt to be mistaken for tuberculous disease, namely, cystic disease of the jaw and simple inflammatory periostitis.

Cystic disease is excluded by the facts that it develops usually between twenty and forty, that it develops exceedingly slowly, gradually distending the bone, and that there is no tendency to the development of superficial abscesses. Any doubt which may exist is cleared away by X-ray examination.

Simple periostitis has usually an acute or subacute history sufficient to demonstrate the nature of the infection.

Prognosis

If the disease is early recognised and completely removed, the prognosis is good. The grave element appears when sinuses open into the mouth.
Tuberculosis of the Bones and Joints

Treatment

While every attention should be given to the improvement of the patient's general condition, there are no conservative means of treatment which can be adopted. It is well to observe any improvement which arises from the removal of decayed and loosened teeth. It remains to discuss the operative treatment, and it should be insisted that this is carried out as early as possible.

Operation.—The preliminary should be observed of having the interior of the mouth in as healthy a condition as possible; a tooth brush is thoroughly used and all decayed teeth are removed. The operation consists in a subperiosteal resection of the diseased bone. The incision begins in front of the lobule of the ear, it passes vertically downwards along the posterior margin of the ramus, turns round the angle and runs forwards as far as is necessary, parallel to and a little below the lower margin of the jaw. The upper part of the incision is so superficial as not to injure the facial nerve, the remainder of the incision passes on to the bone. The facial artery is divided and clamped. The periosteum is incised along the lower margin of the jaw and along the posterior border of the ramus. With a broad periosteal elevator, the periosteum and the masseter are separated off the outer surface of the ramus and forwards to beyond the disease. In the same way the periosteum and the internal pterygoid are separated from the inner surface of the jaw. The bone is now removed, according to the position of the disease. If the disease is limited to the body, the jaw is divided in front of and behind the disease and the segment removed. If the ramus is involved the bone is divided in front with saw or bone forceps, and the posterior part is wrenched away subperiosteally from the temporo-maxillary joint. The end of the torn inferior dental artery is ligatured. The periosteal space is partly closed off with interrupted catgut sutures, a drain is inserted, and the

Fig. 161.—Tuberculous disease of the left malar bone.

Fig. 162.—Tuberculous disease of both malar bones.
skin wound closed. When the disease involves the greater part of the horizontal ramus, tracheotomy should be performed before the bone is removed, as after removal of the bone the loss of attachment of the tongue muscles may produce a falling back of that organ and asphyxia.

After-treatment.—It is essential to keep the mouth as sweet as possible after operation; a mild antiseptic mouth wash is employed.

TUBERCULOUS DISEASE OF THE UPPER JAW AND MALAR BONE

The disease originates in the cancellous tissue around the suture uniting the malar bone and the superior maxilla. Abscess formation readily occurs; the abscess may appear upon the front of the face, in the zygomatic fossa, or in the floor of the orbit. The abscess soon perforates on to the surface, and there is a sinus. Sequestrum formation is common.

Pain.—Abscess formation and the presence of a persistent sinus are, practically speaking, the only clinical features.

As in disease of the lower jaw conservative treatment is of little avail, therefore operative measures ought to be adopted at an early stage. The best incision for the exposure of the part is one which begins a little below the middle of the infraorbital margin, and passes downwards and outwards over the malar bone for the necessary distance. The incision has the double advantage of avoiding the branches of the facial nerve and of leaving a scar which is concealed in the natural folds of the skin. The abscess cavity is

![Fig. 163.—Tuberculous disease of right lower jaw and left malar bone.](image)
cleaned out, the periosteum is separated from the bone and the diseased focus removed.

Fig. 164.—Central tuberculous disease of the patella. (Dr. Kirk’s case.)

TUBERCULOSIS OF THE RIBS

The ribs may be infected with a primary tuberculous osteomyelitis, or they may become involved secondary to tuberculous disease of a neighbouring part, such as the pleura, in which case the disease begins as a periositis.

The clinical features are indefinite, pain is often complained of before the appearance of an abscess. Early abscess formation is characteristic. It may be situated over the site of the bone focus; sometimes it makes its way along the line of nerves, blood-vessels, or tissue-planes, and appears at a considerable distance from the original disease. From a focus in the posterior extremity of the rib the pus may burrow along the line of the intercostal vessels, and appear in the mid-axillary line or at the side of the sternum. When the disease is situated at the costo-chondral junction a secondary abscess may gravitate downwards, enter the sheath of the rectus, and filter down the whole length of the abdominal wall. It is exceptional, but it sometimes happens, that the abscess collects between the pleura and the chest wall.

The treatment consists in complete and early excision of the diseased rib. A horseshoe-shaped incision is preferable to one in the line of the rib, as it gives more complete access. The convexity of the incision is directed downwards, and the flap is dissected upwards off the chest wall. If an underlying abscess is exposed, it is completely dissected away. The ribs are carefully examined for signs of disease, it may be a periosteal thickening, it may be a sinus leading into the bone. The diseased bone is resected.
subperiosteally, and any disease in the periosteum is dissected out. The flap is sutured back into position with or without drainage.

When the abscess has travelled some distance before becoming superficial enough to be recognised, it may be difficult to decide on the situation from which the infection originated. In such circumstances it is proper to open the abscess, and by following the track taken by the pus, to expose, if possible, the original focus.

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