X-rays in diagnosis.

Contributors

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X-RAYS IN DIAGNOSIS.

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CONTENTS.

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INDEX TO ILLUSTRATIONS—*continued.*

INTRODUCTION.

IT is with considerable satisfaction that we are enabled to publish, for the benefit of the Medical Profession generally, an Extra Number of The Practitioner dealing with the use of X-Rays in the diagnosis and treatment of the various forms of accident, injury, and disease. So far as we know, no Text Book dealing with the subject in anything like so comprehensive a form has been published, and we therefore confidently express the hope that this extra number will be found to afford not only information of the utmost value to the general practitioner, but also guidance in the use of X-Rays of the most useful and practical nature. Seeing that hitherto the literature on the subject has been neither comprehensive nor authoritative, the articles which have been selected for the benefit of our readers, coming as they do from authorities whose practical experience must command attention and respect, cannot fail to excite general interest.

The importance of diagnosis in such cases as those to which reference is made is to a certain extent of recent birth, and perhaps on that account will be regarded by many, at least, of our older colleagues with a certain amount of reserve and caution, but when they realise that a far greater amount of accuracy in the determination of the nature of the case is rendered possible, and that consequently a very much higher degree of confidence in dealing with it is afforded, we feel sure that they will at once recognise the indispensable character of the invaluable aid now afforded by means of the use of the X-Rays. We find thus that by the use of these Rays we are no longer dependent on the signs which may, or may not, be clearly indicative of all the details of the case, nor on the symptoms, which, after all, may be altogether misleading, but that, on the contrary, all the facts, as in a picture, are indisputably set before us.

While it must be recognised that the use of the X-Rays affords invaluable assistance in diagnosis, it must also be remembered that the accuracy of the information given very largely depends upon the skill and experience of the operator. Unless the Radiographer correctly interprets the meaning of the shadows, for the pictures are *shadows* only, and not specimens of direct photography, an utterly misleading conclusion may be arrived at. Indeed, nearly all the writers draw attention to the absolute need for skilled interpretation of the pictures obtained.

We confidently commend this very important extra number of The Practitioner to the favourable consideration of the whole Medical Profession.

THE PRACTITIONER.

EXTRA NUMBER.

SOME CLINICAL ASPECTS OF X-RAY WORK.

By SIR WILLIAM BENNETT, K.C.V.O., F.R.C.S.,

Knight of Grace, Order of St. John of Jerusalem; Consulting Surgeon, St. George's Hospital; Surgeon, London School of Clinical Medicine, etc.

[With Plates I.—IV.]

THERE are few discoveries of recent times which have had more striking effects upon the practice of Medicine and Surgery than that which led to the use of X-rays in the diagnosis of disease and injury, and, in a minor degree, to their treatment.

THE NECESSITY FOR SKILLED INTERPRETATION OF X-RAY APPEARANCES.

Although the X-rays have been used for clinical purposes for a sufficient length of time to make them more or less familiar to all practitioners, it is doubtful whether a very great benefit has been derived by the majority from their employment; and it is, I suppose, certain that only a very small minority of those who use them have experience of their real possibilities.

It is further undeniable that the use of the X-rays sometimes leads to results in diagnosis, which are harmful rather than beneficial, in the hands of those who are unskilled in the interpretation of the appearances seen.

The impression, which seems to be pretty generally held, that the interpretation of radiographs is a simple matter, such as any tyro may undertake with confidence, is unfortunate and altogether misleading, excepting in grossly obvious cases. Nothing, in fact, is at times more difficult than the correct interpretation of appearances shown by the X-rays even by those who have had large experience in this matter; whilst, to those who have not been educated in methods of interpretation, it is not infrequently impossible. It is to this latter fact that the majority of mistakes, arising in the course of the use of Radiography in clinical work, are due.

In a word, educated and expert interpretation of appearances shown by the X-rays is, in the majority of cases, as important as skilful manipulation and management in their production, since a radiograph, however skilfully it may be produced, is useless if improperly interpreted, a fact which, so far as I am able to judge from a very large experience, is too frequently overlooked. The fallacies associated with Radiography are so largely due to faulty interpretation, that the necessity for education in this direction cannot be too strongly emphasised.

The first essential in the proper interpretation of X-ray appearances is, naturally, the acquisition of a true knowledge of the aspects of various parts of the normal body, as seen by these means, including, of course, the movements of the diaphragm and lungs, the area of the heart pulsations, etc., as revealed by the screen.

It would, at first sight, seem enough to rely upon an accurate knowledge of the conformation of the bones, as met with in the dissecting room, in interpreting the appearance shown by the X-rays in connection with them, but these appearances are often strangely unlike what would be expected from a mere acquaintance with the bones in the prepared skeleton.

In Fig. 1, for example, is seen the clavicle of a patient in whom, eighteen months after an injury to the shoulder, some pain and stiffness remained. A radiograph revealed the condition shown, which at first sight might readily suggest, to the inexperienced, an old fracture of the clavicle, although it is, in fact, quite normal, the injury being an impacted fracture of the neck of the humerus, with so little deformity that it might easily escape notice, especially if the observer's mind were biassed by the deceptive look of the clavicle.

An instance has recently come under my observation in which an expert, more than usually versed in the nature of X-ray appearances, entirely failed to see anything abnormal in a radiograph of a case in which an operation subsequently revealed a condition, which is, as a rule, quite patent in X-ray pictures. A re-view of the radiograph, *after the operation,* in the light thus thrown upon it, showed the abnormal condition very clearly. The case is, I think, worth mentioning in order to show how really difficult the interpretation of X-ray appearances sometimes is.

The somewhat common want of skill, in the interpretation of X-ray appearances, is clearly shown by the tendency to confuse the natural shadow cast by the arch of the aorta with aneurysm, an error which, in the absence of experience, is excusable, as the pulsating area seen is so large and distinct. Apart from certain abdominal conditions, to which reference will presently be made, one of the commonest causes of deception, in pathological state, is met with in the union of fractures. It does not yet appear to be generally understood that the deposit of lime salts, in "bony" union after fracture, is very slow, and is probably never so complete as to make the bond of union as opaque to X-rays as normal bone in the living subject. Hence it is not uncommon to find "non," or "soft" union diagnosed, because the X-rays show a more or less transparent line at the point of union. As a matter of fact, the line of union, for the reason I have mentioned, is always more or less translucent, provided, of course, that the rays are not interrupted by the overlapping of original bone. Fig. 2 shows a well-united fracture, $4\frac{1}{2}$ years after the injury. The light area, representing the new uniting material, is as hard as normal bone, a fact for which I can vouch, as I had to remove a piece of metal from the neighbourhood of the fracture, and attempted to pass a sharp instrument into the line of union, which, so far as the sense of touch could tell, was as resistant as the natural bone on either side.

THE SCREEN IN CLINICAL WORK.

Unless it is in extremely expert hands, the screen should never be relied upon in any case, in which a radiograph can be taken, excepting as a rough-and-ready means of preliminary examination. It should, therefore, not be usec otherwise in determining the nature of fractures and dislo cations, and in the detection of foreign bodies, renal and other calculi. On the other hand, it is the only means by which the X-rays can be utilised as a guide, during the actual process of "setting" a fracture, or of reducing a dislocation, and, for the examination of movable or pulsating structures; the diaphragm, for example, in suspected subphrenic abscess the heart, aneurysms, etc. Surgically, its most useful function, perhaps, is to allow of guidance, during the performance of certain operations, notably for the removal of foreign bodies, especially when situated in unusually inaccessible places, such, for example, as the bronchus. On no account, however, should any attempt be made to remove a foreign body, with or without the aid of the screen, unless it has been previously localised.

THE IMPORTANCE OF LOCALISATION.

Bearing in mind that the ordinary X-ray picture is a shadow only, which conveys no sense of proportion or relation between the different parts seen, and that the slightest inaccuracy in the placing of a tube, or any accidental deviation, may so contort the shape of things as to make the resulting image a mere travesty of the actual condition of the parts, it follows, almost as a matter of course, that it is impossible to give a really adequate idea of the shape of parts, or of their relation to one another (*e.g.*, in a case of fracture), or in any useful sense to localise the position of a foreign body, by successive exposures of the part in different positions, say, in a case of fracture of the leg, antero-posterior, lateral, oblique, and so on. This is such a well-known fact to those of experience in X-ray work, that I am only induced to refer to it because, from my own knowledge, there are still some who attempt to localise and differentiate in this way.

Not long since, a case came under observation, in which a foreign body was localised in this way, as lying on the carpus; a prolonged operation, which involved opening up the carpal joints, failed to find it. Subsequently, after localisation by a different method, it was easily extracted from a point about one inch above the lower end of the radius.

In contrast with this, it is well known that negatives, seen stereoscopically, reproduce a picture of the parts in the actual relation which they bear to one another, and in the case of a foreign body, it can thus be localised with singular clearness; it is in fact shown almost as it would be seen in a dissection of the part, and, in many cases, all the localisation, that can be desired is so provided. It is, however, true that, even with the stereoscope, fallacies are not entirely obviated, but the liability to them is reduced to a minimum.

The stereoscope is essential for accurate clinical X-ray work, and it is a surprising fact that it is even now less commonly employed than would be expected, seeing the advantages which its use affords. Should the localisation of the stereoscope be insufficient, absolute localisation to a fine fraction of a degree is obtainable by such an instrument as MacKenzie Davidson's localising apparatus, to which many a patient owes the salvation of an eye which would otherwise have been removed. It is indeed, in connection with foreign bodies in and upon the eyeball that the vast importance of accurate X-ray localisation in clinical work can alone be realised.

THE NECESSITY OF CHECK EXPOSURES.

In using the X-rays for purposes of diagnosis, it should be a rule that no definite conclusion is to be based upon a single exposure, or set of exposures, excepting in the most obvious cases, and even in such it is wise to observe this law.

The results of the first exposures should always be corroborated, or the reverse, by check exposures, made after an interval of a day or two, in order to avoid the liability to the repetition of errors, which might occur, if the check exposure were made at the same "sitting" as the first. There is no doubt that serious errors, in diagnosis and treatment, are often made by the neglect of this common-sense rule. The dictates of ordinary prudence would seem to render this impossible, but it is nevertheless a fact that they frequently do not do so.

The only excuse for acting upon a single exposure is either extreme urgency, or some combination of circumstances which renders it impracticable to obtain a check experiment. The following is a case in point.

A girl, 12 or 13 years of age, complained of some obscure pains about the lower part of the spine. For advice, she was taken to a physician, who subsequently saw her with a surgeon. The symptoms being regarded as suggestive of spinal disease, an X-ray exposure was made by an experienced Radiographer, the resulting negative and print showing over the lumbar vertebræ a marked oval shadow with rather indistinctly defined margins. The symptoms described, together with the appearances shown in the radiograph, led to a diagnosis of tuberculous disease of the lumbar vertebræ with abscess. Twelve months' rest on the back was prescribed, and the parents were informed that an operation, with a view to dealing with the abscess, would become necessary. In the face of such a grave opinion, the advice of another surgeon was sought, who could neither reconcile the symptoms with those of spinal disease, nor acquiesce in the view that the shadow shown in the skiagram was due to abscess, a similar shadow being frequently seen in normal subjects in certain conditions of bowel distension. A check exposure was therefore made by another Radiographer of experience, with the result that an absolutely normal spine was shown. Rational exercises, with massage, were prescribed in the place of the long rest and prospective operation, with the happiest results.

It cannot, I think, be doubted that the prudent course, in a case of this kind, is to obtain a check X-ray exposure before giving a definite opinion. In other words, the rule to which I have referred should be observed.

THE USE OF THE X-RAYS IN THE DIAGNOSIS OF ABDOMINAL PAIN.

There is probably no sphere of greater utility for the X-rays in clinical work than the investigation of cases in which obscure abdominal pain is a prominent factor, especially when the pain is situated below the level of the navel.

The difficulty of diagnosis in such cases is notorious, and I have good reason for believing that the advantages, obtainable from the diagnostic point of view by X-ray investigation, are by no means sufficiently realised by the generality of practitioners. The results of long and varied experience lead me to insist upon X-ray examination of all patients, suffering from persistent, or from frequently recurring abdominal pain,

PLATE I.

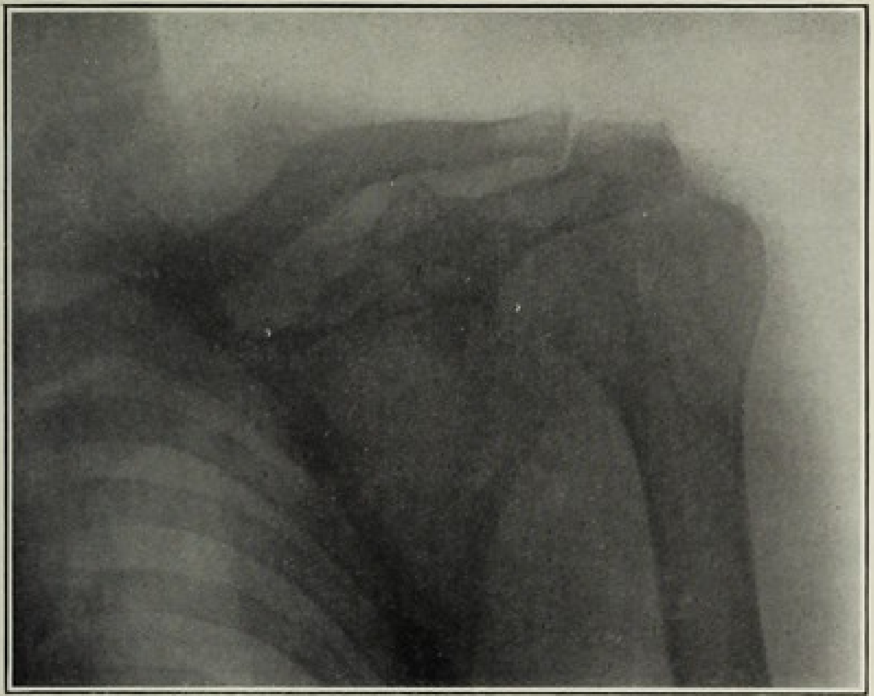

Fig. 1. *Normal clavicle, suggestive of old fracture.*

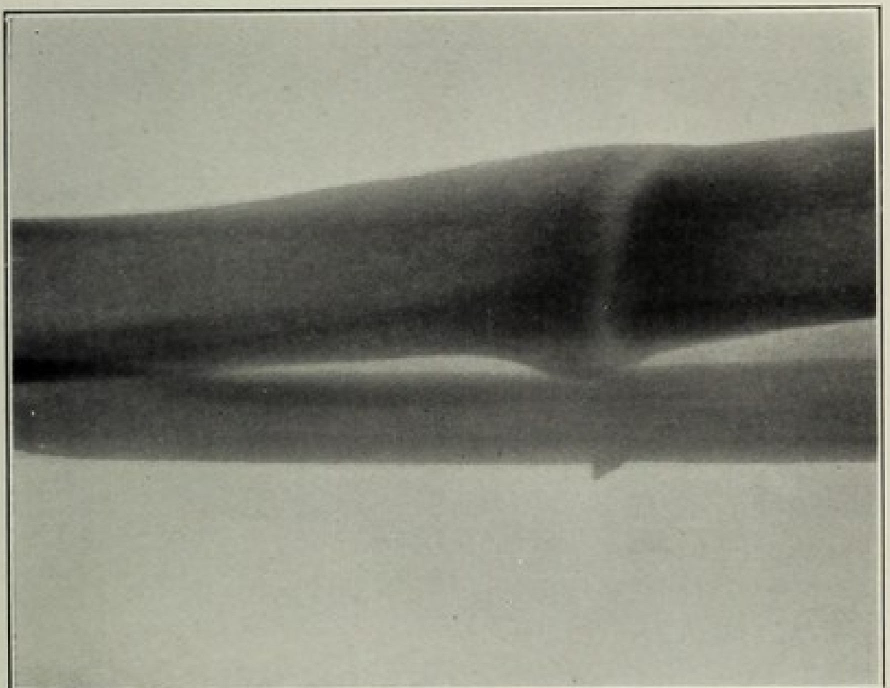

Fig. 2. *Bony union in fracture of the tibia, 4½ years after the injury, showing translucency to X-rays.*

PLATE II.

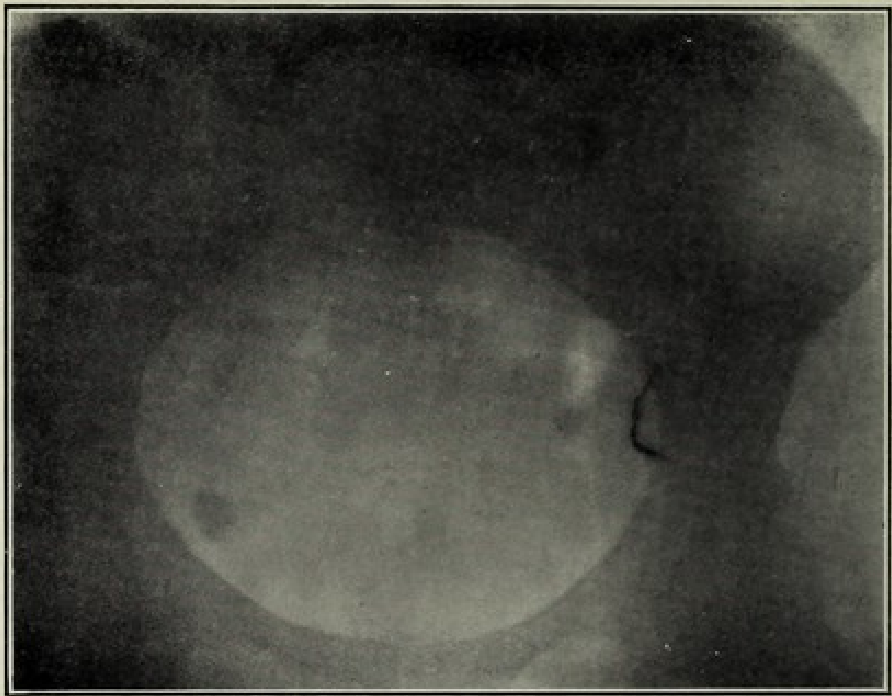

Fig. 3. *Stone in the ureter, shown by X-rays, in a case of pseudo-appendicitis.*

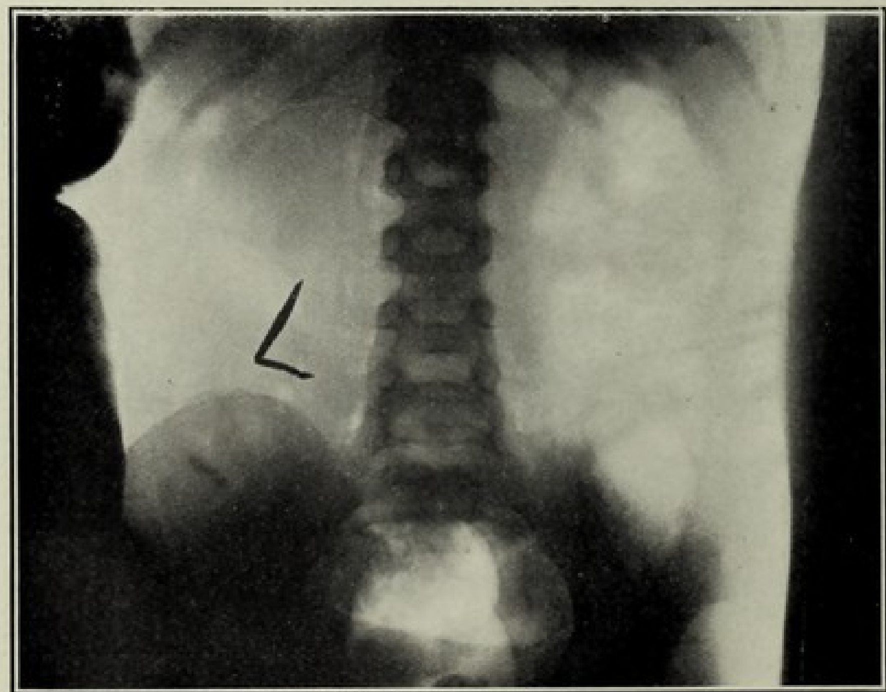

Fig. 4. *X-ray appearances in a case of suspected calculus before the patient has been properly prepared for the exposure.*

PLATE III.

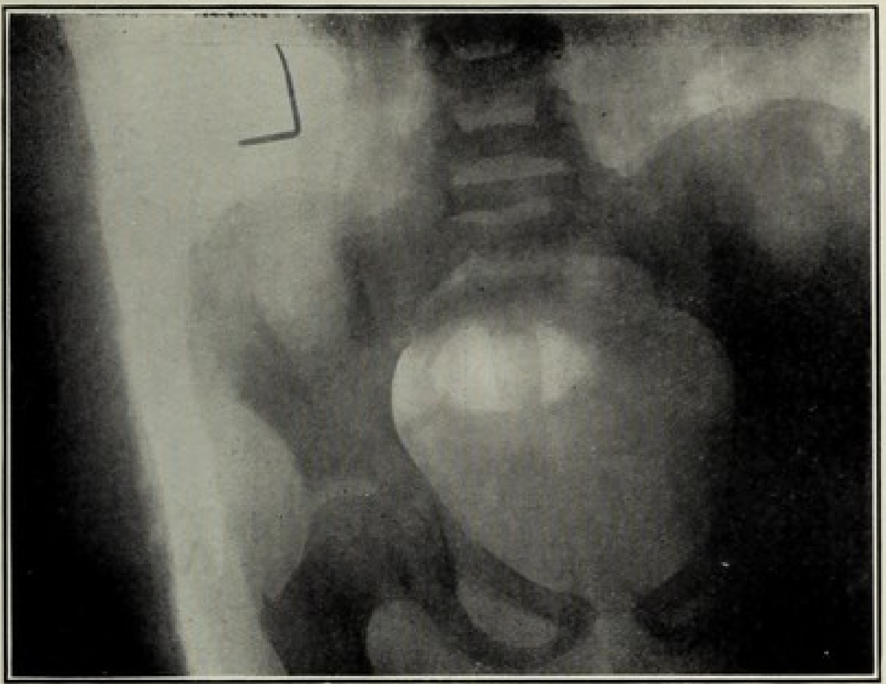

Fig. 5. *The same case after proper preparation.*

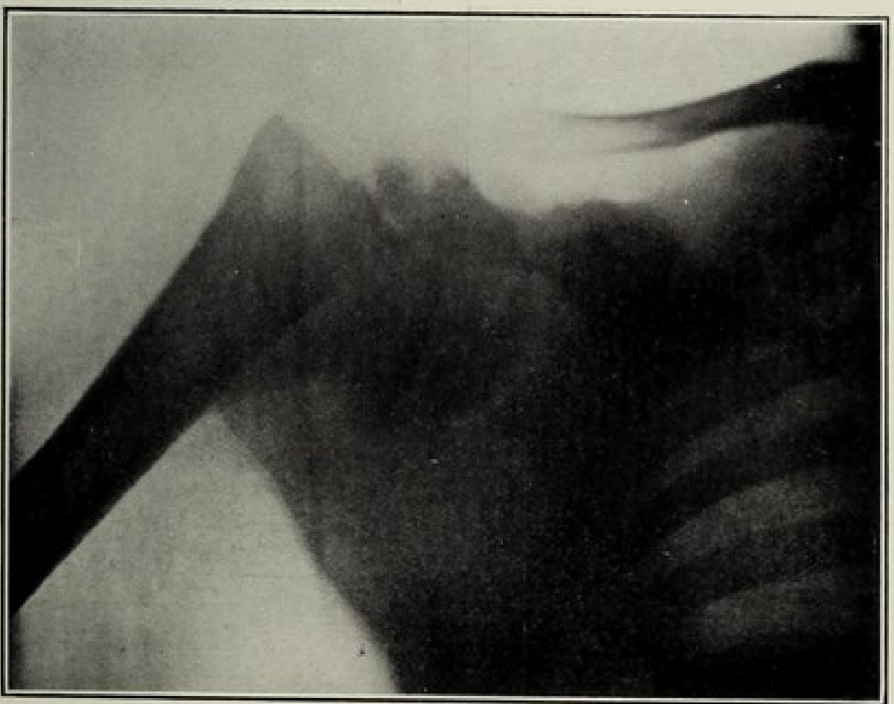

Fig. 6. *A case of fracture of the neck of the humerus, showing faulty position of the fragments.*

PLATE IV.

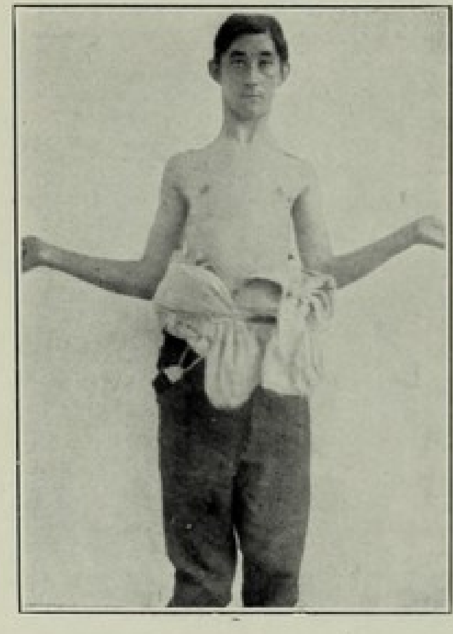

Fig. 7.

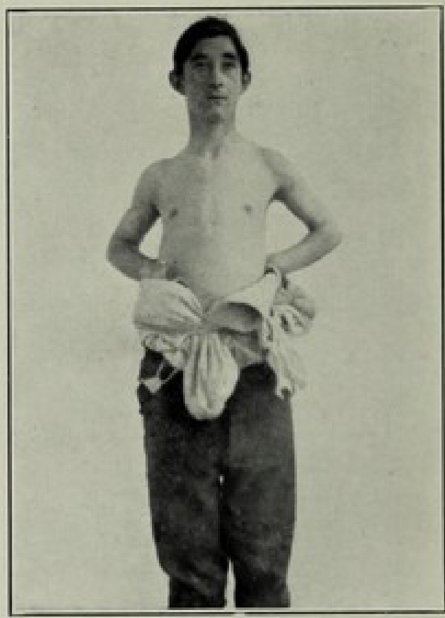

Fig. 8.

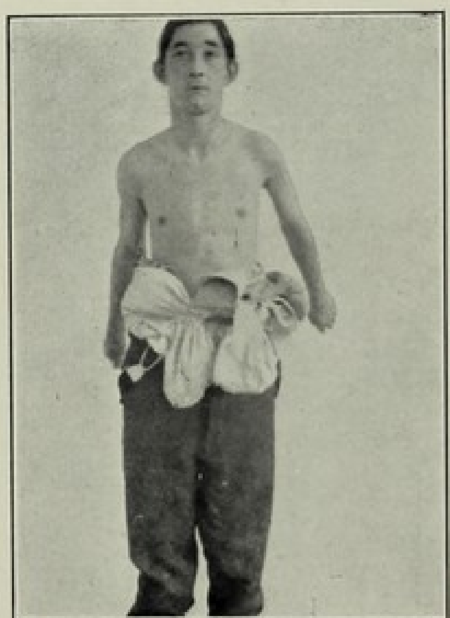

Fig. 9.

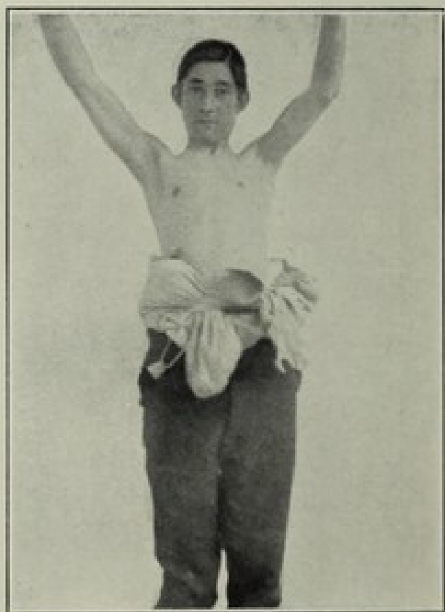

Fig. 10.

Figs. 7–10. *Range of movements attainable by the patient in case shown in* Fig. 6, *thirteen months after the injury.*

unless the cause of it is obvious. On several occasions I have thus been saved from the discredit of having performed an unnecessary operation, and in others I have been prevented from resorting to the wrong operation. It is more especially in connection with cases in which the symptoms point somewhat inconclusively to appendicitis that the X-rays are useful, and I now have all cases, in which the symptom are suggestive of chronic, or sub-acute appendicitis, radiographed.

The following cases are excellent examples justifying this course :—

1. A girl, about 18 years of age, with a history of attacks of "appendicitis," was brought to me. Whilst in London, I saw her in one of these attacks, and it certainly was very strongly suggestive of appendix trouble. There was constipation with the recognised tenderness over "McBurney's spot" and abdominal resistance, as well as hyperæsthesia of the skin over the iliac region. The temperature, however, did not exceed 99·5 degrees, and there was a feeling of nausea only, no actual vomiting.

Taken together, the symptoms, considering the frequency of their occurrence, and the way in which they affected the health of the patient, would, in ordinary circumstances, have fully justified an operation upon the appendix.

Having in mind the way in which appendix disease is simulated by other conditions, notably stone in the ureter, I pursued my usual custom, and had the patient examined by the X-rays. Fig. 3 shows the result. A stone of considerable size is easily seen in the ureter, and it is quite clear that an operation for appendicitis would not have cured the patient. I have no doubt that, if all cases of apparent chronic, or sub-acute appendicitis were submitted to X-ray examination, there would be fewer cases in which operation is followed by disappointment.

2. A middle-aged man, whose case I mentioned in the discussion upon appendicitis at the Royal Medical and Chirurgical Society last year, had eight successive attacks of what were called "appendicitis." He was then operated upon, the appendix, which was said to have had a stricture in it, being removed. The operation had no effect upon the

attacks, which occurred as frequently after it as they had done before. Subsequently one of the attacks terminated very abruptly, and, within three days of this, a small stone was passed by the urethra; no further attacks followed.

It is fair to assume that an X-ray examination before the operation would have revealed the stone, and so have prevented an entirely unsuccessful and unnecessary proceeding.

THE NECESSITY OF PROPER PREPARATION IN ABDOMINAL SKIAGRAPHY.

Upon suggesting X-ray examination in cases of this kind, I have more than once been met with the objection that the results are apt to be nugatory, because the appearances in the abdomen are so deceptive. I have no doubt that this objection frequently holds good, because it does not seem to be generally understood that, in order to obtain a satisfactory abdominal radiograph, methodical preparation of the patient is necessary to ensure the bowel being entirely free of solid material. It is the want of preparation which is generally the cause of deceptive results in radiographs of the abdominal region.

Fig. 4 shows a skiagram of the abdomen of a child, who was suspected of having stone in some part of the urinary tract. The exposure was made immediately upon the patient being referred to the Radiographer. It is difficult to imagine anything more suggestive of stone to the incautious, or inexperienced practitioner, than the oval shadow immediately above the left pubic body. Fortunately the case fell into highly experienced hands, and, before a definite opinion was given, a check exposure, after the bowels had been thoroughly cleared out, was made. The result is seen in Fig. 5, in which the suggestive shadow has entirely disappeared, as it naturally would do, seeing that it was due to the presence of fæcal accumulation. It would, I think, be difficult to produce a more perfect object lesson, showing the necessity of check exposure in X-ray work, than this case presents.

Excepting in certain obese subjects with pendulous bellies, there is little reason for being misled in abdominal skiagraphy, if the patient has been properly prepared for the exposure, and if the apparently little-known fact that the corpora cavernosa and glans penis are singularly opaque to X-rays is borne in mind. I have known the oval shape of the opaque glans penis lying over the symphysis pubes simulate stone in the bladder with remarkable similarity, until the stereoscope has cleared up any doubt upon the matter.

A MEDICO-LEGAL POINT OF IMPORTANCE IN CONNECTION WITH X-RAYS IN CLINICAL WORK.

Before the X-rays were available for clinical purposes, the difficulty of obtaining perfect apposition of the fragments in certain fractures, especially in those occurring near the larger joints, was fully recognised by all practical surgeons. Patients and practitioners, therefore, were alike content, if the results in such cases, in the way of usefulness and mobility of the limbs, were satisfactory; in other words, if a useful limb resulted from the treatment adopted, no thought of complaint or discontent arose.

The use of the X-rays abundantly showed that, in many cases of this kind, in which a useful limb followed, the position of the fragments was very indifferent, and, in a considerable proportion, absolutely bad. In consequence of these X-ray revelations, considerable litigation has already taken place, and it seems probable that more is liable to follow. In this respect, therefore, there arises an actual danger to the practitioner, no matter how careful, or conscientious, he may be in the management of the case.

In an instance, recently tried, an action for damages for neglect, on the part of the practitioners concerned, was brought by a patient on the grounds that the X-rays showed that the fragments in a case of fracture were not in accurate apposition, as it was submitted they should have been, had the treatment been properly conducted. The jury could not agree upon a verdict, and the case has to be retried; comment upon it is therefore inadmissible.

Fig. 6 is a radiograph, showing a very faulty position of the fragments after union, in a case of fracture of the surgical neck of the humerus, whilst Figs. 7 to 10 are photographs, showing the range of movements attainable by the patient, a sailor, about 17 years old, who came under observation at the Seamen's

Hospital, Greenwich, 16 months after the injury, which was caused by a fall from the rigging on to the deck of the ship in which he was serving. When seen after the interval mentioned, the limb was perfectly strong, and the patient could do a long and hard day's work as well as any other able bodied person.

Having regard to the insurmountable difficulties which are sometimes met with in practice, especially in out-of-the-way country places where skilled assistance is unobtainable of retaining the fragments in accurate position in cases of fracture, it is a question for the practitioner to consider whether he should not, before undertaking a case of this kind, insist on a guarantee indemnifying him from the liability to an action at law merely on account of faulty union, if subsequently revealed by the X-rays. It is quite clear that, if the simple fact of a faulty position of the fragments, in some difficult kinds of fracture, is to be held as evidence of neglect in treatment, although a useful limb may exist, the practice of this branch of surgery would become almost impossible by the majority of medical men, on account of the danger of litigation on the part of captious or speculative people.

For the prints reproduced in the illustrations for this article, with the exception of Figs. 6 to 10, I am indebted to Mr. MacKenzie Davidson.

X-RAYS IN THE DIAGNOSIS OF LUNG DISEASE.

By DAVID LAWSON, M.A., M.D. (Ed.), F.R.S.E.,
Senior Physician to the Sanatorium at Bauchory, Scotland.

[With Plates V.—XIV.]

HISTORICAL.

It was in 1895 that Wilhelm Konrad Roentgen,[1] of Würzburg, by announcing his now famous discovery of the existence of X-rays, and demonstrating their power of penetrating certain solid substances and illuminating others, first arrested the attention of the scientific world, and laid the foundation of a new method of diagnosis in medicine and surgery. The possibility of utilising those rays, as a means of diagnosis in the wide domain of pulmonary disease, at once suggested itself to the practical mind of Charcot, of Paris, who, with characteristic energy, forthwith applied himself to the problem which it presented. His early efforts met with immediate success, and, as a result, there appeared from his pen in the following year, 1896, is first contribution to the now fairly voluminous literature which exists upon the subject, in the form of a paper, entitled "X-rays as a Diagnostic Agent in Pulmonary Disease." In this direction he was followed by Stubbert,[2] of New York, who, in 1897, related his experience of the examination of 73 cases of pulmonary disease by X-rays, and, four months later, by Williams,[3] of Boston. Those papers do not appear to have fired the imagination, or inspired the enthusiasm of investigators to a degree commensurate with the importance of the work with which they deal, or with the potentialities with which an inquiry into this branch of medicine might be attended; so that for several years little or nothing further was heard upon the subject. It was not until Walsham[4] delivered his address at the British Congress of Tuberculosis in 1901, in which he graphically described the work on which he had been quietly engaged, and the results which had attended his labours, that the subject really aroused attention in this country. During the next eighteen months signs of activity appeared. Original observations upon the subject were published by Gardiner,[5] Lawson and Crombie,[6] and Halls Dally;[7] and frequent contributions, which have appeared from time to time since then from the pens of others, have shown that the original band of workers, engaged in investigating the difficult subject of the application of X-rays to the diagnosis of lung disease, has materially increased.

MECHANICAL.

In the present paper, the writer has ventured to assume that the reader possesses a knowledge of those principles which underlie the employment of X-rays as a diagnostic agent in medicine, and is familiar with the technique employed in examining a chest by means of the fluorescent screen, and in procuring a permanent record of the condition present by means of a skiagram. Descriptions of complicated apparatus, more fitting in a journal dealing with the physical side of X-rays than in one of an essentially clinical nature, have been purposely omitted. Nevertheless, it has appeared to the writer desirable to acquaint the profession with a mechanical appliance, in the form of a chair, which has been specially designed to meet the more common difficulties which beset the path of him who would practise Radiography in connection with chest diseases. For the following description of this chair, the writer is indebted to its inventor, Dr. A. H. Lister,[8] of Aberdeen, who first described it in his M.D. thesis of 1904:—

"I consider that the ordinary methods of Radiography of the chest are unsatisfactory, inasmuch as, whether sitting or lying, there is no accurate control over the exact portion of the chest which is being radiographed. I therefore designed a chair for the purpose of surmounting those difficulties, introducing into its mechanism arrangements which enable it to be used for radiographic purposes other than that of the chest. The apparatus is shown in accompanying photographs. The strong wooden lateral uprights project upwards on each side of the chair, which swings on a pivot attached to the framework of the chair, near the floor. At the level of the seat, the uprights can be made fast by means of a screw to the framework of the seat. The screw, when untightened, runs in two slots, one vertical in the upright, the other horizontal in the framework of the seat, allowing play backwards and forwards to the desired extent.

Plate V.

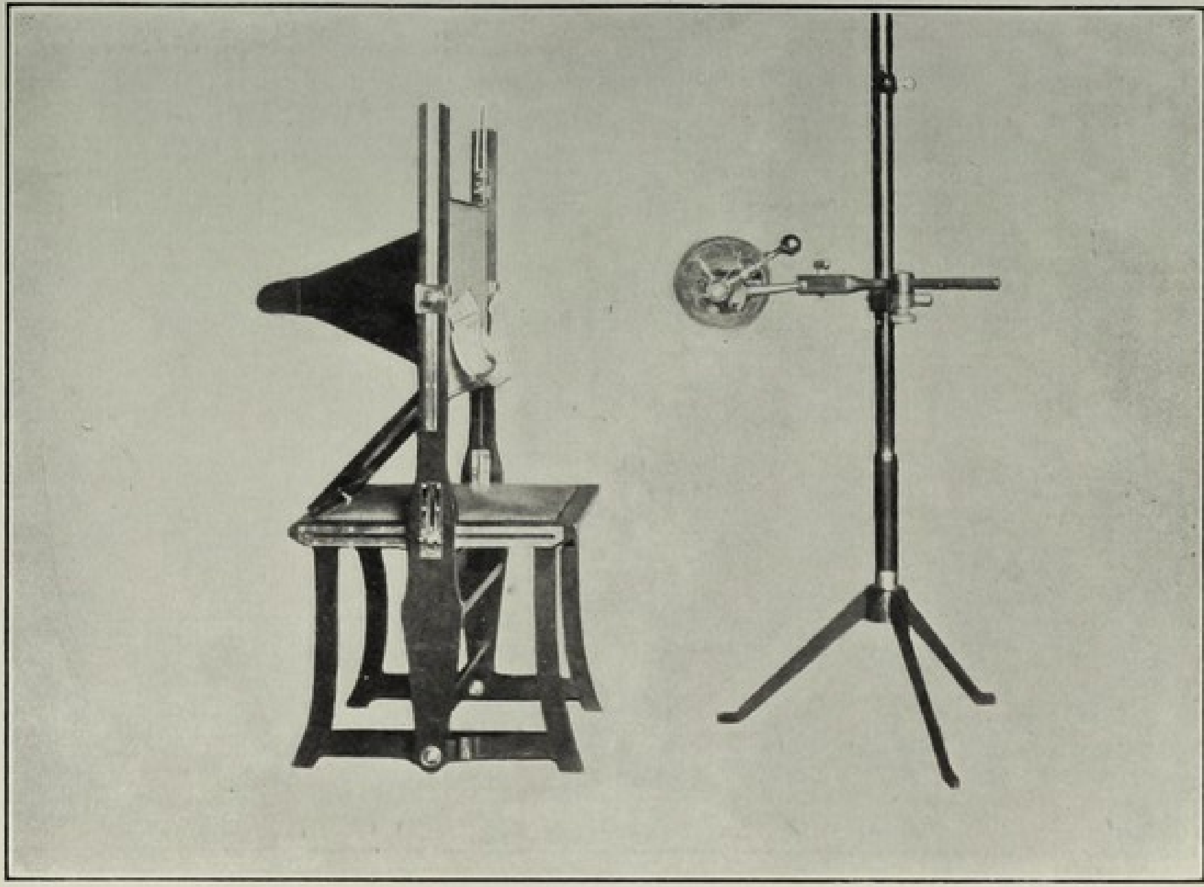

Fig. 1. *Lister's chair.*

PLATE VI.

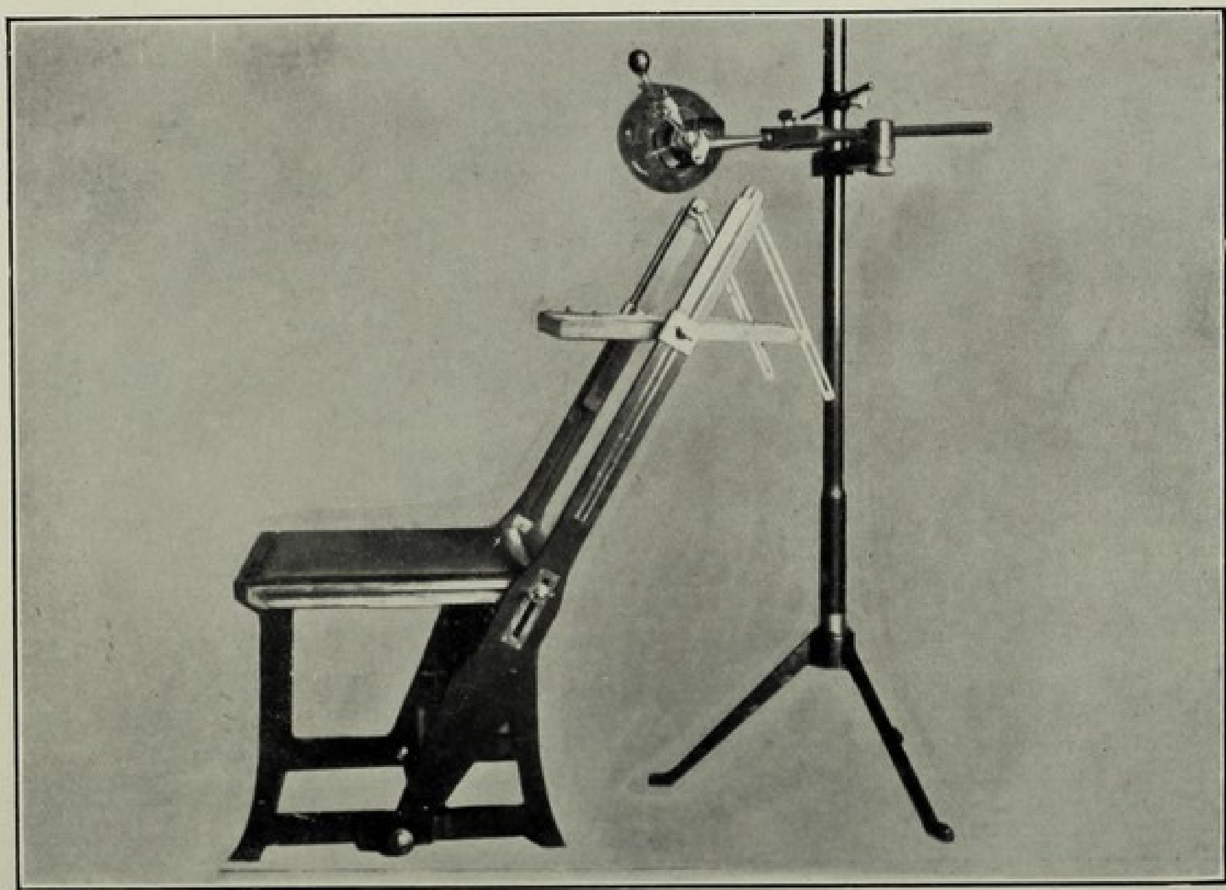

Fig. 2. *Lister's chair.*

"A desk is made swinging about on a horizontal axis between two side pieces carried by two clamps, which fix over the top of the uprights, and which are made fast by means of a screw running through the clamp, and bearing on a **V**-shaped bevel on the outside of the uprights, the two side pieces running in grooves on the inner side of the uprights. The desk is so made as to be reversible. One surface may be either directed backwards or forwards. This arrangement is obtained by accurate symmetry in the upright side pieces and clamps.

"The desk, as I say, swings on a central axis, but is fixed by means of a screw at each side which tightens on a long metal link, one screw passing through part of the framework of the desk and the link, the other through the link and one of the side pieces. This is an absolutely steady arrangement in any position of the desk.

"The desk is covered on the patient's side by strong canvas, which is practically transparent to the rays. Two piano wires cross at right angles in front of this. The back of the desk swings open by a hinge below, and, when open, shows a frame into which a fluoroscope 12″ × 15″ accurately fits. When needed a hood is adjusted to this. The hood is made of layers of lacquer, and is very strong, but at the same time light, and is adjusted so as to exactly fit within the projecting sides of the screen. With this arrangement, I am able to view the thorax, and, after deciding on any particular view, which I can obtain by moving any of the methods of raising or lowering including the screen which I have described, I screw up the apparatus fast, take out the fluoroscope and hood, and put in its place a photographic plate. The back of the desk is then brought up and fastened in its place, thus forming a support to the plate and the skiagram can then be taken. In stereoscopic photographs, a band of webbing passes round the patient, and is attached to suitable hooks in the front of the frame of the desk. By means of adjusting the parts of the chair any part of the body can be examined."

With this introductory statement, it is now proposed to discuss the subject-matter proper of this thesis. And in doing so, for purposes of lucidity, it has been considered convenient to arrange the facts at our disposal under distinct headings, and to discuss them *seriatim*. Passing by, without further allusion, as relatively unimportant in medicine, a consideration of the stereoscopic method of examination, we propose to discuss the parts played severally by :—

1. Radioscopy,
2. Radiography,
3. Orthodiagraphy,

and the special information bearing upon the diagnosis of lung disease, which becomes available to us by the employment of each of those methods.

RADIOSCOPY.

Considering, in the first place, the radioscopic method of examination, where observations are made by means of the fluorescent screen, it is to be noted that this method finds its special sphere of usefulness in revealing certain conditions, which, apart from Orthodiagraphy, either cannot be ascertained without very great difficulty, or cannot be recognised at all. And amongst those conditions, in virtue of its importance, we accord the first place to the *movements of the diaphragm.*

Previous to the application of Radioscopy to the diagnosis of chest conditions, our implicit faith in the teaching of physiologists[9] led us to believe that the movements of the diaphragm during respiration were those of contraction and expansion towards the central tendon. Now Walsham,[4] by demonstrating its actual behaviour by means of the fluorescent screen, proved the movement to be not a lateral but vertical one, and this movement he named the "piston movement" of the diaphragm. The accuracy of this information, the writer has frequently been able to confirm, and there can no longer exist any doubt that the teaching of physiologists on the point was quite wrong. During inspiration, the diaphragm moves in a downward, and during expiration, in an upward direction. The dome of the diaphragm on the right side has been observed by Radioscopy to stand at a slightly higher level (about $\frac{1}{2}$-inch) than on the left side. Furthermore the amplitude of the range of movement of the diaphragm in an average normal chest during the complete respiratory cycle, *i.e.*, from full inspiration to full expiration, has been shown by Radioscopy according to Dally,[7] Gardiner,[5] Guilleminot,[10] and others, to be slightly greater on the right side than on the left side. Now these facts, trivial in themselves, assume a position of material importance when we come to consider their bearing upon diagnosis. Thus we recognise the impaired movement of the diaphragm upon the affected side, associated with early tubercular apical involvement,[3] the wavy movements of asthma,[11] the fixed diaphragm of emphysema,[11] and the paradoxical movements of pneumothorax.[12] Of these undoubtedly the most important is the impaired movement of the diaphragm associated with early pulmonary phthisis, whether we regard it from the point of view of its practical value as an element in diagnosis, or from that of other claims which have been advanced upon its behalf. That impaired ascent and descent of the diaphragm is one of the very earliest changes which take place in pulmonary disease is undoubted; that it is due to reflex action, afferent by the vagus and efferent by the phrenic, (as has been suggested by Dr. G. A. Gibson, of Edinburgh, in a private letter to the writer), is in the highest degree probable. But that it is present, as is asserted by Walsham,[4] Diffenbach,[13] and others at a stage, so early that radioscopic examination of the apex of the lung, and examination of the same area by physical methods, alike yield negative results, is in the mind of the writer open to grave doubt. In this connection, Dr. Bonnet Leon[14] has gone so far as to assert that "of a hundred cases in which this condition of the diaphragm is recognised associated with no physical signs of disease, in ninety will be found, sooner or later, clear evidence of Tuberculosis."

Notwithstanding the weight of the authorities who stand committed to the view, the contention is one which, after a large experience of radioscopic work extending continuously over a period of five years, the writer is altogether unable to endorse. So far he has not yet met with one single instance to support it. The fact that patients are not usually sent to the X-rayist until the physician, from a study of the cunical and physical signs, has discovered grounds for suspecting the presence of disease must always add an element of difficulty in proving the accuracy of so sweeping a generalisation as Dr. Bonnet Leon has seen fit to make.

Where the condition, known as *fixed diaphragm*, is met with, it is well to examine it by the lateral oblique method of Mignon. In one such case, which the writer examined by this method, the posterior mediastinum was found to be only very slightly enlarged during full inspiration, the heart being hardly, if at all, thrown forward during the act. The observation has a special interest in relationship to Keith's [15] researches upon the limiting action of the crura of the diaphragm.

Next in importance to its relationship to the movements of the diaphragm is the value which Radioscopy possesses in enabling one to distinguish between *fluid* and *fluid + air* in the *pleural sac.* Three years ago, the writer was led, by perusing a communication of Walsham's on a case [16] of pneumothorax, to perform a simple experiment, and the point which it demonstrated is so clear that he ventures to reproduce it here.

Two similar rubber bags *A* and *B* were taken,[17] and into each was poured an equal quantity of serous fluid which had shortly before been obtained by aspiration from a case of fluid pleurisy. From one of the bags air was, so far as possible, extracted; but in the other it was allowed to remain. The bags were then examined by screening, and afterwards the skiagram (Fig. 3) now shown was taken. The reader is asked to give his careful attention to the different appearance presented by those bags. He will at once note the fact that the lower portion of the bag, which contains fluid only, is represented by a dark shadow, whose upper border gradually merges off into a clear area above. The appearance is different in the case of bag *B*, which contains not only fluid, but also air; for there he will observe that, unlike the appearance obtaining in the case of *A*, a clear line of demarcation exists between the shaded area below and the clear portion above. And again, whilst the upper level of the fluid in *A* takes a somewhat irregularly curved form, it is not so in *B*, for there the line of demarcation is absolutely horizontal. Moreover, the edges of the shadow in *A* are seen to be drawn up to a considerable distance above the upper portion of the curve. It is not so in bag *B*, whose clean-cut horizontal line extends right across to the outer edges. In short, in the first bag, in which the upper portion is not distended by air, the force of capillarity has full play, and tends to draw the fluid up in a wedge-shaped column, which eventually tapers off and

PLATE VII.

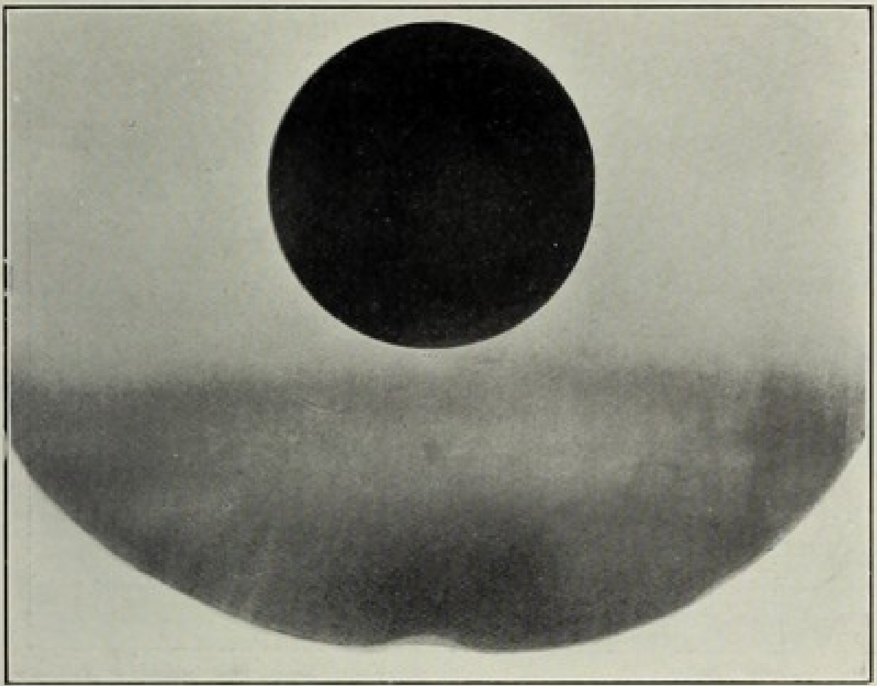

Fig 3 *Bag containing fluid only.* (*A.*)

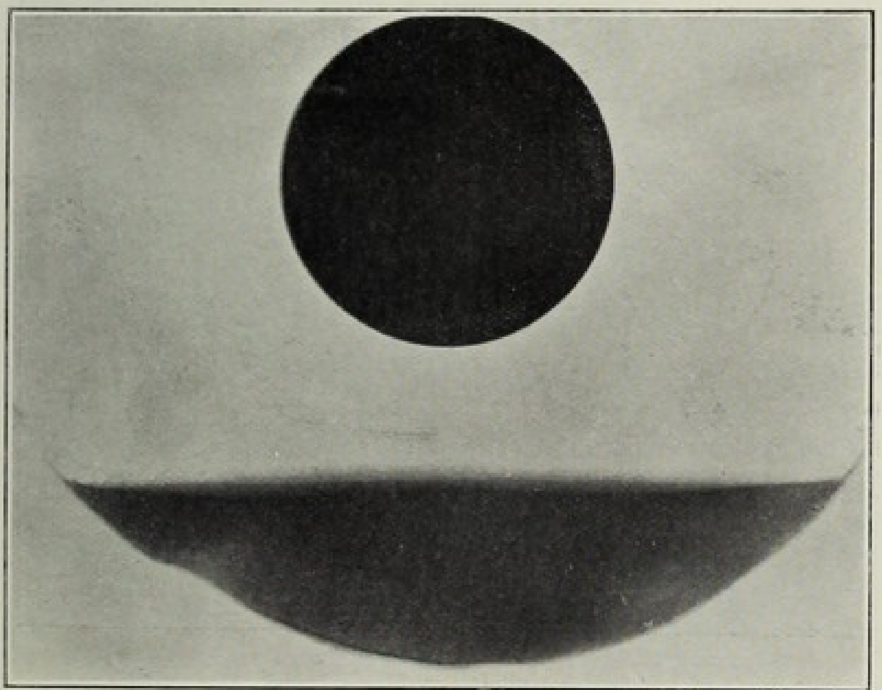

Fig. 4. *Bag containing fluid plus air.* (*B.*)

PLATE VIII.

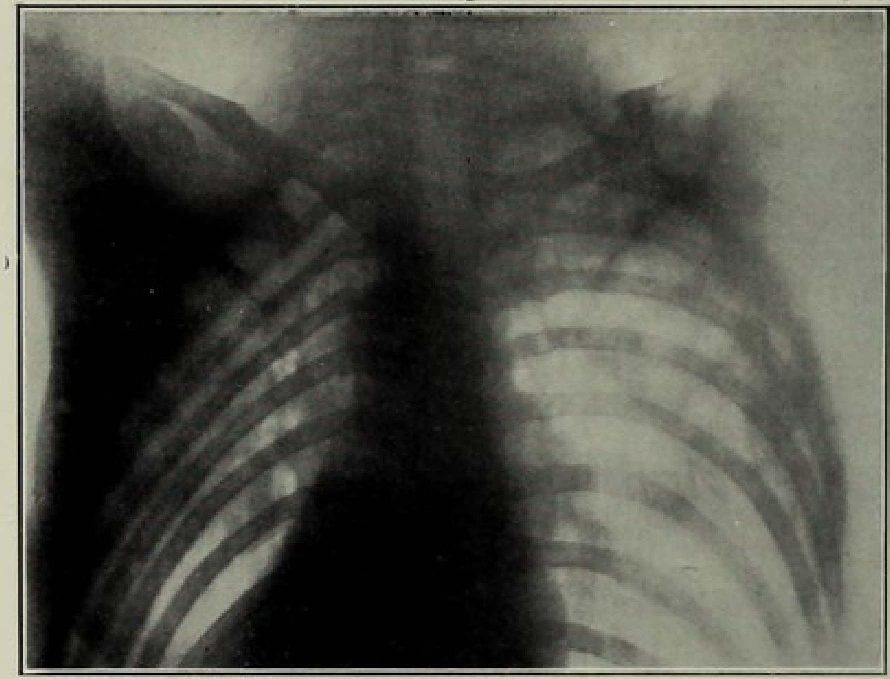

Fig. 5. *Complete roof-tile arrangement of ribs (left side).*

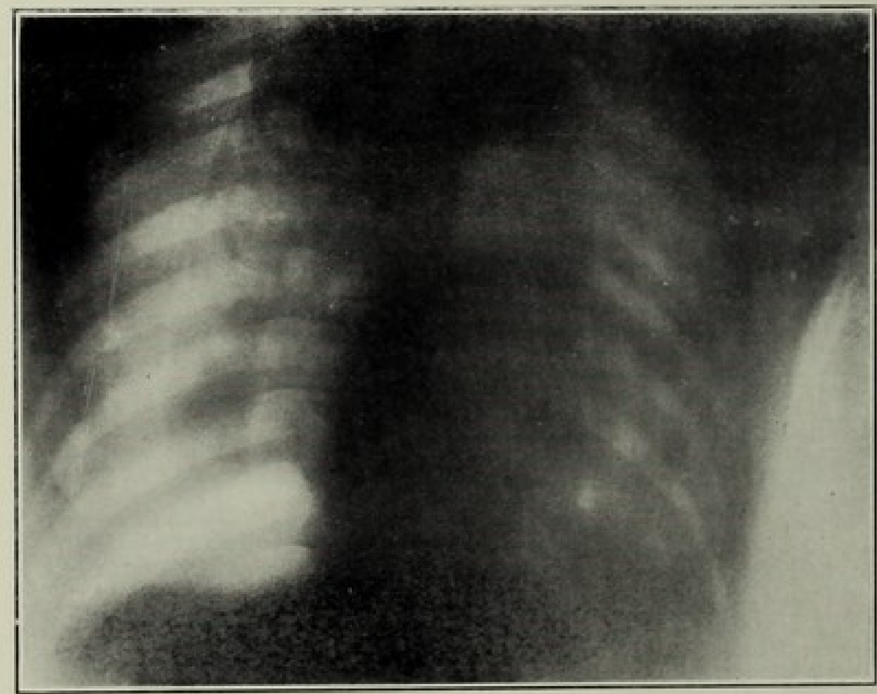

Fig. 6. *Left-sided pneumo-thorax, showing* (a) *Separation of ribs;* (b) *Mottled shadow corresponding to collapsed lung;* (c) *Heart displaced towards the right side.*

disappears. This accounts alike for the curve at the edges and for the gradual diminution of the intensity of the shadow from below upwards. In the second bag, which, in addition to fluid, contains air at atmospheric pressure, owing to the edges of the bag being kept apart by the air, the action of capillarity is reduced to a minimum, and, consequently, the fluid is allowed to remain, in accordance with the laws of gravity, in a horizontal position. The analogy existing between a rubber bag containing fluid and a close serous sac such as the pleura with contained effusion, may be considered sufficiently close to warrant the inference that the phenomena observed in the case of bag *A* were not unlike those which one might reasonably expect to find in the case of a fluid pleurisy, and that those present, in the case of bag *B*, might closely resemble the appearance present in the case of hydro- or pyo-pneumothorax. Fortunately there were at that time available two cases, one of fluid pleurisy, the other of pyo-pneumothorax. These were radioscoped, and the inferences were found to be absolutely correct. The similarity of the behaviour of the fluid in the pleura to that in bag *A*, and of that of the air and fluid in the pleural sac to that in bag *B*, was complete. Moreover, the further interesting and important points were observed in the case of the air *plus* fluid in the pleura, which have since been found to be absolutely diagnostic of the condition—first, a wavy rippling movement, corresponding with the action of the heart, could be distinctly seen at the surface of the fluid; and, secondly, when the side of the chest was gently tapped with the finger at the level of the fluid, the movement so conveyed to its surface could be seen travelling across the chest to the point from which it had set out. Thus the differential diagnosis between fluid in the pleura, fluid *plus* air in the pleura, and consolidation of the lung, becomes simple and trustworthy where Radioscopy is available.

The third direction, in which Radioscopy possesses a special value peculiar to itself, lies in its power of enabling one to differentiate between an *early acute and an old healed lesion.* The impaired translucency of the apices, compared with the bases of the lung, and of the right as compared with the left apex, due mainly to the thickness of the muscles in that vicinity, is a feature with which it is well to become familiar. But, after having allowed for this peculiarity, one may sometimes find the opacity of one apex decidedly greater than that of the other, and may feel in doubt as to whether the increased opacity indicates a new or an old lesion, whether acute or arrested disease. The writer has found, in such cases, the following to be a satisfactory test. Let the patient inspire deeply, and, whilst he is so breathing, observe closely, by means of the fluorescent screen, any change which may take place. The shadow may become lighter and the shaded area become illuminated. In that case, the lesion is not an old one. The proportion of fibrous tissue present is too great, in the case of an old lesion, to permit of the entrance of a supply of air sufficient to affect its translucency. Hence, if no improvement takes place in the translucency of the part, we may safely assume that the lesion is an old, it may be an arrested one. There are those, notably Walsham, who maintain that the shadow caused by an old lesion is invariably darker than that caused by a more recent infiltration. Whilst this is so, there is no doubt that there remains a certain number of cases in which the shadow, present in an early lesion, entirely disappears with the subsidence of other signs of the disease. An undoubted example of this came under the writer's notice quite recently.

RADIOGRAPHY.

Passing from the subject of Radioscopy, we come next to deal with that of Radiography, or the art of producing an impression upon a photographic plate by means of X-rays. The print which is secured, called skiagram, constitutes a permanent record of the impression received at the time it was made. Just as Radioscopy has its special value and uses, which justify its employment, so Radiography, in its turn, possesses advantages which are peculiarly its own. Broadly speaking, these advantages are two in number. In the first place, by Radiography we secure a *permanent as compared with a temporary impression* by Radioscopy, and in the second place, *phenomena are sometimes recorded by Radiography which have passed unobserved by Radioscopy.* This arises from a well-known fact that a photographic plate, under certain conditions, becomes more sensitive to impressions than the retina. In this way shadows caused by calcified glands and even miliary tubercle, which escaped detection at the preliminary radioscopic examination, have become revealed by the skiagram taken immediately afterwards.[18] Impressed by the advantages which Radiography affords in the latter direction, some have gone so far as to assert that we can secure by it all the information which Radioscopy affords, and, like Pfahler,[19] of New York, have abandoned Radioscopy in their routine chest examinations. Against this new practice the writer ventures to enter an emphatic protest.

As the power of interpreting aright the appearances which are presented by a skiagram of the chest is to the uninitiated by no means an easy matter, it may not be amiss to refer, in the shortest possible terms, to the principles which ought to guide one in seeking to interpret such correctly. For our present purpose it is convenient to regard the chest as a box, the sides and bottom of which are movable, and to look upon the lungs, pleura, heart, vessels and glands as contents of that box. As those parts, container and contained, are, by means of mutual pressure, maintained in health in a constant relationship to one another, it becomes clear that any change in size or position of one part must to a greater or less extent affect the position and relationship of the remaining parts to each other. Thus, in attempting to form an opinion as to the extent or nature of disease in a lung or pleura indicated upon a skiagram by a shadow, it is not sufficient to confine our attention to the shadow in question. Shadows, showing the position of other parts, are of hardly less importance than that caused by the lesion proper, and if we are to arrive at a correct conclusion, due attention must be paid to those shadows and a proper significance attached to them.

Of these it is suitable in the first place to consider variations in the appearance of the *ribs* associated with lung disease, and we begin by noting (*a*) a condition in which the ribs tend to descend and become approximated together, termed *roof-tile*[20] or *waterfall*, and we recognise in this condition two varieties according to the extent to which it is present. Thus, on the one hand, we speak of *complete roof-tile* (Fig. 5), where the whole of one lung is involved, and, on the other, we recognise the condition of *partial roof-*

tile (Fig. 10), where only a portion of one side of the chest wall has descended, as in the case of the ribs covering a single old-standing apical lesion as in (Fig. 10). In contradistinction to roof-tile is to be noted the condition in which the ribs, instead of descending towards the vertical, tend to ascend towards the horizontal position, and, instead of approximating, tend to separate to a greater extent than normal. This condition is well seen in emphysema and pneumothorax (Fig. 6). The action of whooping cough and asthma, especially if the latter occurs in early life, in altering the shape of the ribs, from the 7th to the 11th, should not be lost sight of. Nor should the position of the *clavicles* be passed unnoted. These occupy a nearly horizontal position in health, but, with disease, their position is apt to be disturbed, the inner end of the clavicle upon the side of the contracting apical lesion passing downwards (Fig. 12), and that over an area of compensatory emphysema passing upwards.

Like that of the sides, the position of the bottom of the box, viz., the *diaphragm*, may be altered. Thus the diaphragm on the right side, instead of standing at a somewhat higher level than that upon the left side as it does in health, may be found to stand at the same level, or even at a lower level than that of its fellow upon the other side as in some cases of old basal pleurisy with adhesion. Or again, instead of the well-formed, dome shape, characteristic of health, one may recognise the flattened, or irregular, or triangular diaphragm characteristic of emphysema.

Having observed changes, present in the form or shape of the walls of the box, it is well, in the next place, to turn one's attention to its contents. And of these, one naturally notices first the shadow caused by the presence of the HEART. Considering, in the first place, the size of this organ, one notices that the typical heart of an ordinary case of fibro-caseous, or fibroid, disease *is smaller than normal*, and that departure from normal in the opposite direction, viz., enlarged heart, is rarely found in pulmonary disease. The position of the heart is far from constant. In well-marked pulmonary disease, *displacement* is invariably present. And here one would like to draw attention to a point in method, in which ordinary physical examination differs entirely from examination by X-rays. The first landmark one looks for in examining by percussing is the position of the apex beat. Not so in Radiography, for if we were to look in a skiagram of a normal chest for the apex in the fifth space our labours would be in vain. We should not find it there. On the contrary, a search in the region of the 9th or 10th interspace will usually be met with success. This phenomenon is explained by the action of the divergent rays, which project the shadow, caused by the apex, downwards, so that it tends to occupy a relatively lower level in the skiagram than it actually occupies in the body. What then, it may be asked, is to be our guide ? The reply is, the position of the right border. If the shadow, caused by the right border of the heart, does not appear within half inch of the right border of the sternum, then displacement is almost certainly present. When the presence of a contracting fibroid lesion is suspected, the suspicion would be strengthened if the heart were found to be displaced toward the shadow caused by the pulmonary lesion. And, on the other hand, as one would naturally expect, when the cardiac shadow is found to be displaced away from a unilateral shadow, the fact would lead one strongly to suspect the presence of a neoplasm in the lung, or of fluid in the pleura (Fig. 7) upon the shaded side.

The next "content" which claims attention is the PLEURA. The pleura in health presents no features, by which its presence can be recognised by means of Radiography. But it is not so when pathological conditions arise, particularly so when that pathological condition is associated with the presence of air, clear fluid, or pus, or air *plus* fluid or solid body in the pleural sac. It is, I take it, fairly well settled amongst men, who devote a large portion of their time to the practical application of chest skiagraphy, that the lightness of an appearance present is in direct proportion to the amount of air contained in the area under observation. Thus, in a hyper-aerated condition, such as where AIR is present within the pleural cavity, one expects to find an extremely light appearance. And this is exactly what one does find. In referring to Fig. 6, one recognises the characteristic light appearance, in association with the alteration in the position of the surrounding parts, which is to be expected in a case of left-sided pneumothorax. Thus the ribs are found to be elevated somewhat, and to be separated from each other to an abnormal extent. The heart shadow is clearly displaced towards the right side. Above all, the presence of a small mottled shadow of triangular shape, upon the left side near the middle line, reveals the presence of a temporarily collapsed lung, which has become shrunken towards the root. It is the typical appearance presented by an ordinary case of left-sided pneumothorax.

An earlier allusion in this paper will lead the reader to anticipate the appearance to be expected when FLUID alone is present within the pleural sac. Remembering the experiment of the bags, one expects to find, and, on referring to Fig. 7, taken from a case of left-sided pleurisy, one will not be disappointed, a dark shadow at the lower portion of the chest corresponding with the presence of the fluid, the upper level of which merges almost imperceptibly into the clear area above. Nor is the upper line of demarcation a horizontal one. On the contrary its form is concave (*vide* Fig. 7).

In this connection, it may be profitable to dwell for a moment upon a singular disparity which exists between the accepted theory of clinicians, and a view which is suggested by a consideration of the appearance, presented by the skiagram of an ordinary case of pleurisy. Clinicians tell us that, in a case of fluid pleurisy, first the intercostal spaces are largely increased in size, and second that the cyrtometric measurements invariably show the circumference to be greater upon the side containing the fluid than it is upon the healthy side. If this view is correct, and when practically all authorities agree, as they do, upon its correctness, its accuracy may be assumed, then it seems to follow first, that the spaces separating adjoining ribs should be greater upon the affected side than they are upon the sound side, and, second, that the measurement from the mid-sternal line to the outer border of the ribs, as shown by skiagram, should be greater upon the affected side than the corresponding measurement upon the sound side. This skiagram is one of left-sided pleurisy of moderate amount. In view of what has been said, it is particularly worthy of note that the spaces, here separating adjacent ribs, upon the affected side, are not greater but less than those separating the ribs upon the sound side, and

PLATE IX.

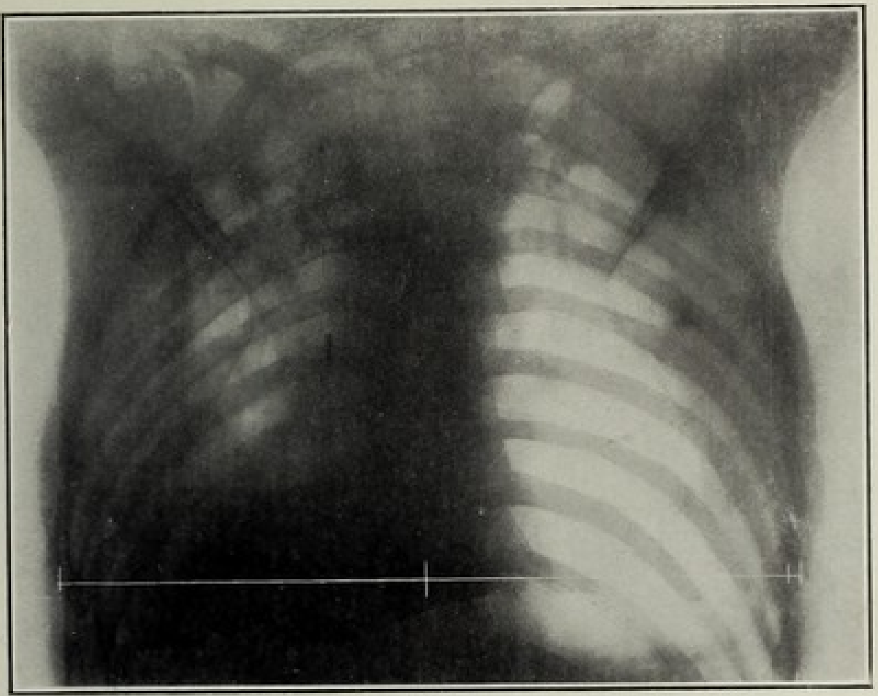

Fig. 7. *Left-sided fluid pleurisy (compensating emphysema in right side is well marked).*

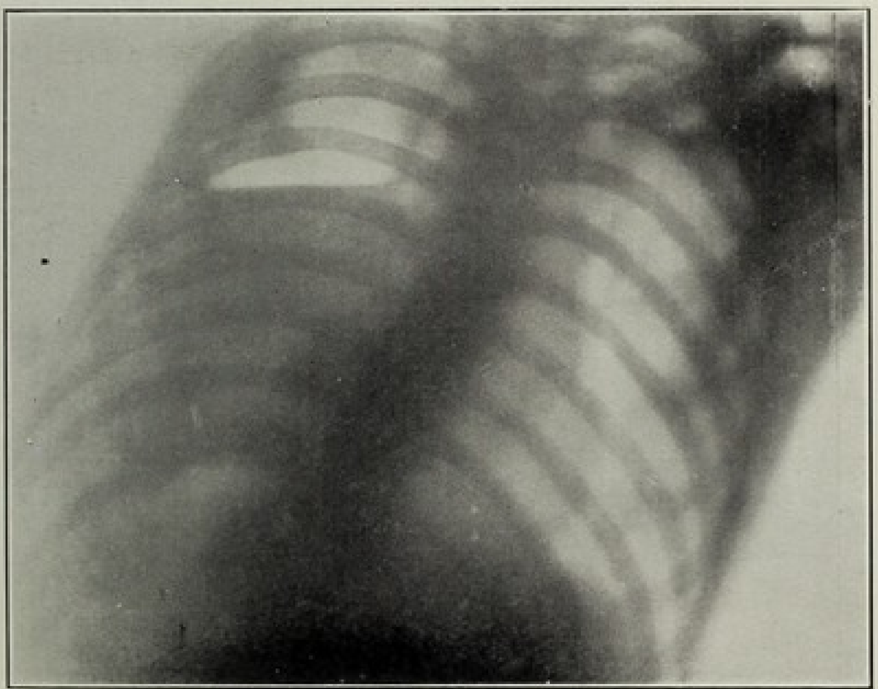

Fig. 8. *Left-sided pyo-pneumo-thorax (skiagram taken when body tilted at an angle of* 45°).

PLATE X.

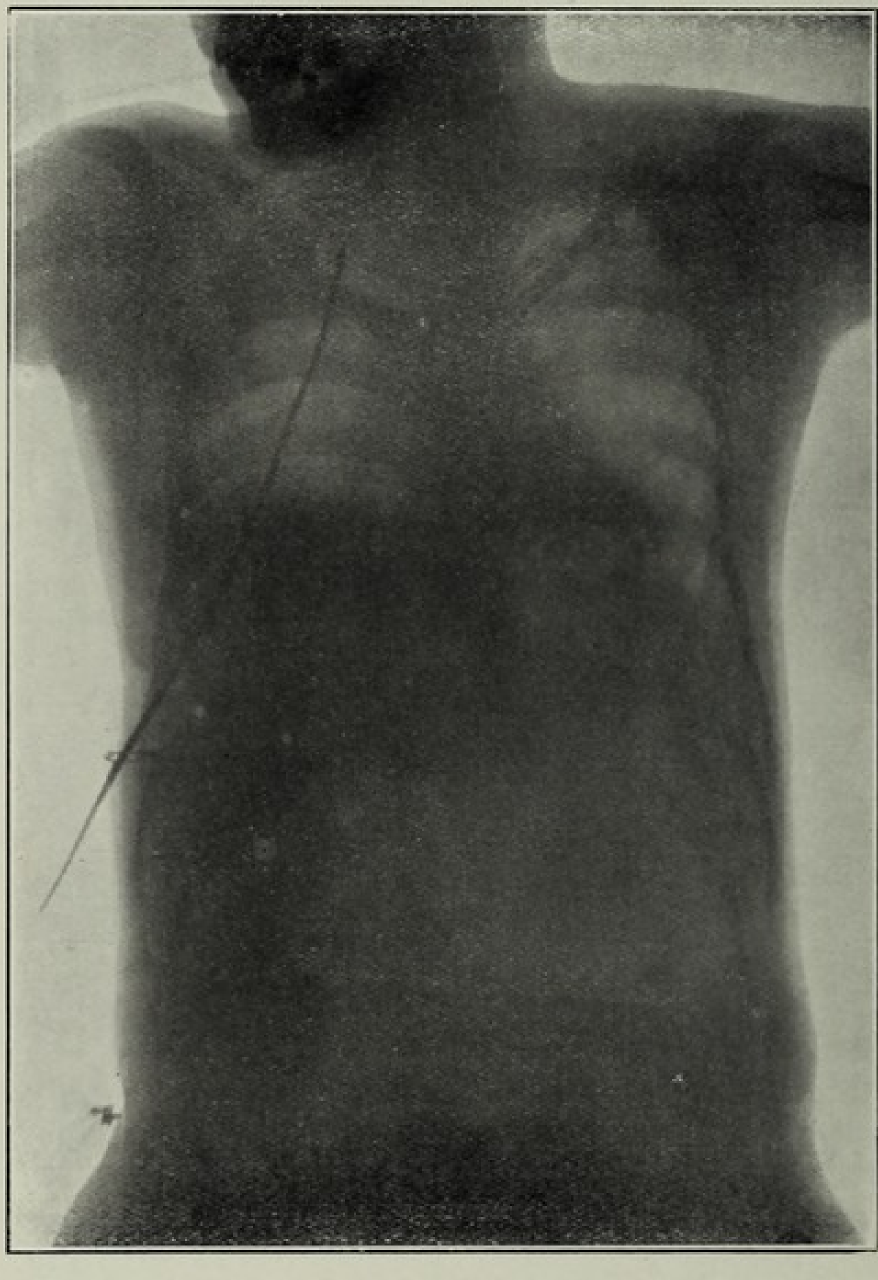

Fig. 9. *Solid body in the pleural cavity.*

further that the measurement from the mid-sternal line to the edge of the chest upon the affected side is not greater, but is less than that upon the sound side. Limitation of space does not permit us to enter here upon a consideration of various possible explanations of this curious phenomenon, but the matter is fully dealt with by the writer elsewhere,[17] where it can be referred to by those interested in the subject.

Where it is desired to differentiate between the presence of fluid alone and fluid *plus* air within the pleura, this can always be easily effected, by skiagraphing the patient, not in the upright position, but in a tilted position, the body lying over at an angle of 45° to the vertical, as shown in Fig. 8, which was taken in this position, and which clearly exhibits the characteristic appearance presented by fluid *plus* air under such conditions. The points of diagnostic value are two in number. In the first place, the shadow corresponding to the right border of the heart is displaced *away from* that corresponding with the fluid ; and, in the second place, the dark shadow upon the left side, indicative of fluid, is separated from the clear area above, corresponding with the air, by a clear line of demarcation, which, notwithstanding the removal of the patient from the vertical position, has in obedience to the laws of gravity remained horizontal. These combined phenomena are only produced by one condition, and are absolutely diagnostic of the presence of air and fluid within the pleura.

There is an anxiety in some quarters to know whether Radiography can be relied upon to distinguish between the presence in the pleura of pus and clear fluid respectively. In this connection, experiments, undertaken by the writer and Hill Crombie, 3 years ago, conducted *in vitro,* clearly demonstrated the fact that, under those conditions, pus undoubtedly gave rise to a darker shadow than did clear fluid, which had been withdrawn from a pleurisy shortly before. Some seem to think that this method of distinguishing between the two conditions in the human body is practicable and trustworthy. Ample experience, however, since that time, has led the writer to an opposite conclusion. So many variable factors, the thickness of the pleura, the condition of the underlying lung, the muscularity of the patient, etc., etc., intervene to disturb one's calculations, that he is no longer of opinion that, as a means of distinguishing between these two conditions, Radiography is to be trusted.

That a *Solid Body* in the pleura can be readily recognised is well shown in Fig. 9, which has been very kindly lent by Dr. Alex. James, of Edinburgh, for the purpose of this paper. Here the presence of a probe passed into the pleura through a sinus following upon an operation undertaken for the relief of an empysema, is distinctly apparent.

With regard to the feasibility of recognising well-marked thickened pleura, the writer holds that it is perfectly practicable. In doing so, he is aware that he is expressing a view that is at variance with that of some others, notably that of Walsham,[17] whose opinions are entitled to the very highest respect. He has, in another quarter,[21] drawn attention to the fact that, whilst an intra-pulmonary infiltration and pleural thickening alike produce a shadow, that produced by the pleural thickening can be distinguished from the shadow due to the intra-pulmonary infiltration, by reference to the overlying ribs; for whilst, in the case of the latter (Fig. 10A.), localised roof-tiling is usually found, it is not so in the case of simple pleural thickening, for there, so far as has been observed, no appreciable change in the position of the ribs takes place (*vide* Fig. 10B.).

With regard to the LUNG proper, variations in the appearances shown seem to be largely a matter of the quantity of air present. Experience enables one to recognise the appearance presented by a normal lung. When the quantity of air present in the lung falls, the lightness of the appearance diminishes. This diminution in the lightness of the area proceeds, *pari passu*, with the lessening of the air content of the lung, until a condition is reached, in which the air is entirely absent, as in the condition of permanent collapse. The mildest form, and that most frequently encountered, in which diminution of the translucency of the lung takes place, is to be found in early infiltration. A shadow, corresponding in density to the degree of infiltration present, enables one to recognise the infiltrated area (Fig. 11). A collapsed lung occupies less space than a normal one, and, consequently, the organ upon the other side of the chest becomes displaced towards it, the ribs falling down upon it, and assuming a roof-tile form. These points

PLATE XI.

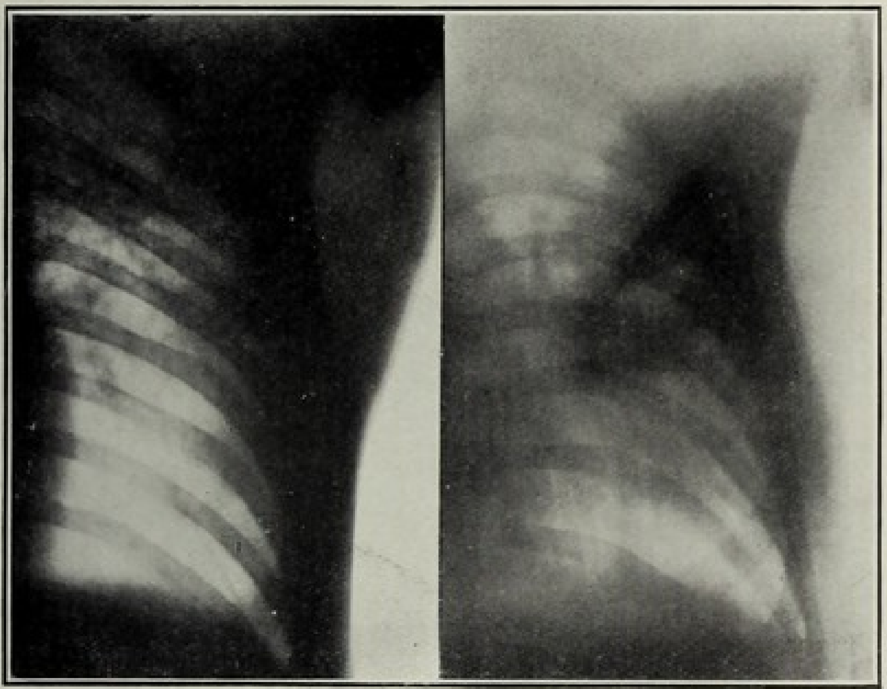

Fig. 10. *A.—Intra-pulmonary lesion. (Ribs—roof-tile.)* *B.—Pleural lesion. (Ribs—normal.)*

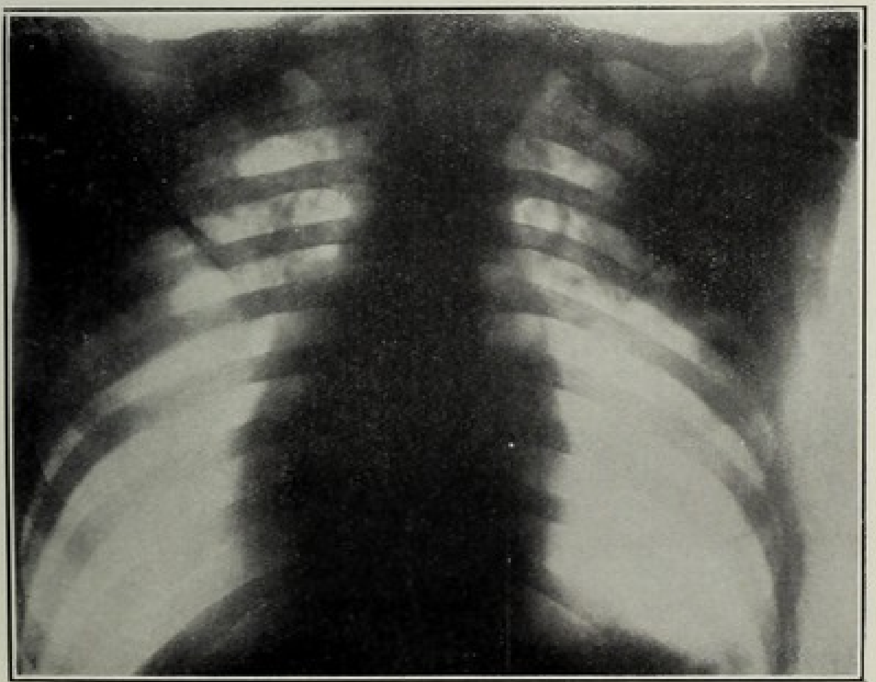

Fig. 11. *Early infiltration of lungs with air.*

Plate XII.

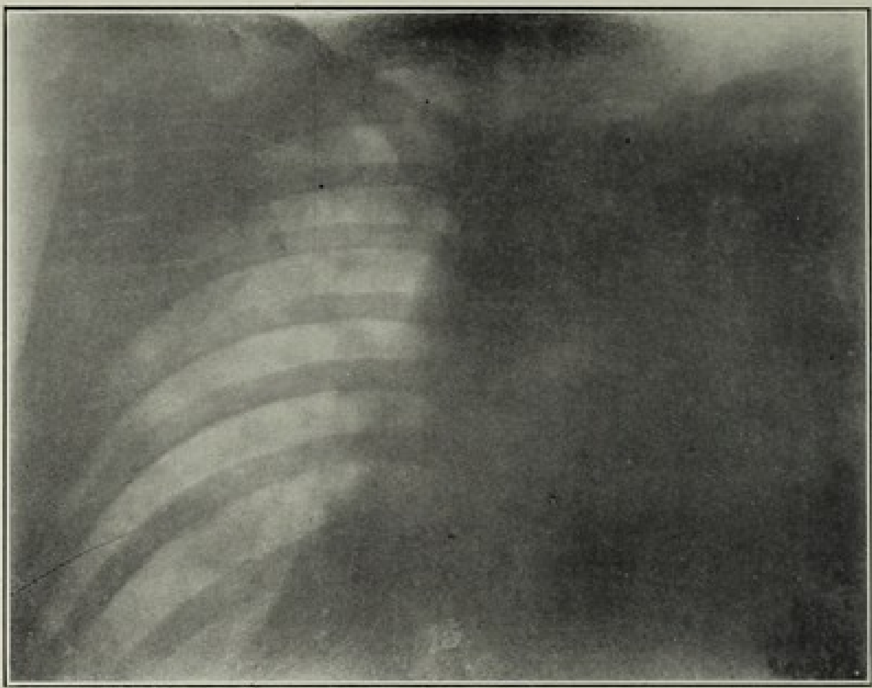

Fig. 12. *Collapse of right lung.*

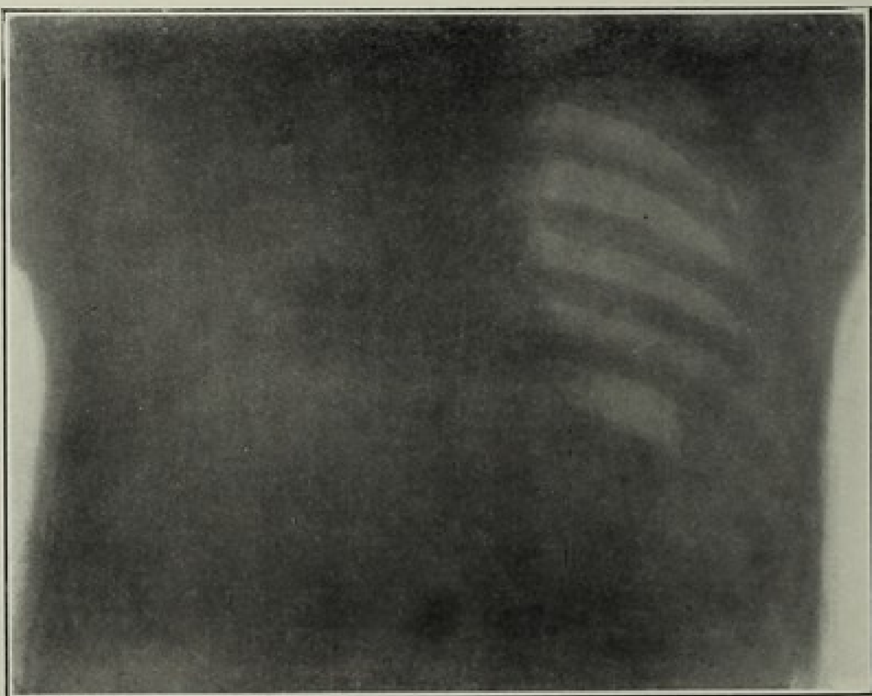

Fig. 13. *Actinomycosis of lungs and pleura.*

are well shown in the accompanying case (Fig. 12), in which permanent collapse ensued as the result of pressure exerted upon the right lung by a large empyema.

But collapse need not necessarily be permanent. When it is of a temporary character, the air is only partially driven out of the lung, and, consequently, the appearance presented by such a condition, unlike that just alluded to, is of a mottled nature, light and dark shades alternating. As an example of this condition *see* Fig. 6.

In contra-distinction to a state of lung from which air has been partially or totally expelled, there is to be noted a condition in which air is present in abnormal amount. Such a condition, *e.g.*, emphysema, skiagraphy represents clearly. The skiagram in that case may show the ribs abnormally far apart, even approaching so near to the horizontal position as to give rise to a modified barrel shape. The other organs are usually seen to be pushed away from the emphysematous area, and that area itself is represented by an abnormally light appearance. Associated with this, one may even find an alteration in the shape of the diaphragm, the normal dome form giving place to an angular shape on the affected side, and the level of the diaphragm upon that side being pushed downwards so as to increase, for the time being, the depth of the chest upon that side.

Midway between these two conditions, deficiency of air and excess of air in the lung, falls that of cavity formation; for here we are dealing, at all events, in the case of chronic cavity, with an air-contained space surrounded by a band of dense unaerated fibrous tissue. Such a cavity, in accordance with one's expectations, is represented by skiagraphy by a clear area encircled by dark surroundings. This condition is well shown in skiagram (Fig. 14), in which the presence of the four cavities, suggested by the appearance presented in this skiagram, was afterwards verified in the post-mortem room (Fig. 15). A word of caution is necessary in this connection. One must be careful to distinguish between a cavity at the apex of the lung and a condition, simulating cavity, often found in skiagrams of the normal chest, in which a clear area is surrounded by an unusually dark shadow caused by the first rib.

Few observers, Gardiner,[5] Walsham,[18] find much difficulty in recognising the presence of *thickened or calcareous glands* at the root of the lung, by the marble-like appearance which they present. By general consent, for their recognition, Skiagraphy possesses a distinct advantage over Radioscopy, the cumulative action of the rays upon a photographic plate in this instance proving superior to the fleeting impression produced upon the retina during examination with a fluorescent screen. A few enterprising workers claim to have succeeded in detecting the scattered tubercle of miliary disease by this means. But their success is one with which the writer's efforts have, so far, never been attended.

In employing Skiagraphy in connection with Neoplasm in the chest, one must remember that there are no distinctive features which enable one to accurately diagnose the nature of a new growth. At best the information supplied by Skiagraphy, in such a case, can only be of a presumptive nature. Nevertheless, the application of these principles, which have been described, employed in conjunction with a knowledge of the special distribution more commonly found associated with particular forms of growth, will often help one to arrive at a more accurate opinion, concerning the nature of a condition present, than might be otherwise formed. Thus Fig. 13, a skiagram taken from a case of Actinomycosis of the lungs and pleura, presents some unusual features ; the invasion of the chest and advance of disease from below upwards, instead of along the familiar line of march of Tuberculosis being the most notable.

ORTHODIAGRAPHY.

Those of us who have been applying X-rays to the diagnosis of chest disease have for long felt that the accuracy and completeness of the information, yielded by this method of examination, fall far short of our reasonable expectations, and that they do so in two directions. In the first place, the shadow, produced upon a photographic plate by X-rays, is never an exact measure of the diameter of the object producing it, but is always an enlargement. That is, we have hitherto been unable to ascertain by X-rays the exact diameter of any given organ, or patch of disease. This arises from the fact that the source of the rays is a point, and that the rays

Plate XIII.

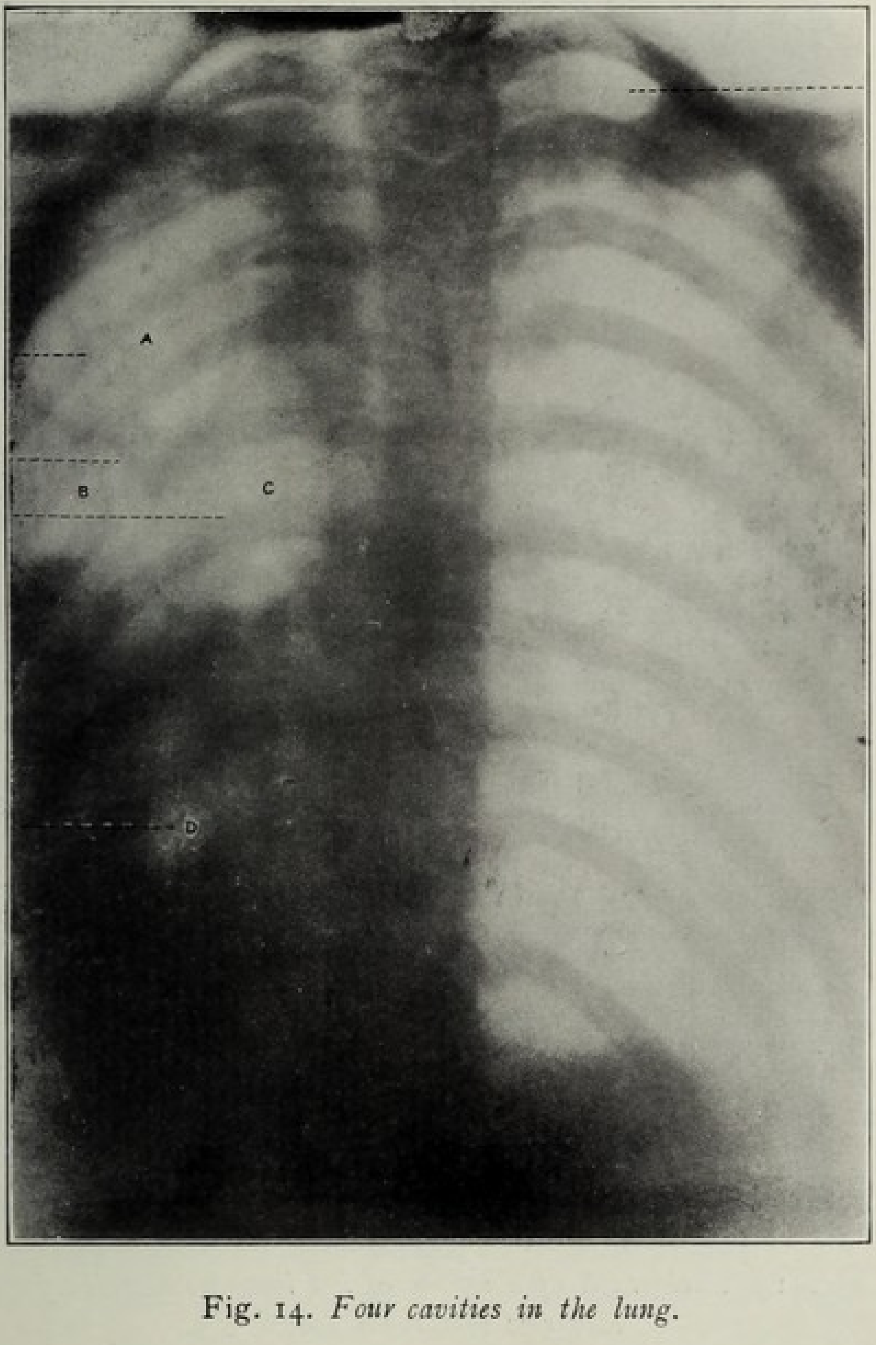

Fig. 14. *Four cavities in the lung.*

PLATE XIV.

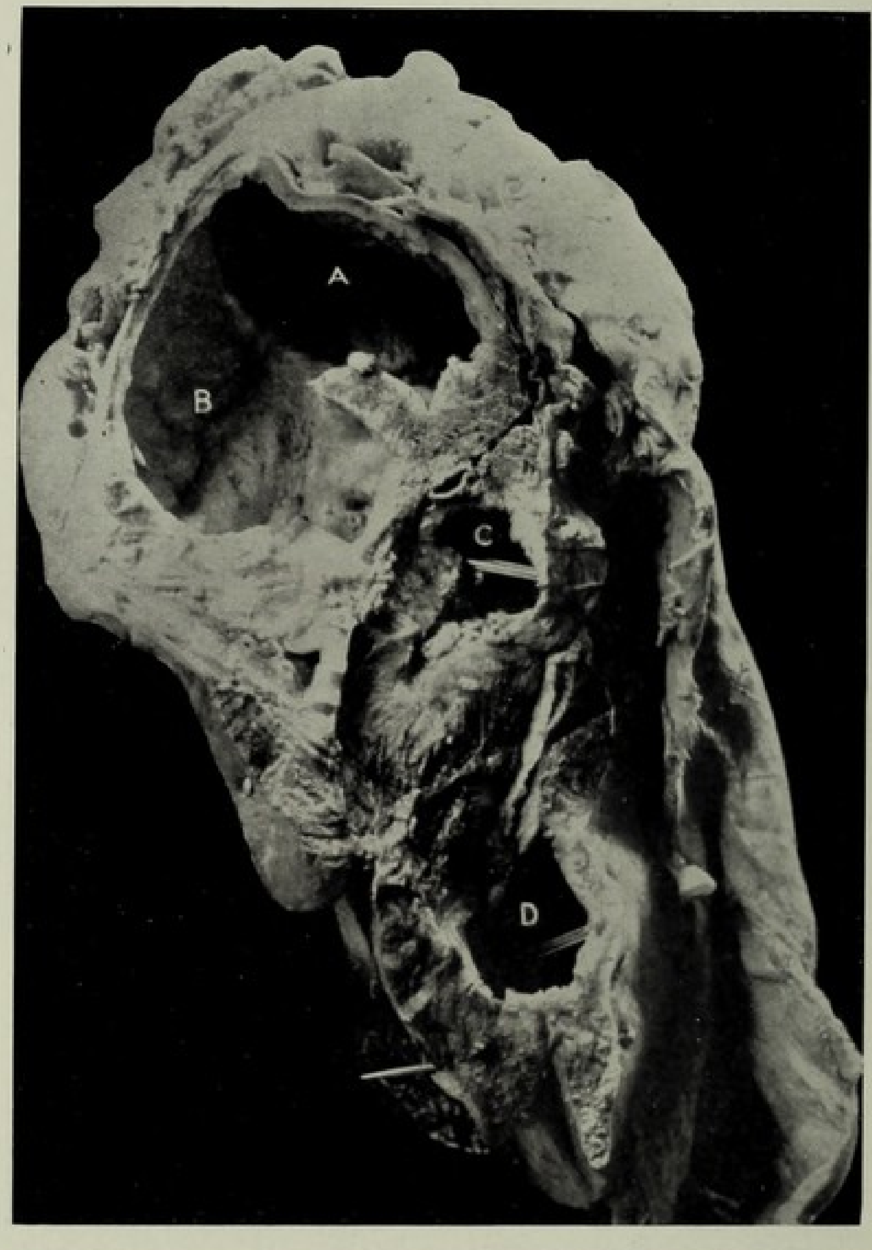

Fig. 15. *Photograph of a section of left lung from which foregoing skiagram was taken during life.*

emanate from that point in divergent lines so as to form a cone. A shadow, caused by the interposition of a body between the source of light and the screen which the rays illuminate, is, therefore, usually (for there are certain exceptions which need not here detain us) of larger diameter than the obstruction causing it.

The second disability, which we have felt, is that, generally speaking, we have been unable to obtain a skiagram, or *skiagrams, enabling us to measure accurately movements* which take place in the size and position of organs, *e.g.*, the heart, during systole and diastole, the ribs and diaphragm, during inspiration and expiration, and the variations in the density of shadows present, in certain areas, during the various phases of the respiratory cycle.

Now Dr. Guilleminot,[10] of Paris, working upon an idea supplied by Prof. Bouchard so far back as 1898, has devised an apparatus by means of which these difficulties have been effectually overcome. It is not within the scope of this paper to enter upon a detailed description of a complicated electrical appliance, but it may be advantageous to briefly outline the means by which the end in view is secured. By means of a shutter all the divergent rays are cut off, and only the mesial ray, which falls at right angles upon the screen, is allowed to pass. A small metal indicator, which shows upon the screen, is interposed in the course of the ray. This central ray is placed at a point opposite to the edge of the shadow caused by the object to be examined, and slowly moved round the object in such a manner as to give an outline upon the screen ; such outline is marked upon the screen by the observer with a pencil. The outline secured in this way exactly corresponds with the diameter in the plane of observation of the object under examination.

The other difficulty of obtaining a skiagram showing the range in movement, or in density, which takes place in an organ at work, such as the diaphragm, is overcome by dissociating the phases of respiration by means of the introduction of an automatic interrupter. In this manner one may even secure a cinemato-radiograph of respiration. Furthermore, it enables us to ascertain the costal angle of inspiration and the costal angle of expiration, and, by estimating the difference between those two, obtain the functional costal angle. Now it has been shown that, in a normal chest, the functional costal angle may vary from 3° to 5°, and variations beyond that limit are extremely suggestive of a pathological condition, especially Tuberculosis. Guilleminot says: "Where the functional costal angle is small upon one side or other, we are led to suspect a possible 'Tuberculous deposit'" but, unaccompanied by physical signs, this evidence should not be considered conclusive.

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THE RADIOGRAPHIC EXAMINATION OF DISEASES OF BONE AND JOINTS.

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[With Plates XV.—XXVI.]

THE value of radiographic examination in all cases of injury is now well understood, and this method of examination is at the present time fortunately almost universal. In diseases of bone and joints, however, the X-ray has almost as great a field of usefulness as in cases of injury, and by this method facts are available which, in the future, will render diagnosis more exact and treatment more successful in this very difficult branch of surgery. A complete survey of its use in the diagnosis of these diseases is not possible within the brief limits allowed; the more important of them, and especially those most capable of illustration, will be discussed, and the radiographs, it is hoped, will tell their own story.

Many joint diseases of a chronic nature present great difficulties in the matter of diagnosis. Signs and symptoms characteristic of one disease are also found, with perhaps slight modification, in another the pathology of which is quite different. The pathology of the whole group of chronic arthritis is obscure, the ætiology is doubtful, and in the case of deep-seated joints, such as the hip or shoulder, it is exceedingly difficult by ordinary methods of examination to discover the actual condition of the parts affected. Such titles as osteo-arthritis, or rheumatic gout, have been invented to disguise the confusion of ideas that exists, and no two text books will be found in which exactly the same classification is adopted.

All these difficulties are not removed by radiographic examination, but if a good radiograph of the joint, or part affected, is obtained, the eye may be brought to the aid of the other senses in the effort to understand the nature of the changes that have taken place. The whole question of treatment rests upon success in diagnosis; if rheumatoid arthritis is mistaken for gout, the result of treatment must be bad, or if gout is mistaken for rheumatoid arthritis, and the diet arranged accordingly, the patient's sufferings will probably be increased, and his physician's reputation diminished. The same arguments apply to disease of bone. How difficult it sometimes is to decide between an endosteal sarcoma and a chronic inflammation, or, say, between an acute epiphysitis and scurvy rickets affecting one joint, and how serious to the patient is a mistake that may so easily be made ! Any disease of joints, or bone, that presents the slightest difficulty in diagnosis should be radiographed, with the certainty that aid will be afforded, and, if this were done more frequently than is the case at present, many mistakes would be avoided, and treatment would be carried out with greater confidence and success.

A few words might usefully be spoken on the subject of interpretation of radiographs. These are used so much more frequently now than was the case a few years ago that medical men have considerable skill in appraising results. To those, however, whose familiarity with the subject is still not great, it is certainly advisable to obtain the aid of a medical Radiographer in order that no point may be overlooked, and that the greatest possible advantage may be gained.

Gout, as is well known, is characterised by the deposit of the salts of uric acid in the tissues of the joint. This deposit takes place primarily in the ligaments ; but later the articular cartilages are also affected. In marked cases considerable accumulations of the combined urates of sodium, potassium, ammonium, magnesium, and calcium take place in the neighbourhood of the joints. The first three salts are only slightly opaque to the rays, but the urates of calcium and magnesium are more dense. As the urates do not exist in a pure form in the tissues, but in combination, it is found practically that a radiograph, in a case of gout, throws a shadow of considerable density on the plate.

In Fig. 1, there is seen the outline of the bones of the finger of a patient, who was undoubtedly suffering from gout (A). In the positions marked ⋙——→ there is seen distinct addition to the outline of the phalanges ; this is more readily seen when the radiograph is compared with the normal (B). Fortunately an opportunity of confirming the diagnosis of gout occurred in this case. One finger, on account of septic infection and suppuration of a joint, required amputation. This afforded the opportunity of examining the remaining joint of the finger. Deposits of chalky material were found in and around the joint, and a portion of this deposit gave the murexide test. Another portion of the deposit was separately radiographed, and the resultant shadow was obtained (C). No doubt, therefore, can exist that gouty deposits can be seen in a radiograph.

These deposits can only be observed in the profile of the joint. The finger joints, on account of the ease with which they may be radiographed, are *par excellence* the place to make out even the slightest deposit (although deposits may be clearly seen round other joints). In this position they are often small and sharply marked, they are seen as additions to the outline of the bone, and, as they are less opaque than bone, the outline of the bone can be seen through them. In the phalanges, the position in which they are most commonly seen is on the sides of the bones just below the joint, where the lateral ligaments are attached to the bone. They may be of fair size, but the most distinct ones are often small with a sharply marked outline, about the size of a large pin's head. An example of a typical gouty deposit is shown in Fig. 2.

Rheumatoid arthritis is characterised, as is gout, by swelling of the joints of the hands and feet; later all the joints of the body may be attacked, the maxillary joint being particularly susceptible to this disease. Well-advanced cases present no difficulty in diagnosis, as the characteristic condition of the sufferer is only too evident. In early cases, in which the trouble is just commencing, there is often considerable difficulty in differentiating this disease from gout.

As in gout, a radiograph of the hands gives, for the reason already stated, the best results. In advanced cases, the ulnar deflection of the bones of the fingers and the sub-luxation of the joints is well shown.

Changes in the bones of the carpus and metacarpus are also to be seen, and also in the articular surfaces of the joints. These changes are entirely different from those seen in gout. In Fig. 3, the heads of the phalangeal and metacarpal bones have been destroyed and eroded to an extraordinary extent.

PLATE XV.

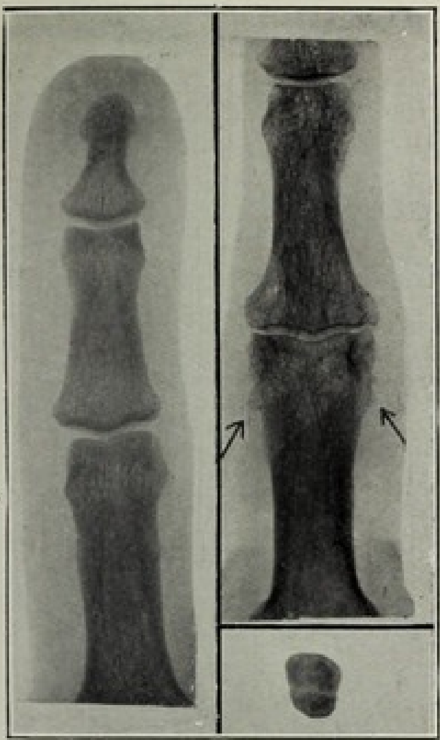

Fig. 1. *Gout showing deposits of uric acid salts about the joints and these deposits opaque to the rays.*

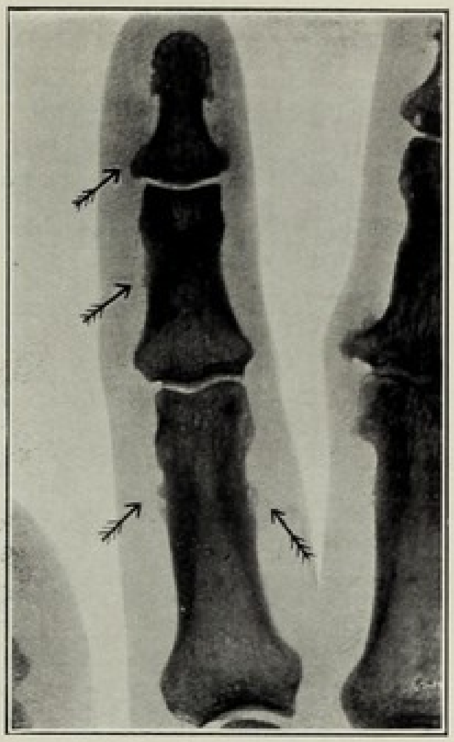

Fig. 2. *Typical gouty deposits.*

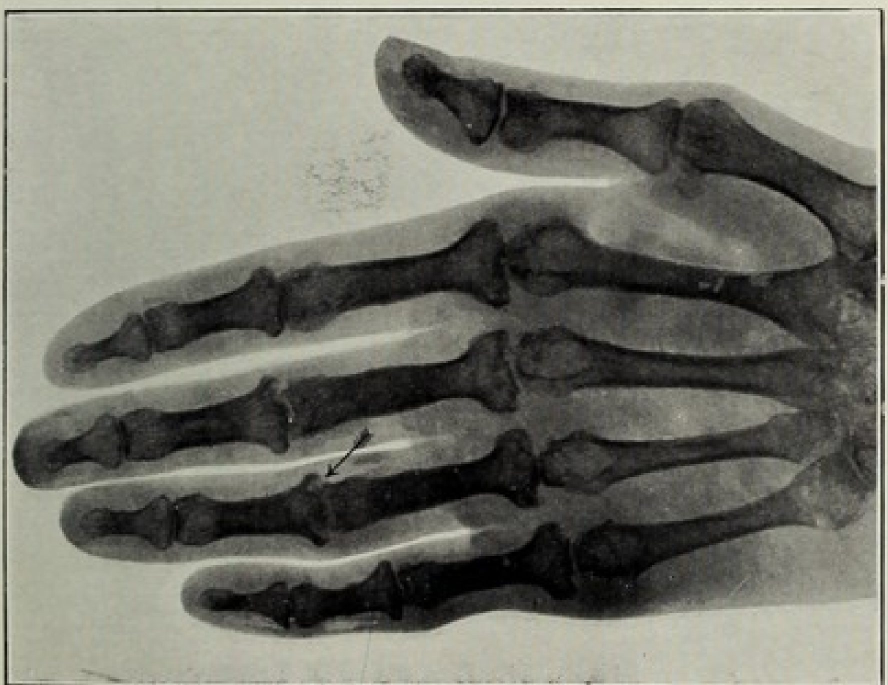

Fig. 3. *Rheumatoid arthritis.*

PLATE XVI.

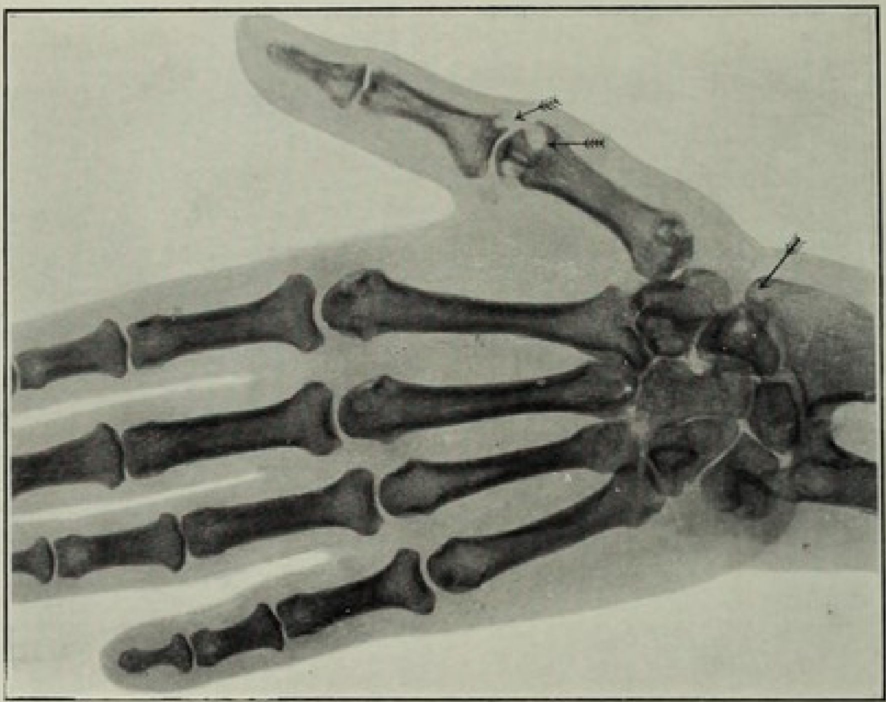

Fig. 4. *Rheumatoid arthritis showing necrotic areas.*

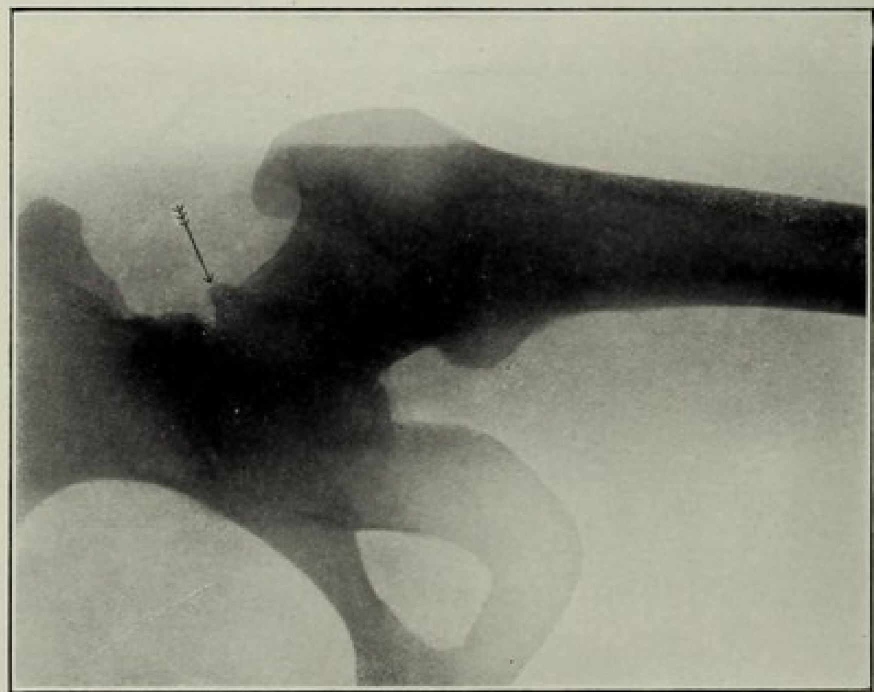

Fig. 5. *Arthritis deformans.*

At one point, marked ⋙⟶, there is to be seen a sharply defined punched-out-looking cavity, which has the appearance that a carious cavity in a tooth would present in profile. This peculiarity is better seen in Fig. 4. The bones of the carpus, which normally should be clear and distinct in outline, present an appearance which is best described as a "mashed-up" appearance. Their outline is lost, and they all appear to have more or less blended together into one mass of bone; so much so is this the case that the radiograph is often thought to be an indifferent one. The lower ends of the radius and ulna are often curiously affected, though not clearly in either of the two of the above cases. For about half an inch from the joint the bone is peculiarly transparent, this appearance ending abruptly in a sharp line where the bone resumes its normal appearance. It is characteristic of this disease that all the bones affected tend to be abnormally translucent to the rays. In early cases of this disease, when it is at first largely peri-articular, the outline of the bone is normal; there may be a suggestion of what I term translucency with a loss of definition of the outlines of the carpal bones, but there is never any deposit about the phalanges as seen in gout.

The appearance of any necrotic areas as described above, with the absence of additions to the outline of the bones, at once suggests the diagnosis.

Arthritis deformans most commonly affects the hip-joint in elderly people; it is sometimes seen in the shoulder, one joint only is, as a rule, affected. It is a very common cause of the pain in cases of sciatica, and the hip-joint should always be carefully examined in such cases.

If a radiograph of the affected joint is taken, the appearances presented are very characteristic. In early cases, the whole head of the bone is more translucent than normal. This translucent area is sharply marked off by a curved line where the bone tissue is of greater density, and the lip of the acetabulum is often more prominent than normal. In advanced cases, of which Fig. 5 is an example, the lipping of the acetabulum and head of the femur is more marked, and other irregularities appear in the outline of the bones forming the joint.

LOOSE BODIES IN JOINTS.

The ease with which this condition can be detected by the X-rays is well exemplified in Fig. 16. The loose bodies lie just above the patella in the position marked ⋙——→

GONORRHŒAL ARTHRITIS.

Fig. 7 is an example of this disease affecting the wrist joint.

There are to be observed, to a certain extent, the same bony changes as are seen in the example of this joint affected by rheumatoid arthritis.

There is the same translucency of all the bones of the joint and those distal from it. The carpal bones are similarly obscure in outline. There are not, however, any of the necrotic areas which may be observed in rheumatoid arthritis.

TUBERCULOUS DISEASE OF JOINTS.

In this disease, X-ray examination has become nowadays almost necessary, for by it one is able to form an opinion with regard to the extent and limitations of the disease, and so to determine on the line of treatment to be adopted. Fig. 8 is an example of tuberculous disease of the ankle joint which presented externally its usual characteristics. There is to be seen in the radiograph, however, an obvious tubercular cavity in the lower end of the tibia, which communicates with the joint (marked ⋙——→). In this case it would appear that only the more severe surgical methods of treatment would be of any avail. Where the deep joints are affected, examination by this method is often of great assistance in the early diagnosis of the disease. In Fig. 9, there is shown an example of early morbus coxæ; the disease, which is confined largely to the acetabulum, is plainly to be seen. In this case the radiograph was able to exclude with certainty the existence of a suspected coxa vara.

PERIOSTITIS.

Periostitis, whether acute or chronic, usually affords ample evidence of that condition by radiograph, as is well seen in Fig. 10. This is an example of a suppurative periostitis, a sequela of enteric fever. The outline of the tibia has been disturbed (in the portion marked ⋙——→), and the periosteum

PLATE XVII.

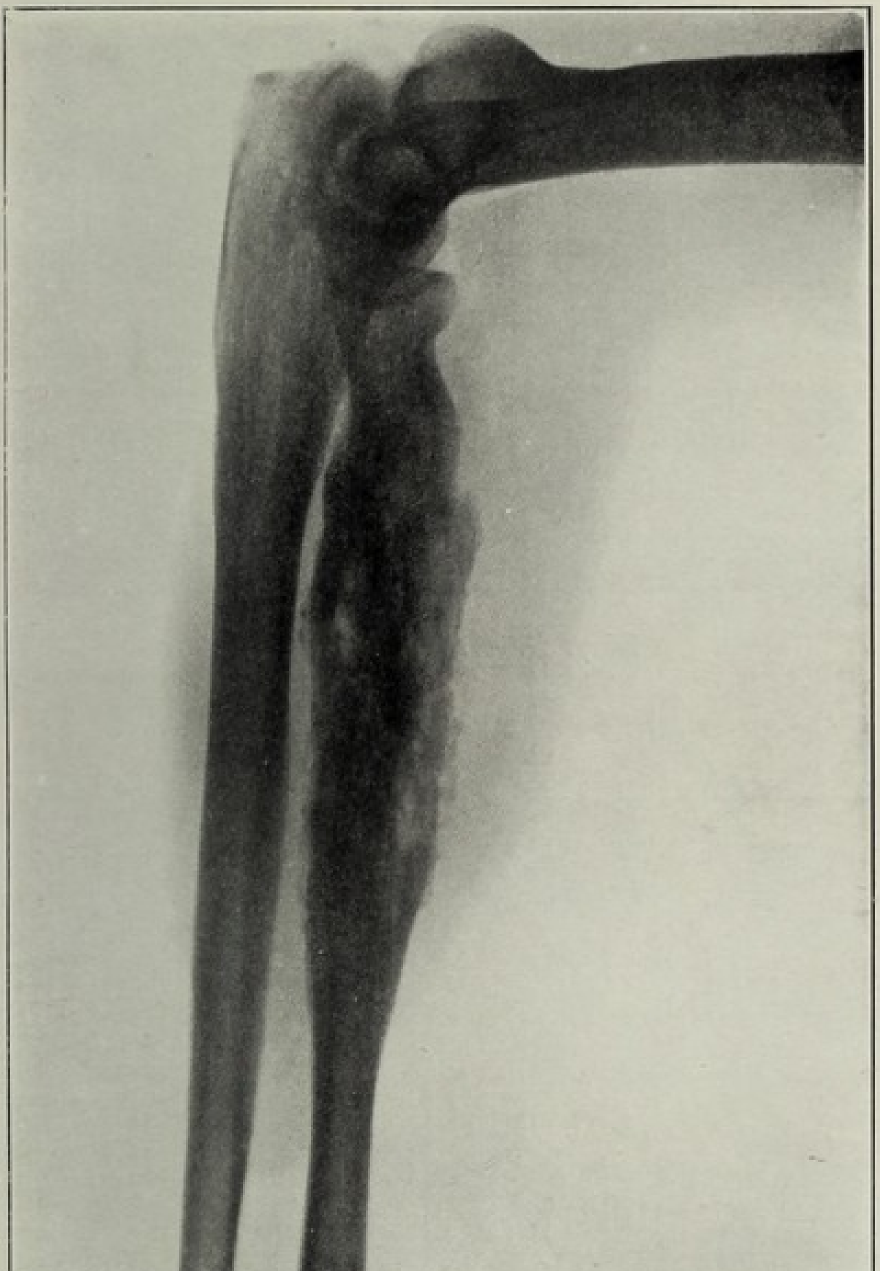

Fig. 6. *Endosteal sarcoma of radius.*

PLATE XVIII.

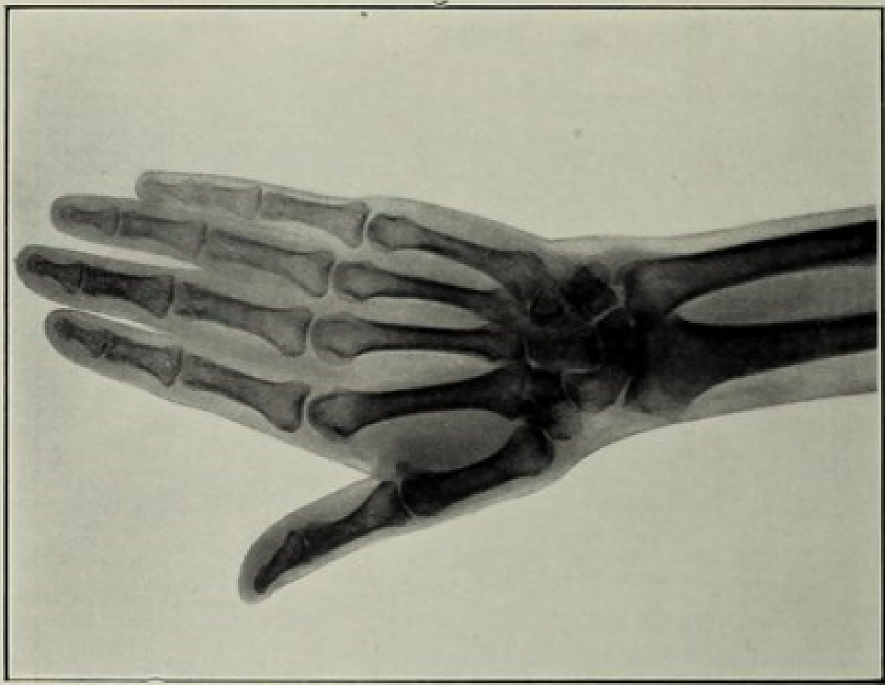

Fig. 7. *Gonorrhœal arthritis.*

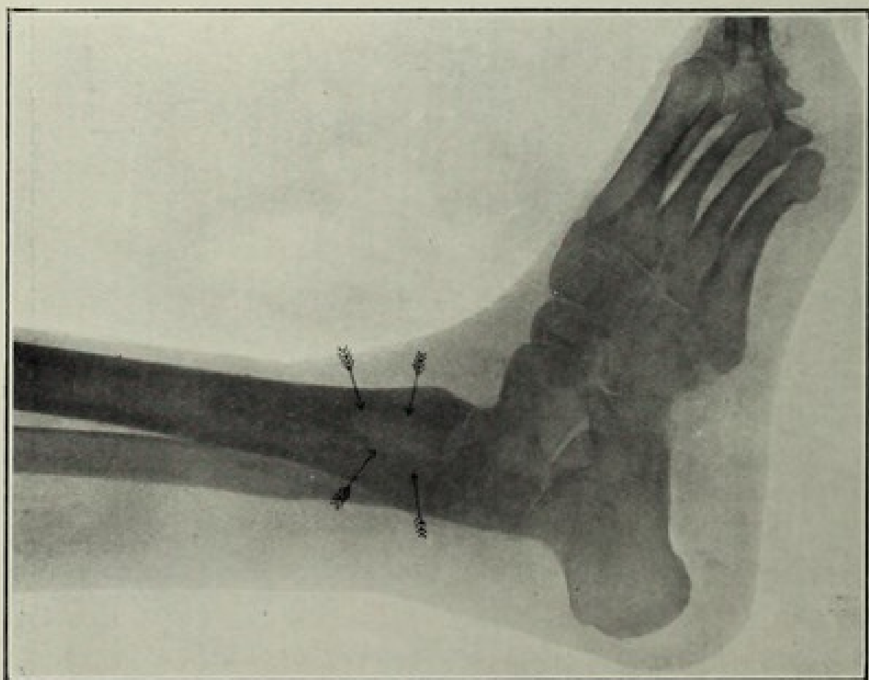

Fig. 8. *Tubercular arthritis.*

Plate XIX.

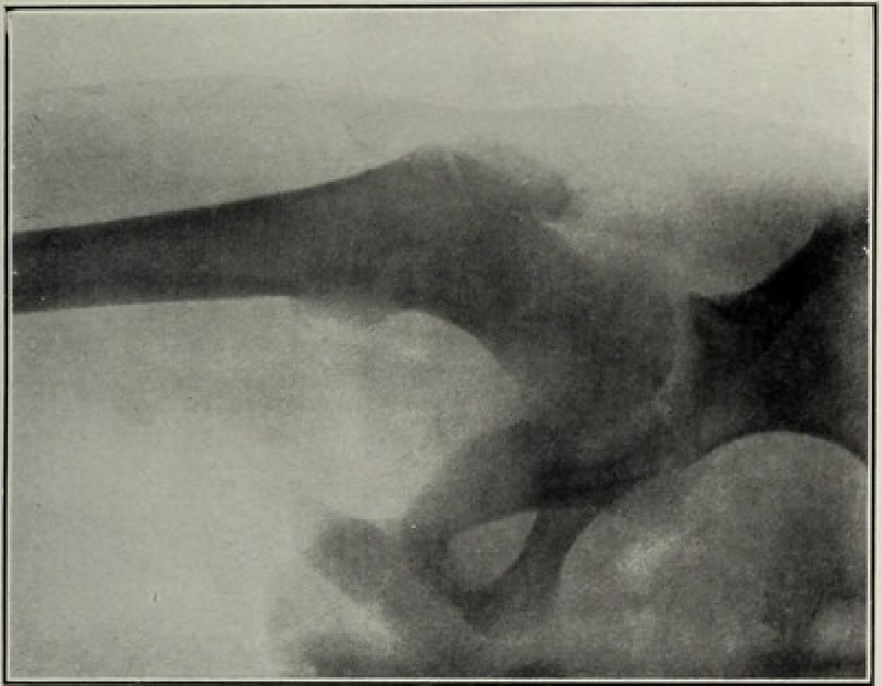

Fig. 9. *Morbus coxæ*

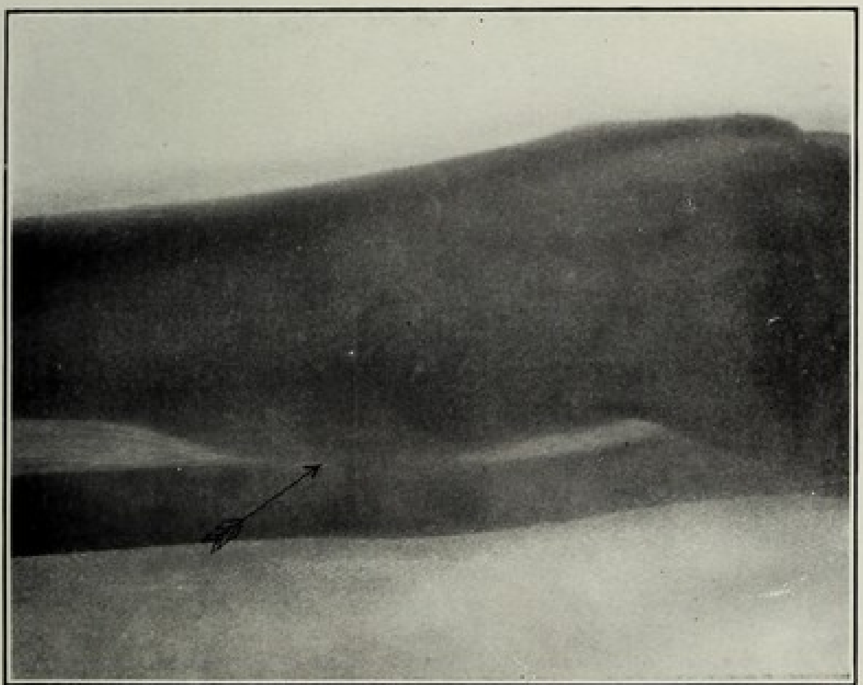

Fig. 10. *Chronic periostitis.*

PLATE XX.

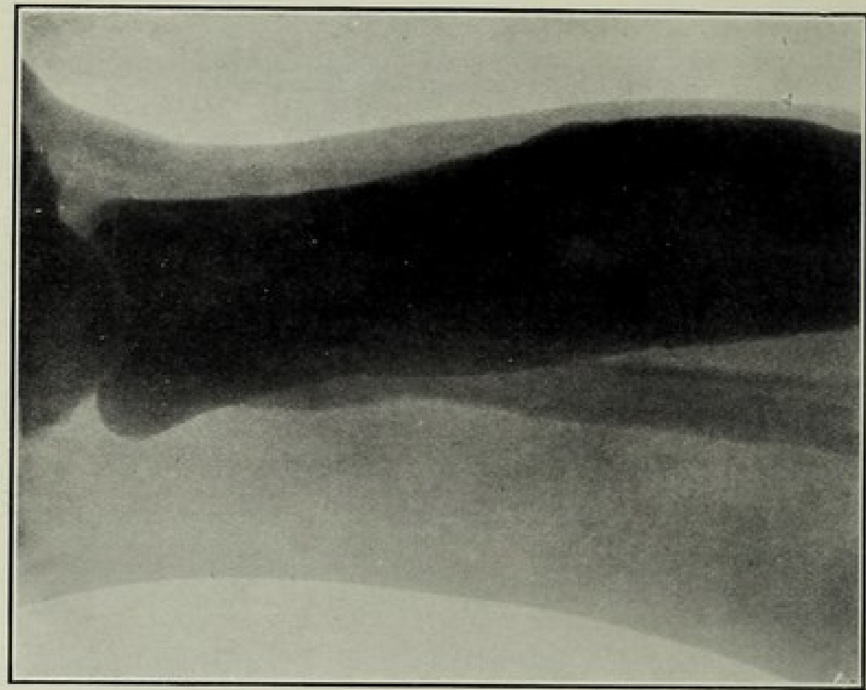

Fig. 11. *Chronic osteo-periostitis.*

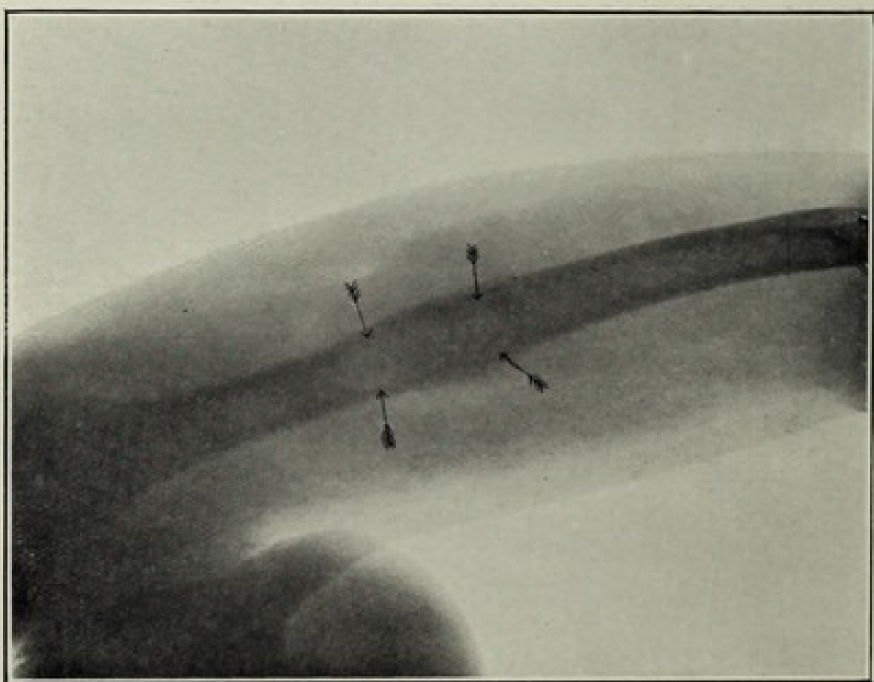

Fig. 12. *Tubercular osteitis.*

Plate XXI.

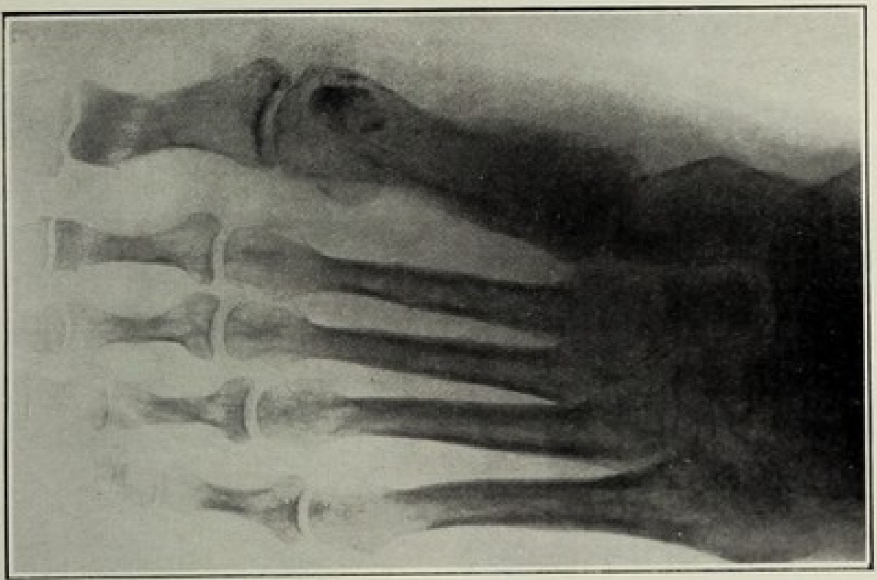

Fig. 13. *Tubercular periostitis of first metatarsal bone.*

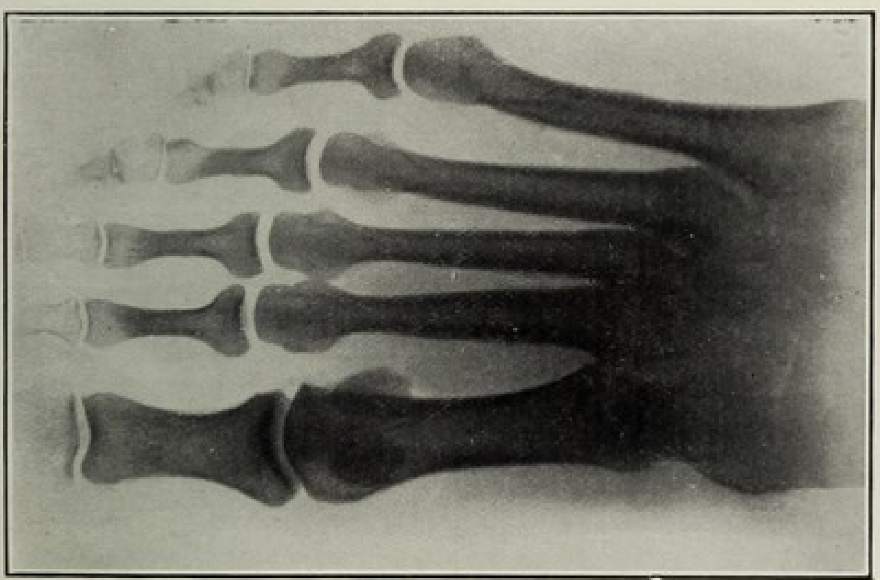

Fig. 14. *Normal foot.*

Plate XXII.

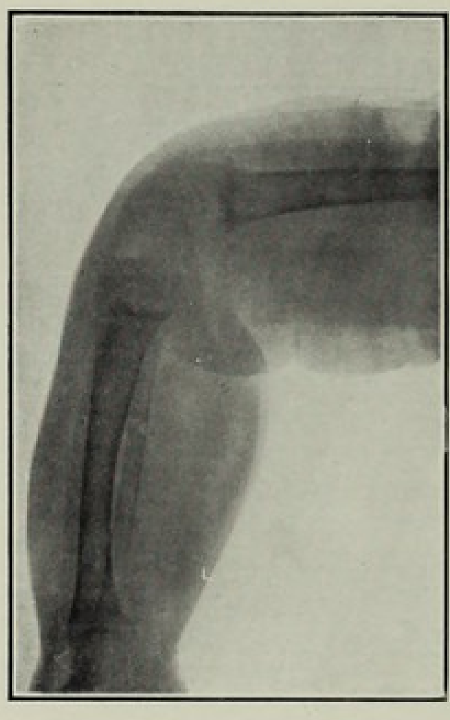

Fig. 15. *Tubercular epiphysitis.*

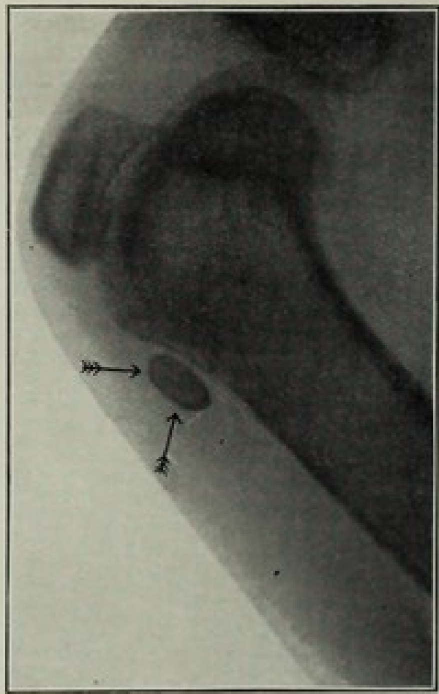

Fig. 16. *Loose body in lower joint.*

Fig. 17. *Tubercular dactylitis.*

Fig. 18. *Gumma in clavicle.*

has been displaced outwards. Immediately beneath it there is to be seen an area, which is less opaque to the rays, and which no doubt corresponds to the pus underlying the diseased periosteum. It is often difficult to determine whether an abscess, which has been evacuated, has a deep or a superficial origin. X-ray examination, should the abscess originate in the periosteum, would at once clear up any doubt that might exist. The actual cause of the inflammation of the periosteum must be deduced from the clinical history. In cases, in which there is some question of acute periostitis following injury, it is an easy matter to decide on its existence by X-ray examination.

TUBULAR NECROSIS.

The difficulties in recognising and localising the seat of necrosis, when situated deeply in bone, is well known. In Fig. 23, there is to be seen in the position, marked ⋙——→, an area of necrosis lying on the outside of the head of the tibia. In this particular case, there was some evidence of the condition externally, but it was very misleading, and pointed to the trouble being situated in the inside of the head of tibia. The operation for its relief was attempted in this situation, and on that account failed. On referring to the radiographic evidence the line of operation was changed to the outside. The cavity was discovered and evacuated.

CHRONIC OSTEOPERIOSTITIS.

The similarity, which exists between this disease and the early stages of a malignant growth, makes X-ray examination of the utmost importance. So far as the clinical symptoms are concerned, it is often impossible to distinguish between these diseases. In Fig. 11, there is shown an excellent example of chronic osteoperiostitis of the lower end of the tibia. In the radiograph, the shadow of the bone is homogeneous and well defined, though obviously abnormal in outline. It is, moreover, more opaque to the rays than normal bone This appearance is directly opposite to that presented by endosteal sarcoma (Fig. 6), in which there is evidence of a considerable amount of soft tissue both centrally and towards the periphery, there being many gaps in the shadow cast by the tumour.

TUBERCULAR PERIOSTITIS.

The appearance presented by this disease in a radiograph of the affected bone is similar to that seen in chronic periostitis (Fig. 10). It is often important to make such an examination, for it affords an accurate means of ascertaining the exact position and extent of the disease. In Figs. 13 and 14, there is shown an example of tubercular periostitis of the first metatarsal bone of the foot.

TUBERCULAR OSTEITIS.

In Fig. 17, there is seen an example of this disease affecting the terminal phalanx of the middle finger of a child, 11 months old (tubercular dactylitis). The appearance of the bone so affected is easily made out in the radiograph; in the middle of the shaft is an irregular area of lesser density, corresponding to the necrosed bone. Where this disease affects other bones in the later stages of life, the importance of X-ray examination lies in the fact that, in a case, in which sinuses have already been formed, and in which there is much swelling of the affected part, it is difficult and often impossible to determine the limitations of the disease. This difficulty occurs especially in the bones of the carpus and tarsus, and a thorough knowledge of the limitations of this disease in these parts is extremely important, both from the point of view of prognosis and treatment.

Fig. 12 is an example of central tubercular osteitis of the shaft of the humerus; there is plainly to be seen an area of less opacity indicating the presence of an abscess surrounded by the more opaque normal bone. The margins of the cavity are not sharply outlined but are rough, and, here and there, within the light area, are seen small darker spots. These smaller dense areas suggest the presence of osteophytes (marked »»——→).

Fig. 19 shows an example of tubercular osteitis of the fifth lumbar vertebra. The patient is, in this case, a young girl of 16, who suffered only from vague pains down the back of the thighs and legs, and from difficulty in stooping, presented altogether no symptoms which suggested such a grave state of affairs; examination by this method showed plainly the existence of this disease. There is to be seen a perfectly

Plate XXIII.

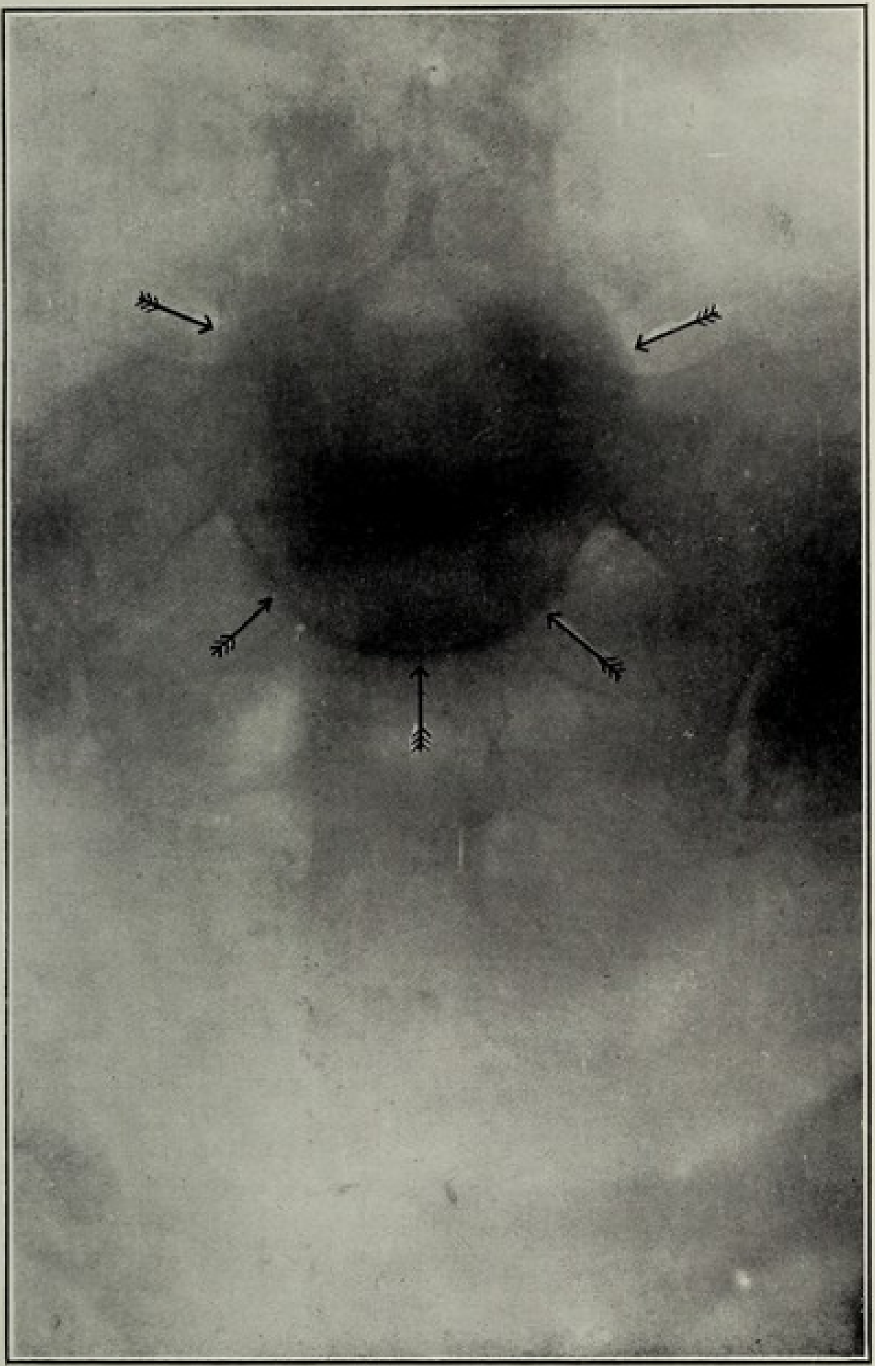

Fig. 19. *Tubercular osteitis of fifth lumbar vertebra.*

Plate XXIV.

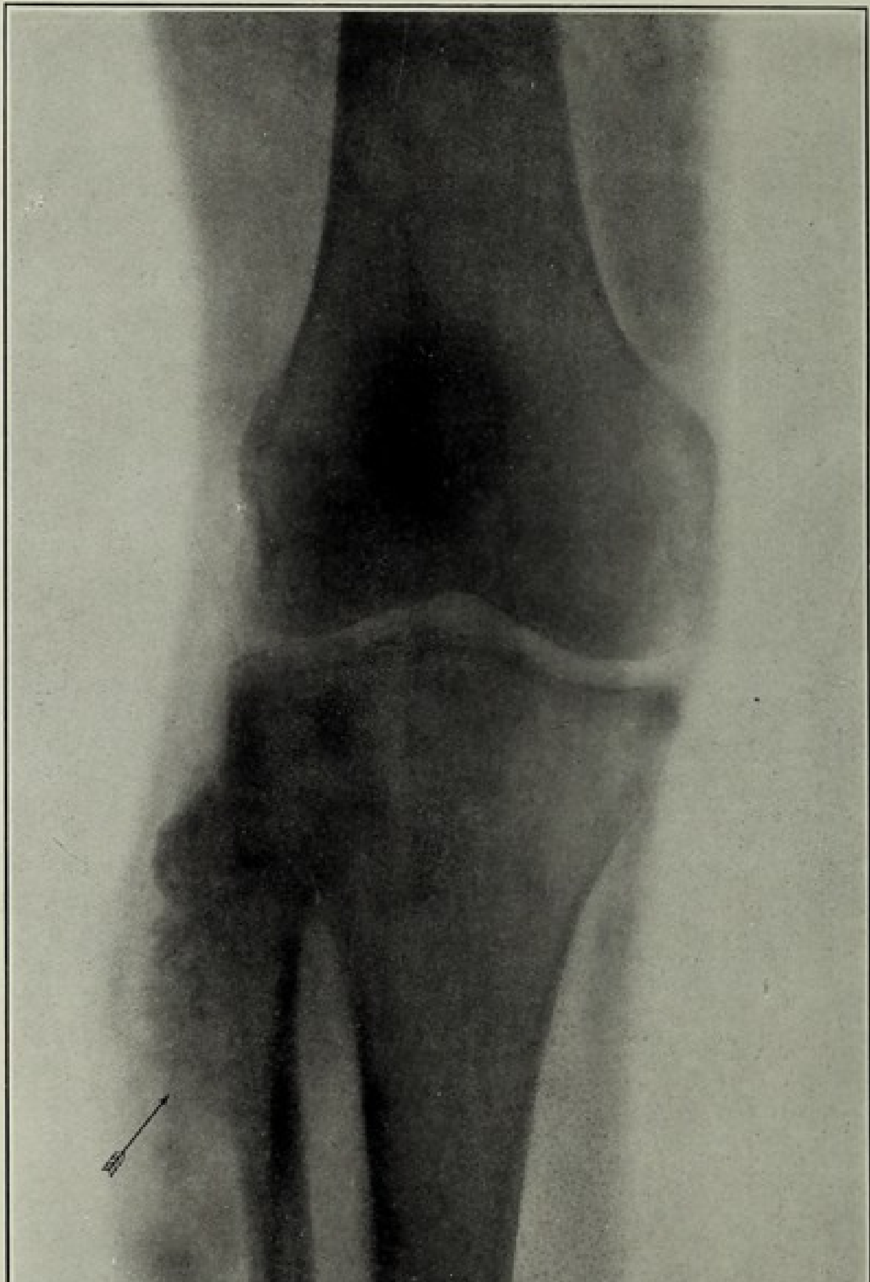

Fig. 20. *Periosteal sarcoma of head of fibula.*

Plate XXV.

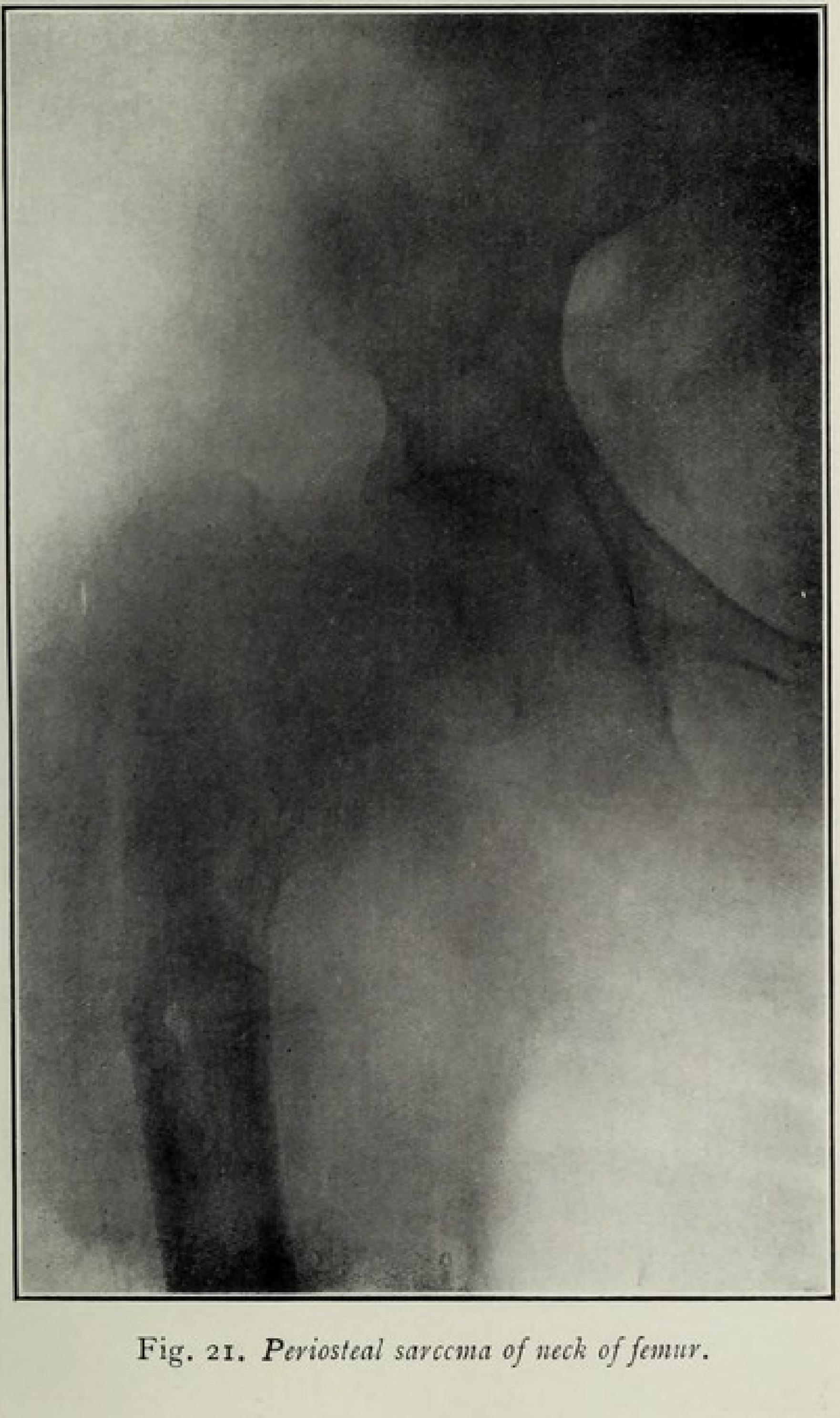

Fig. 21. *Periosteal sarcoma of neck of femur.*

PLATE XXVI.

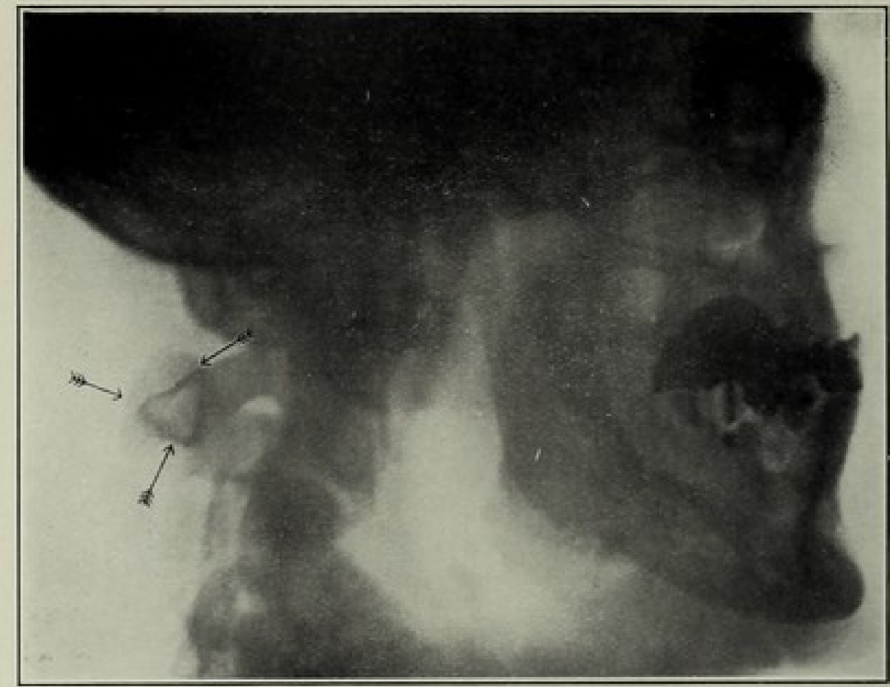

Fig. 22. *Gumma of cervical vertebræ.*

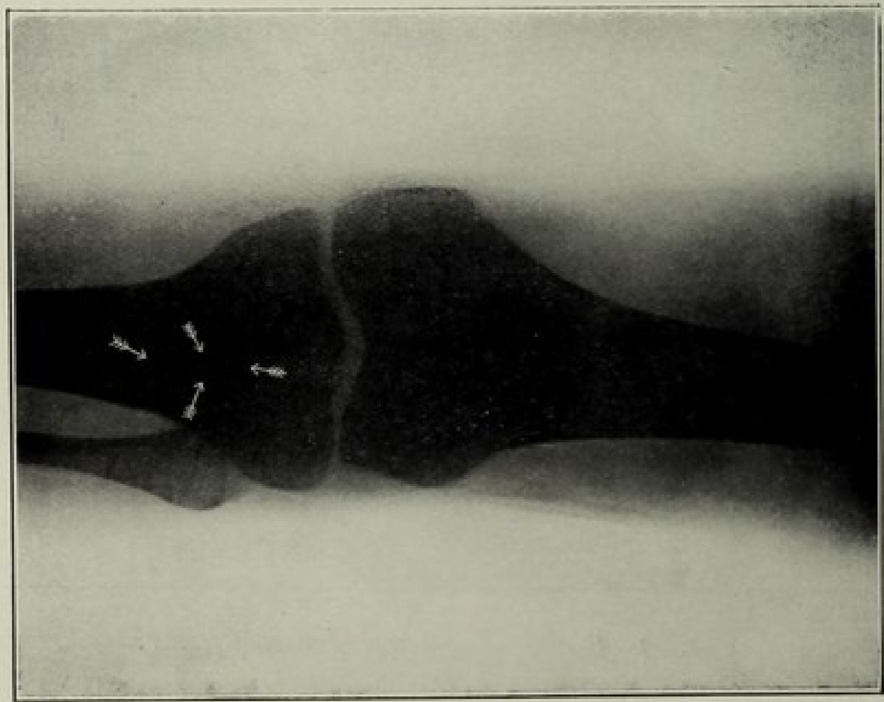

Fig. 23. *Tubular abscess of head of tibia.*

symmetrical area of less opacity in the region of the last lumbar and first sacral vertebra, its shape being like that of the articular surface of the body of a lumbar vertebra (marked ⋙——➝). Absolute proof of the existence of this condition was afforded, in this case, by subsequent operation, when a tubercular abscess was evacuated and the symptoms relieved.

ACUTE EPIPHYSITIS.

The differential diagnosis of this disease presents, as a rule, little difficulty; its symptoms may, however, be confused with such a condition as scurvy rickets. X-ray examination will at once clear up any doubt that may exist. No grave changes would be observed in the outline of the bones in scurvy rickets, but, in a case of acute epiphysitis, there would be partial, or complete disappearance of the epiphysis. In a case in which there was some doubt as to which of these two conditions existed, X-ray examination carried out by the author showed no sign of translucency of the epiphysis, the case being one of rickets. In acute epiphysitis, the ossification area of the affected epiphysis becomes less dense to the rays, and may become perfectly translucent; the change is best discovered by taking a radiograph of the unaffected limb and by comparing it with that of the diseased one. Fig. 15 is the knee joint of a child, 11 months old, showing disappearance of the epiphysis.

SYPHILITIC DISEASE OF BONE.

Fig. 22 is an excellent example of the benefit that may be derived from X-ray examination in a case of tertiary syphilitis. The bodies of the cervical vertebræ, the seat of the disease, have been eroded and eaten away by the encroachments of a gumma, so that there is to be seen an obvious angular deformity. The spinous processes have been principally attacked, and, at the tip of the third vertebra, there is a heart-shaped area (marked with an arrow) which shows well the characteristic radiographic appearance of bone affected by gumma. In this particular case the X-ray examination further assisted the diagnosis, for, as is shown in Fig. 18, there was discovered, although there was no external evidence of the same, an obvious gumma in the clavicle.

The radiographic appearance of tertiary syphilitic disease of bone when it takes the form of a gumma is very characteristic:—(1) There is an area of less opacity in the position occupied by the gumma. (2) This area of less opacity is surrounded by a sharp denser area which shows on the print as a dark line. (Best seen in Fig. 22.) Tubercular disease of bone cast a much less opaque shadow, and there is not the sharp line surrounding the less opaque area. This radiograph should be compared with Figs. 6, 20, and 21, in order to realise the difference in the radiographic appearance of gumma and sarcoma affecting bone.

SARCOMA.

In osteo-sarcoma, the necessity of early diagnosis, and the difficulty of distinguishing this disease in its early stages from chronic periostitis, medullary gumma, or deep abscess of the bone, make X-ray examination almost a necessity. Fig. 6 is a typical example of endosteal sarcoma. The shadow cast by the tumour is not uniform, the usual dark appearance, cast by bony material, is displaced throughout its surface at irregular intervals by areas of a lighter appearance. These areas no doubt correspond with such parts of the tumour as are composed of softer material. Since it is characteristic of osteo-sarcomatous growths that they are composed of partly bony and partly soft tissue, this irregular appearance of the shadow is of the utmost importance. It serves to distinguish it from the other diseases mentioned above.

Chronic osteo-periostitis casts a solid and uniform shadow, medullary gumma a uniform though less dense shadow, and deep abscess of bone imparts a uniformly lighter appearance to the area of bone affected by the disease. Fig. 20 is an example of periosteal sarcoma affecting the head of the fibula. The outline of the shadow cast by it is indefinite, unlike the endosteal variety, its substance is not composed, to any extent, of material which is opaque to the rays. Its appearance, however, is sufficiently characteristic to warrant its recognition as such. In its later stages, when it leads to erosion and spontaneous fracture, its presence is more appreciated, as is well seen in Fig. 20.

X-RAYS IN THE DIAGNOSIS OF FRACTURES AND DISLOCATIONS.

BY R. HIGHAM COOPER, L.S.A.,

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[With Plates XXVII.—XXXIV.]

THE diagnosis of fractures and dislocations was the first application of X-rays to surgery, and the advantages of their use in this direction is now almost universally recognised. There are, however, still a few surgeons, who contend that no advance has been made either in the diagnosis or treatment of fractures or dislocations due to the rays, and that their use is frequently misleading. The latter fact is solely attributable to faulty technique, or to unskilful interpretation of the negative, or appearance on the fluorescent screen. The making of an X-ray examination requires considerable care and skill, and can in no way be compared with the taking of a photograph. It is unfortunate that so many medical men are slow to grasp this important fact, and are content to send their patients to an unqualified person for an "X-ray photograph." The X-ray operator, who may be totally ignorant of anatomy and surgery, produces a negative, which the medical man, either because the part has been badly radiographed, or because he is himself unskilled in its interpretation, naturally condemns as useless and misleading, and promptly blames the X-rays instead of the misuse of them.

In radiographing a patient, the first principle to be borne in mind is that the X-ray negative is not a "photo-" but a "shadow-" graph (hence the term skia-graph). Now the interpretation of a shadow is infinitely more difficult than that of an image, and hence the medical man, who is not thoroughly conversant with the skiagraphic appearances of bones and joints in health and disease, cannot hope to make an accurate diagnosis for himself of any but the most straight-forward lesions, in which the help of X-rays is probably not needed at all. Two simple examples will explain my meaning. Medical men, without previous experience in X-ray work, when examining a shoulder with the screen, have frequently suggested to me that there was a dislocation of the outer end of the clavicle, being misled by the normal bony separation at the acromio-clavicular articulation (where there is a cartilage which casts no shadow), as well as by the shadow of the end of the clavicle, which normally projects above that of the acromion. Again, a radiogram of the hip, taken with the plate behind and the tube in front, shows considerable foreshortening of the neck of the femur, which leads not infrequently to a mistaken diagnosis of intracapsular fracture. Against these and other fallacies the experienced surgeon is on his guard, and many can only be detected by constant practical experience in the interpretation of X-ray negatives.

Another frequent source of error is the taking of a radiogram with the tube, patient, and plate in wrong positions, thus causing undue distortion. For instance, I have taken two radiograms of a boy's elbow, after reduction of a separated epiphysis; the one, taken properly, showed the epiphysis replaced in a good position, while the other negative gave the appearance of absurd displacement. It is evident that distortion will be least when the normal ray from the tube strikes the plate at a right angle, and passes through the centre of the part of the patient under examination. Shadows, for all practical purposes, are always larger than the objects which cast them, and consequently a certain amount of distortion is inevitable. It is obvious that the closer the object is to the plate the less will be the enlargement of the shadow, until, if the object is in actual contact, the shadow it casts presents practically no distortion at all. We must then place the bony parts under examination as close as we can to the plate, and must direct the rays from the tube perpendicularly downwards. The farther the tube is from the part the more parallel become the rays, and, therefore, the less is the distortion of the shadows; so that it is an advantage to have the tube far away, though in practice the distance must be limited, since the necessary length of exposure of the plate varies roughly with the square of the distance.

On a negative, which has been properly produced, we find that the central parts present practically no distortion, the shadows being as nearly as possible "life-size." As we go towards the periphery, the distortion becomes greater, and much practical experience is needed to accurately interpret the conditions present.

As the X-rays penetrate the whole of the limb, or other part of the body under exposure, it follows that, where two bones overlap, there are two shadows superimposed. These are frequently a source of difficulty, but it should be remembered that the bone, which casts the clearest and least enlarged outline, is the one nearest to the plate, while the enlarged and more indistinct shadow is that of the bone nearest the tube.

All the difficulties mentioned above refer to the single "flat" negative with which so many Radiographers are satisfied; but there is a method of skiagraphy, by the use of which, misleading results, even to the novice, become next to impossible—I refer, of course, to stereoscopy. The medical man, who has once seen a fracture stereoscopically represented, can never afterwards be content with a single negative, for all the parts are accurately seen in their actual positions, and difficulties in diagnosis almost entirely vanish.

In speaking of stereoscopic effects, I must warn the reader against the curious effect of shading, which is seen in all radiograms, and sometimes gives a false idea of the part standing out in relief. True stereoscopic pictures can only be obtained by the combination in a stereoscope of two negatives taken in a particular manner. Any effect of "relief" obtained from a single plate is false and misleading.

It is often the case that those, who discount the value of X-rays in diagnosis, do not possess binocular vision, and are therefore unable to appreciate stereoscopic negatives.

I have been requested to deal mainly with difficulties in diagnosis, hence, as these are almost non-existent where satisfactory stereoscopic results have been obtained, I must confine my attention to the single negative, or the appearance on the fluorescent screen. I would, however, in passing, most strongly urge the use of the stereoscope in all cases where the slightest difficulty is anticipated.

The best, or rather the least bad, substitute for stereoscopy is the taking of two views at right angles to one another, that is to say, lateral and antero-posterior; where this is possible an accurate estimate of the amount of displacement and the positions of the parts can usually be made. This method is impossible in some cases, and these I shall consider separately later on.

In X-ray work, as with scientific photography, the negative is always superior to the print, and the diagnosis should always be made from the former, though it may appear more difficult at first sight.

The negative must be evenly illuminated; this is best done by holding it in front of a piece of opal or ground glass with a good light behind it.

As the X-ray negative represents shadows, the print is of necessity reversed, a point which the novice is apt to overlook. All substances are opaque to X-rays in proportion to their density, hence cartilage is comparatively translucent, and a clear space will be seen between articular surfaces corresponding with the cartilages present. Displaced cartilages cannot often be made out, though their absence from their normal positions may sometimes be discovered through seeing bony surfaces in apposition, which should normally be separated by a clear interval. Periosteum is more opaque than cartilage, though less so than bone, and, when stripped up, can frequently be seen on the negative. Callus is visible in proportion to the amount of calcification which has taken place, and, therefore, to its age, where the healing process is normal. It is obvious then that the cause of delayed union can be demonstrated by Radiography. Callus generally becomes visible when about four to six weeks old.

With children and young adults, the process of ossification must be remembered, and an epiphysis, or ossific centre, with a clear cartilaginous interval between it and the shaft of the bone, must not be mistaken for fracture or dislocation.

It is usual to commence an X-ray examination with the use of the fluorescent screen, but, unless absolutely positive evidence is obtained, a radiogram must be taken in addition. A negative diagnosis of fracture should never be given from the screen, as fissures and fractures without displacement may be easily missed. An example of this is given in Fig. 1. This fracture, while perfectly plain in the radiogram, was missed both by the patient, who was a medical man, and by myself, when we were examining with the screen.

PLATE XXVII.

Fig. 1. *Fracture of terminal phalanx, not visible on the screen.*

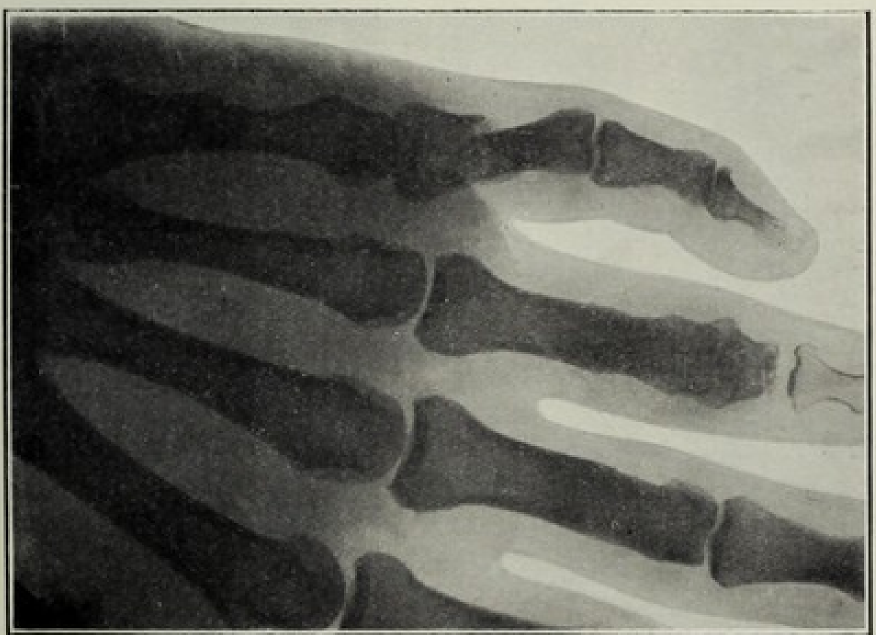

Fig. 2. *Impacted fracture of phalanx and splitting of its base. Note also deformity in third finger.*

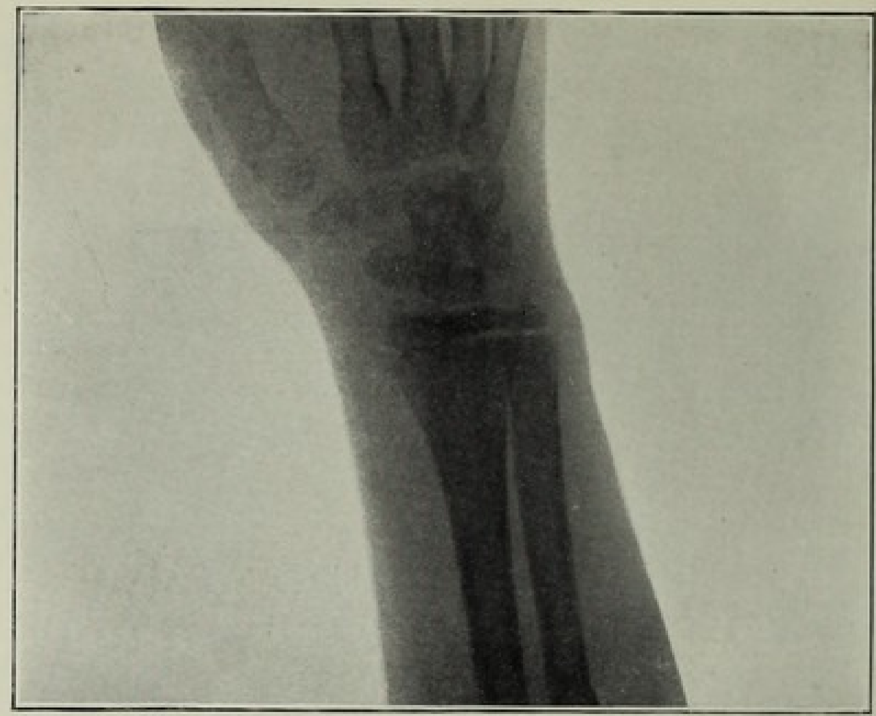

Fig. 3. *Wrist of child of seven, showing normal condition of the carpus and epiphyses of ulna and radius.*

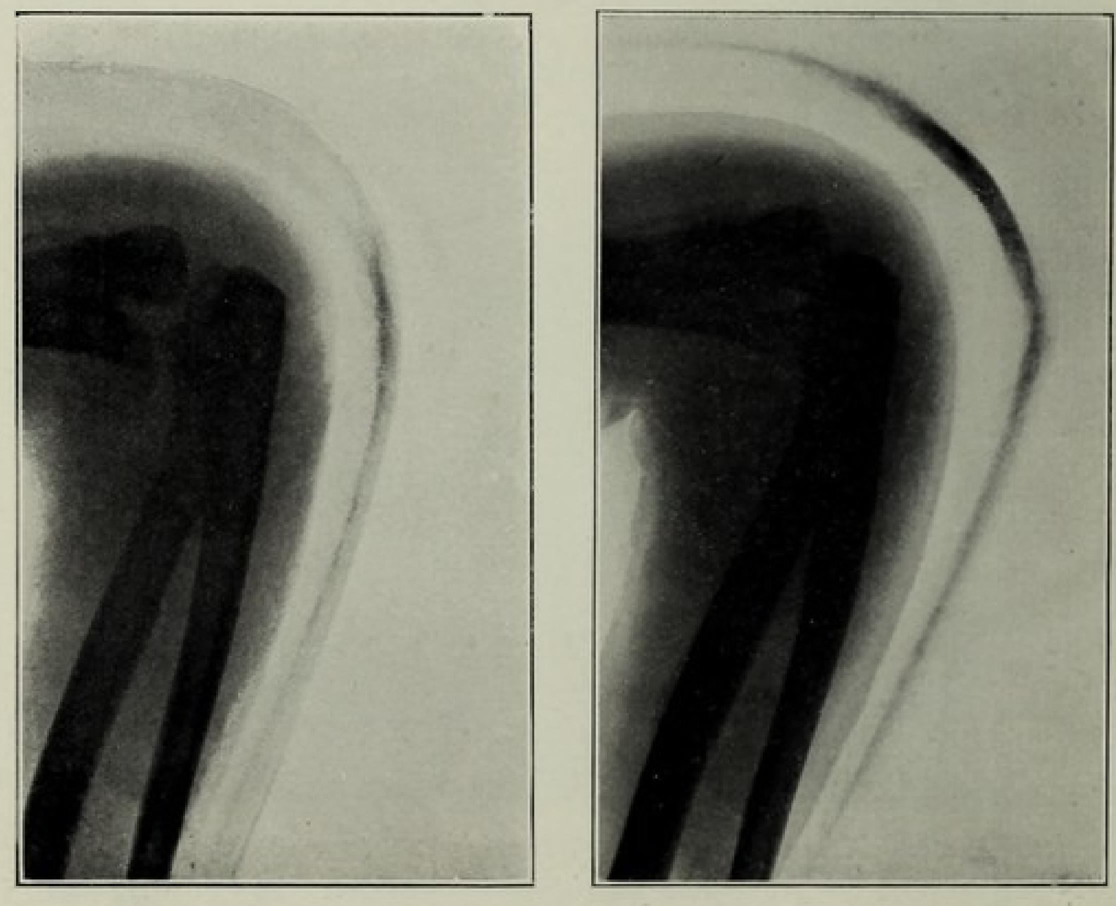

Fig. 4. *Stereoscopic skiagrams of a fracture-dislocation of the elbow. The limb is in a poroplastic splint.*

It is a great help in diagnosis to radiograph both sides of the body for comparison, but it is very necessary, in such a case, to see that the limbs are taken in similar positions, and with the same relations of tube and negative. Where it is possible, the two limbs should be taken on the same plate with the tube midway between them.

The limb should be free from coverings during the examination, except in the case of fractures which are being radiographed, to see if they have been put up in good position. The reason for this is that seams or folds in clothing or bandages, and the grain of a wooden splint, may sometimes simulate a fissure in the bone on the single flat negative. It would, of course, be most unwise, as well as unnecessary, to remove splints and bandages from a fracture that has been put up, for the patient in such case is only radiographed to show that there is no actual displacement, and the faint shadows cast by the dressings do not obscure the diagnosis. There are some substances which are sufficiently opaque to prevent the taking of a satisfactory radiogram ; such are thick layers of cyanide gauze (but only when many layers are used), iodoform gauze, even in thin layers, iodoform paste, any metallic ointment, and strapping (which generally contains lead). Ordinary wooden splints cast no appreciable shadow, except where they contain nails or screws, though the grain of the wood is visible on the negative. A radiogram may be taken through a poroplastic splint, and even through thin aluminium, but other metallic splints offer too much resistance to the rays. When a limb is put up in plaster sufficient outline may be obtained to show whether the bony fragments are in their proper relations ; but the negative is always hazy and mottled from the uneven deposits of plaster. Starch and water-glass dressings offer little obstruction to the rays.

It would be quite beyond the scope of this paper to deal with the varieties of fractures and dislocations that one is likely to encounter. Fractures of the shafts of long bones present few difficulties in diagnosis, and I propose to deal only with a few practical points which may help in the X-ray examination of joints and the smaller bones.

Head.—X-rays are not often employed in fractures of the skull, and results are not very satisfactory unless stereoscopic negatives are taken; the base is naturally much more difficult to skiagraph than the vertex. Fractures of the bones of the face are also difficult to show, because the two sides are superimposed in the negative; but this difficulty can be largely overcome by placing the plate against the affected bones, and by bringing the tube close up to the other side. This method may also be employed in radiographing the jaws for pieces of broken teeth, etc. The propinquity of the tube to the other side almost blots out its outline on the negative. Though my intention in this paper is not that of giving advice as to the practical taking of the radiogram, but rather as to its interpretation when taken, there are one or two points which I should like to mention, as they are frequently overlooked; and here I would remind the medical man that, when the X-ray tube is brought close up to the patient, as in the present instances, the part should be covered with a towel or other substance, which, though not interfering with the X-rays, will remove the risk of an electric burn.[1]

Fractures in the jaw and pieces of broken teeth are best seen by using a small piece of photographic film, wrapped in black paper and dental rubber. This is placed inside the mouth and pressed against the affected jaw by the tongue.

Dislocation of the jaw can be easily radiographed.

A lateral view of the hyoid bone can be obtained without difficulty. I have known a patient greatly alarmed by an unqualified X-ray operator diagnosing the hyoid as a swallowed piece of bone.

Spinal Column.—The upper three or four cervical vertebræ cannot be well shown in an antero-posterior direction, since the shadow of the lower jaw will be superimposed upon them; below this point an antero-posterior view of the spinal column can be secured throughout its entire length. In the thorax, however, the sternum and ribs, as well as the heart and great vessels, interfere to some degree, but this is mainly got over by bringing the tube quite close up. I have, by these means, obtained radiograms of the dorsal vertebræ

[1] I need scarcely say that I do not here refer to an "X-ray burn," but to destruction of tissue due to the static electricity surrounding the tube.

without the slightest visible shadow of sternum, ribs, heart, or aorta on the plate. Careful adjustment of tube and plate will prevent the superimposition of the pubes on the sacrum. A lateral view can only be obtained as low as the sixth, or occasionally the seventh cervical vertebra; this is due, not so much to the thickness of the parts, which would in itself be a great drawback, as to the necessary distance of the spine from the plate, causing such distortion as to render the negative useless. It follows, then, that, in suspected dislocation of the spine backwards or forwards, the single negative may become, not only useless, but even dangerous. I have seen two cases, in which a diagnosis was made from single negatives of "no dislocation," when stereoscopic pictures, which were subsequently taken, showed considerable displacement.

Pelvis.—Fractures in the pelvis can frequently be made out on the single plate, but it is unwise to make a negative diagnosis without a stereoscopic examination.

Sternum and Ribs.—Here there is usually little difficulty though the amount of displacement cannot well be made out without stereoscopy, since a lateral view is of little service. Negatives taken in a sagittal plane will sometimes help. The clear space left by the costal cartilages must not be mistaken for a bony separation.

Clavicle and Scapula.—Radiography of the clavicle presents no difficulties. The body of the scapula is so thin that it scarcely casts any shadow, but the borders can always be made out. The axillary border is best seen by raising the arm, and thus pulling the scapula outwards. The acromion process is well shown in the antero-posterior position, but the coracoid is usually superimposed on the spine of the scapula. A clear outline of the coracoid may be had by placing the tube in front and below; the negative thus obtained shows little but the clavicle and the coracoid process. It must be remembered that there is a cartilage, and therefore a clear space in the negative, at the acromio-clavicular articulation; the end of the clavicle also projects above that of the acromion. These appearances, as I have said before, are sometimes mistaken for a dislocation. There is normally a greater distance than one would expect between the shadows of the acromion and the head of the humerus. The two shoulders should be compared.

Shoulder-Joint.—Fractures of the glenoid, though very uncommon, have been shown by X-rays to be less rare than was supposed. It is almost impossible, apart from the rays, to diagnose between fracture of the glenoid, dislocation of the head of the humerus, and fracture of its anatomical neck. Stereoscopic pictures should be taken of this joint, as a lateral view cannot be obtained, so that it is difficult to diagnose on a single negative between forward and backward displacement. Views may, however, be taken sagittally, which will give a roughly accurate idea, and the amount of distortion of the head of the humerus, as compared with that of other bony points, will show its relative distance from the plate. X-rays show that a sub-coracoid dislocation may sometimes occur without obvious physical signs. A lady was sent to me for examination of the shoulder; stereoscopic negatives showed a sub-coracoid dislocation, and yet two surgeons whom she had consulted in Dublin, and three in London, had all diagnosed a simple sprain. Her physical signs, beyond limitation and pain in movement, were practically nil.

It is said that fracture of the surgical neck of the humerus is usually accompanied by dislocation, the writer basing his statement on radiographic examinations.

The elbow joint can be examined both in its antero-posterior and lateral aspects, so that diagnostic difficulties ought not to be great. Personally, I find it one of the most difficult joints in the body when the diagnosis has to be made from a single negative, the greatest difficulty occurring with displacement of epiphyses. The elbow is a joint which rapidly swells after an injury, thus making it difficult for clinical diagnosis, hence X-rays are especially useful. After most injuries to the elbow the joint is more or less bent, and therefore the antero-posterior view is either useless, or shows considerable distortion; it is the lateral view, then, on which we have to principally depend. In order to obtain the most useful negative, the condyles should be exactly superimposed on the plate, forming two concentric circles, the larger and more indistinct of which is naturally the farther from the plate. The arm should be bent nearly to a right angle. On such a negative, in the

Plate XXIX.

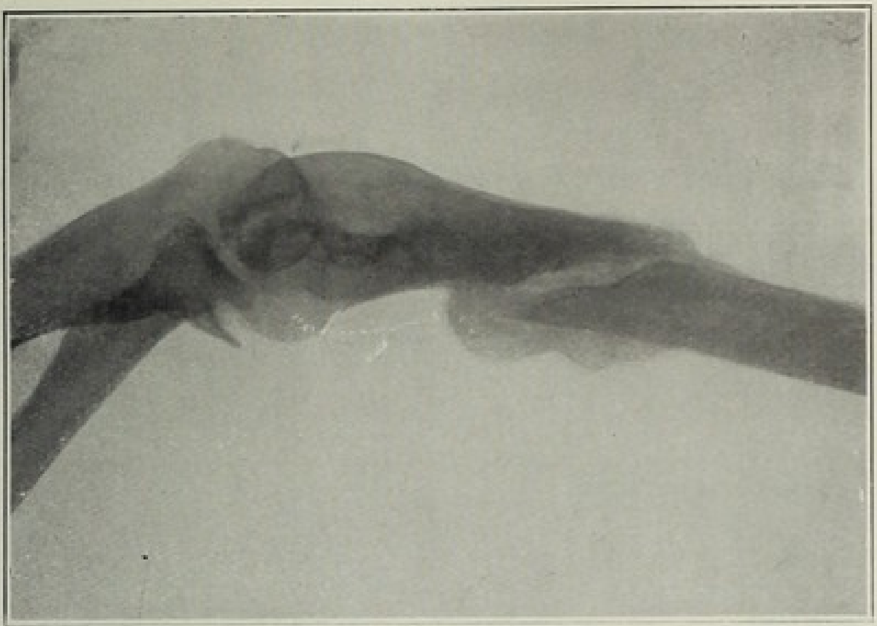

Fig. 5. *Fracture of shaft of humerus four months old. Note the amount of callus. Union was incomplete, the patient being syphilitic.*

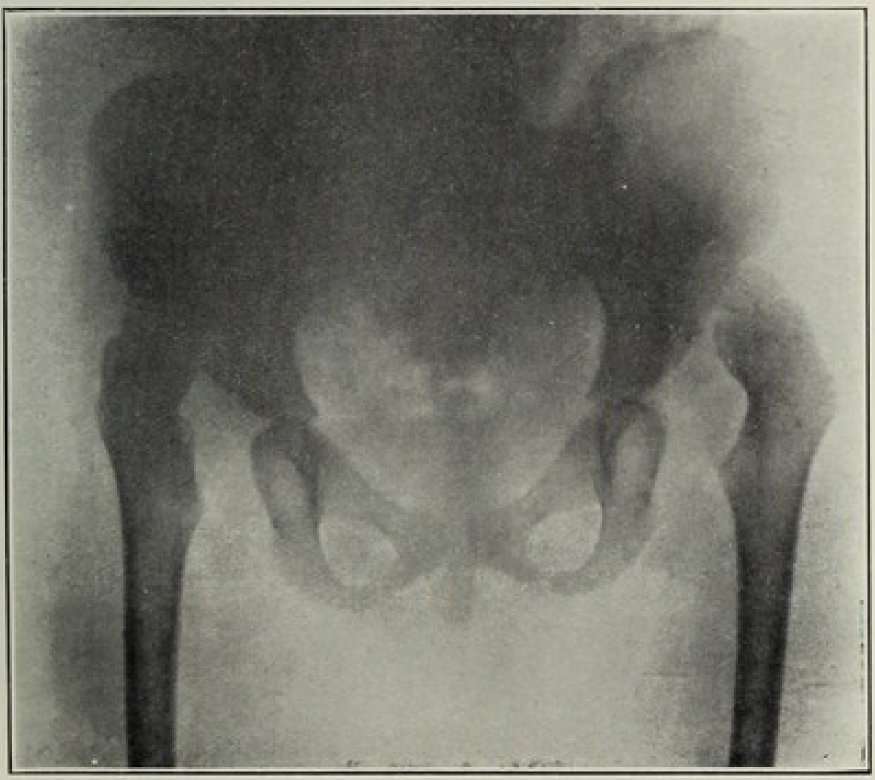

Fig. 6. *Congenital dislocation of both hips.*

Plate XXX.

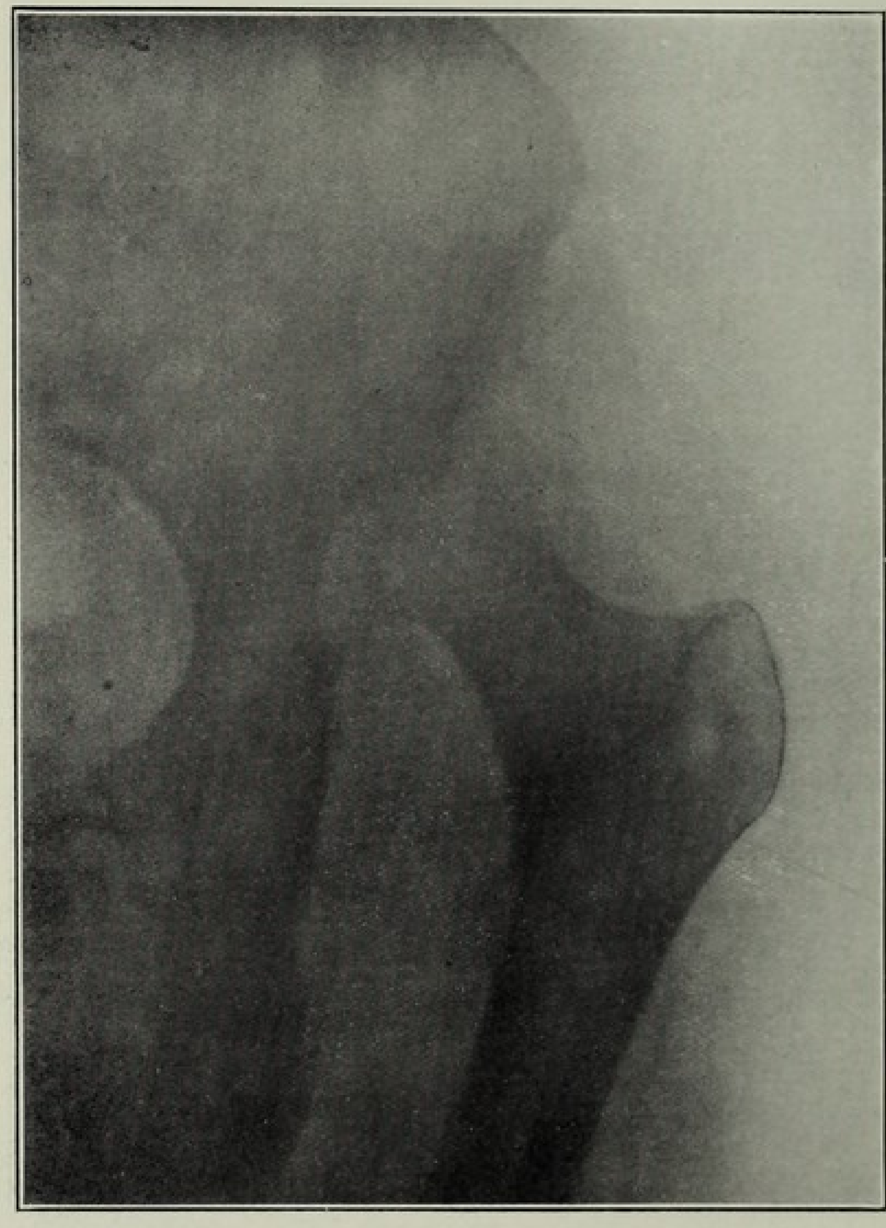

Fig. 7. *Traumatic dislocation of the hip (see text).*

normal joint, a clear space will be seen between humerus and ulna and radius, and a very slight space between radius and ulna. It will be noticed that the lines of the anterior borders of the shadows of radius and humerus would meet, if produced, either at, or just behind, the centre of the concentric circles. In a fracture of the lower end of the humerus, the line of the humerus lies in front of the centre, while the position of the radial line is unchanged. In dislocation of both radius and ulna, the radial line lies forward, while the humeral is normal. These points will be found very useful when examining a doubtful case. Both of the supracondylar ridges of the humerus will show on a negative taken in any position; I have seen one of them mistaken for fracture. The appearance of the edges of the coronoid fossa seen through the olecranon is sometimes confusing, and must not be mistaken for fracture.

Wrist.—In examining this joint, we can obtain both antero-posterior and lateral views without difficulty. When using the screen, it is not easy to make out an impacted fracture of the lower end of the radius, but comparison with the opposite side, which can be so easily effected with this joint, will usually clear up the diagnosis. In reading a negative taken in the antero-posterior direction, a line joining the tips of the styloid processes of radius and ulna is often useful. In the normal wrist, this should not cross the perpendicular line of the forearm at right angles, but, in cases of fracture of the radius, it frequently does so. The X-rays have shown that fracture of the ulnar styloid process occurs in Colles's fracture more commonly than was supposed. Out of several hundreds of cases examined it was found in over 60 per cent.

Carpus.—Since the introduction of Radiography, it appears that fractures and dislocations in the carpus, instead of being rarities, are really quite common. Where a diagnosis used to be made of "sprained wrist," it is frequently found that there is some bony lesion in the carpus. Fracture of the scaphoid is the most common injury. Destot has discovered 64 of these fractures in a little less than nine years. Sometimes fracture of the scaphoid is simulated by a subluxation. The diagnosis in such cases is really of great importance, especially from a medico-legal point of view; it may, of course, considerably influence the prognosis, though it does not usually affect the treatment. Destot recommends radical measures, sometimes going so far as resection of the wrist. The normal appearance of the carpus on the screen, or negative, is somewhat confusing, as the bones do not lie in the exact positions pictured in anatomy text-books. It is fortunate that one can so easily place the suspected limb side by side with the normal one for comparison.

Metacarpals and Phalanges.—Although these bones show up so well on the screen, it is unwise to negative the presence of a fracture without the help of a radiogram. A lateral view is usually confusing, as the superimposition of several bones is difficult to avoid.

Hip.—This joint is the one above all others in which X-ray examination proves of so great value. Information can be obtained as to the condition of the head of the femur and the acetabulum, which could not be obtained in any other way. A good example of this is seen in Fig. 7. This represents the left hip of a girl of 20, sent to me by Mr. Carless for diagnosis *re* coxa vara or dislocation. The negative shows undoubted dislocation, but the interest of the case lies in the condition of the bones. It will be seen that the head of the femur appears rounded and normal, and the acetabulum is clean cut and not filled by any calcareous matter. Unfortunately X-ray negatives do not reproduce well, so the outlines are not as clear as I should like.

Now in congenital dislocation of the hip, the head of the femur is never normal, and the acetabulum is also malformed. This will be seen on reference to Fig. 6, which represents a little boy with congenital dislocation of both hips. The diagnosis then pointed to a traumatic origin, and a history was forthcoming of an accident at 18 months.

Such evidence naturally alters the prognosis and treatment, and the question of operation is being considered. The hip cannot be radiographed laterally, but may be taken with the plate either in front or behind. In the latter instance, although we can usually get the bone nearer to the plate, the neck of the femur is foreshortened, making it very difficult to diagnose an intracapsular fracture. With stout persons, one can get nearer to the bone by radiographing with the plate in front, and a negative, taken in this position, gives more trustworthy

PLATE XXXI.

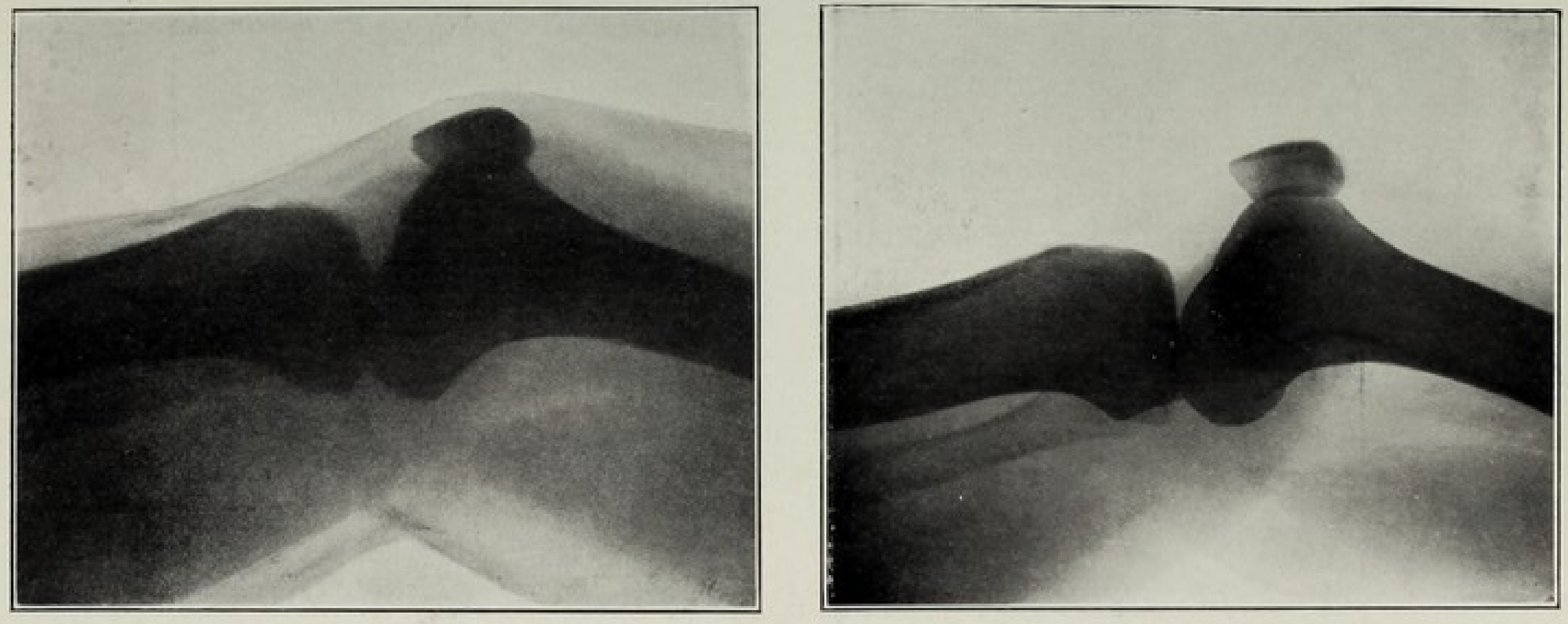

Fig. 8. *Splinter of bone separated from the patella. Simulating osteo-arthritis of knee joint.*

PLATE XXXII.

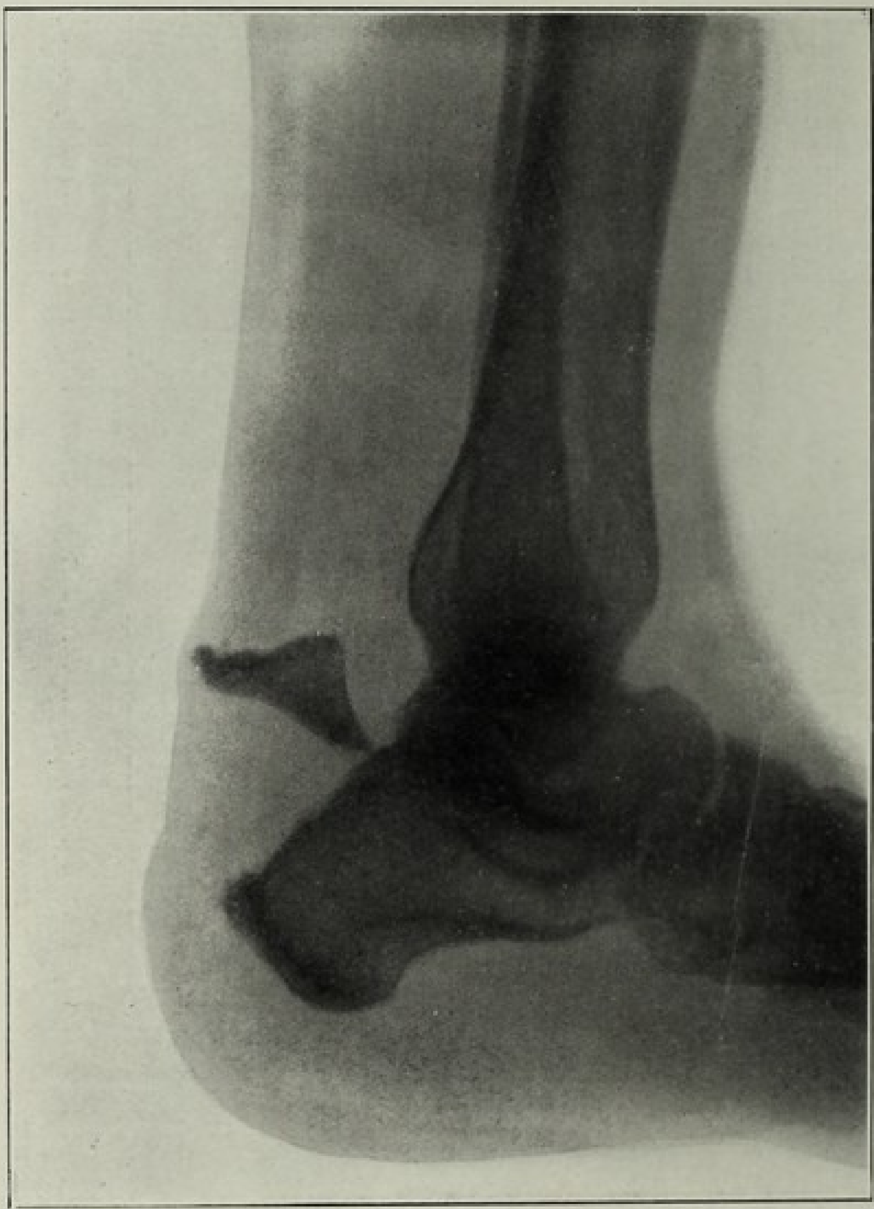

Fig. 9. *An unusual fracture of the os calcis.*

information. If possible the femur should be somewhat rotated by placing the patient's toes together and separating the heels, but this of course cannot always be done. It is of the greatest value to radiograph both hips on the same plate, the tube being placed in the mid-line. With children this can easily be done, but adults would need so large and unwieldy a plate that it is better to use two negatives, side by side, exposing both at the same time.

Fractures about the head and neck of the femur are very difficult to diagnose accurately from a single negative. With intracapsular fractures especially, it is necessary to obtain a stereoscopic view. A surgeon, who had not binocular vision, once insisted that a certain injury was fracture of the neck of the femur, while all, who could see the negatives stereoscopically, agreed that it was an oblique fracture of the shaft, through the great trochanter.

With dislocations, it may be difficult to estimate the exact position of the bone. When examining with X-rays it will be seen that, in all positions of the normal joint, there is an unbroken arch made up of the top of the obturator foramen and the inner side of the neck of the femur. This line is broken where dislocation is present.

Knee.—This joint is easy to examine with X-rays, and both antero-posterior and lateral views are possible. In the antero-posterior position we see the patella superimposed on the femur. The lateral view is the more useful; with a good negative the patella shows a somewhat faint outline, and the quadriceps extensor tendon can usually be clearly seen, as can the ligamentum patellæ, occasionally a faint shadow is visible representing the popliteal artery. The semilunar fibro-cartilages are fairly transparent to the rays, but usually a displaced cartilage can be made out. Sesamoid bones are sometimes found in the tendons at the back of the joint.

Fig. 8 represents stereoscopic pictures (which should of course be examined in a stereoscope) of the knee of a lady, sent to me by Mr. Godlee, with a history of three accidents and symptoms of osteo-arthritis. The negatives show a splinter of bone separated from the patella, and which could only be diagnosed by X-rays. The piece of bone was removed and the patient has a sound knee.

Ankle.—A lateral view of this joint is the easiest of interpretation, though the antero-posterior gives the better information. Since the direction of fractures in this situation is almost invariably downwards and forwards, in a lateral view, a sharp bony prominence, pointing upwards and backwards, represents the upper end of the lower fragment.

Tarsus.—The os calcis is best seen laterally; as the posterior portion joins up very late, its separate position is liable to be mistaken for fracture. Fractures of the os calcis are usually without much displacement, but a curious form is shown in Fig. 9, where the lower part of the attachment of the tendo achillis is torn away and the bony fragment pulled upwards.

X-rays show fractures of the astragalus to be fairly common, but a condition, frequently diagnosed as fracture, is the presence of the os trigonum tarsi. The mid-tarsal joint is rather difficult to radiograph, but a good negative may be obtained by placing the sole of the foot upon the plate and drawing the leg backwards and inwards.

Fractures and dislocations of the metatarsal and phalanges may be compared with the hand. The sesamoid bone to the outer side of the first metatarsal sometimes casts a very curious shadow, which, unless one is on the look out for it, closely resembles a fracture of the head of the bone. Dislocation with osteo-arthritis of this joint is commonly found in cases of hallux valgus.

A radiogram then, when properly taken and interpreted, is of the greatest service in the diagnosis of obscure fractures and dislocations; and, although new methods have not resulted from the use of the rays, yet the treatment is largely influenced by the conditions found. Question as to the advisability of wiring, screwing, or removal of fragments can be settled without delay, and valuable assistance given in forming a prognosis. Though I have somewhat discredited the use of the fluorescent screen in diagnosing a case, its help, during the setting of the limb, is very great, and there is no doubt that fractures are now put up in better positions, and consequently heal more quickly, and give the patient a much more useful limb.

The public are now beginning to wake up to the fact

PLATE XXXIII.

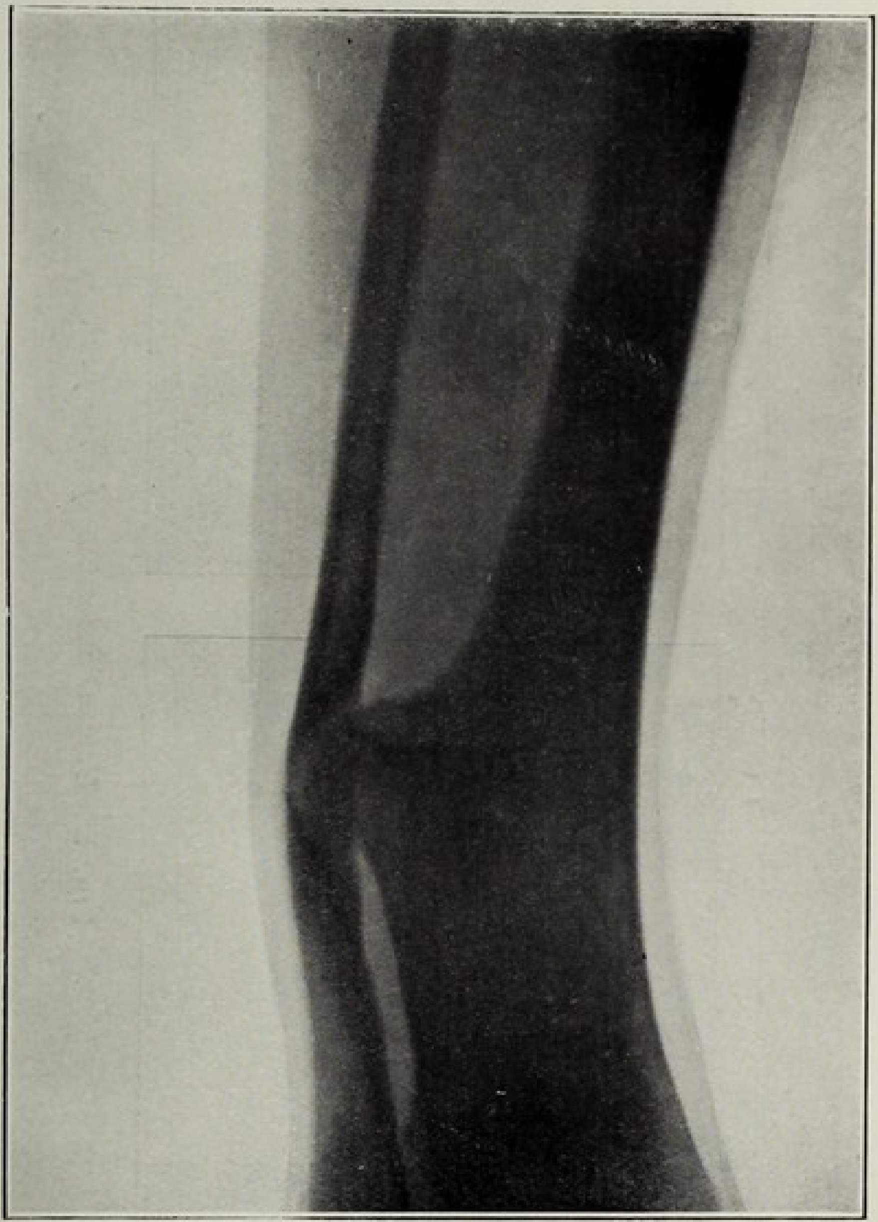

Fig. 10. *Exostosis of the tibia causing pressure absorption of the fibula. This case was diagnosed clinically as fracture of the fibula.*

PLATE XXXIV.

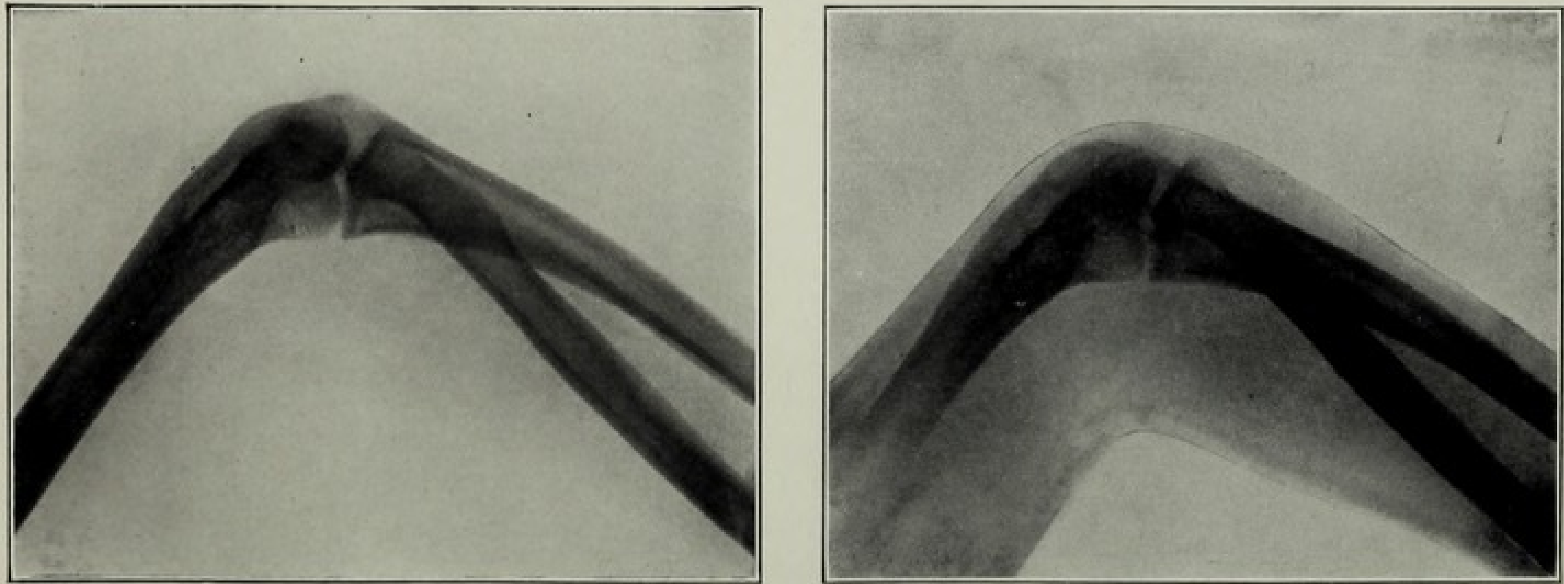

Fig. 11. *Unusual dislocation of elbow joint.*

that Radiography is an integral part of surgical science, and medical men, who have neglected the use of X-rays in seeing that their fractures were put up in good positions, have several times during the past year been mulcted in heavy damages. Radiograms are now continually put in as evidence in actions for damages for injury, and carry great weight with the jury. Although the treatment may not be influenced, it may sometimes be to the advantage of the medical man to diagnose a fissure; an instance of which is the fact that a poor-law medical officer is remunerated on a higher scale when attending a fracture than he is in the case of a sprain.

In hospitals and infirmaries there is certainly a tendency on the part of the house-surgeon to at once send a suspected fracture "for X-rays," without a preliminary clinical examination. Although this avoids discomfort to the patient, it robs the house-surgeon of a very important part of his surgical training, which he may have cause to regret, if, at some future date, he is stranded with a patient in some part of the country where access to X-ray apparatus is out of the question.

In conclusion, a few hints to the surgeon who does not possess the apparatus, but wishes to send his case for examination. Do not use dressings that are opaque to the rays; such, for instance, as any preparation of iodoform, or a quantity of strapping. Do not use metal splints, and see that nails, screws, etc., (if any) in your wooden splints do not come just opposite to the injury. See that the splint is adjusted as far as possible to allow the negative to come close up to the part, and to allow of a clear "view" for the tube on the other side of the limb. The elbow should not be bandaged close up to and in front of the chest when a patient is sent up for examination. These few points, coupled with careful examination of the negatives by an observer skilled in their interpretation, will invariably lead to an accurate diagnosis of the case.

ON TWENTY CASES OF DISJUNCTION OF THE LOWER EPIPHYSIS OF THE RADIUS.

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[With Plates XXXV.—XL.]

THE present brief article is based on 20 cases of disjunction at the lower end of the radius. Last year I published a short account[1] of eleven of them, and since then I have had nine additional cases under my care. Taking all these cases together, they might be analysed as follows:—

Age.—The youngest was 7 years, and the oldest 19. The exact ages were:—One at 7 years, one at 8 years, three at 9 years, two at 10 years, five at 14 years, two at 15 years, two at 16 years, one at 17 years, one at 18 years, and two at 19 years.

Sex.—All occurred in male subjects. This preponderance in males is referred to by Poland.[2] He collected a series of 89 cases in which the sex was mentioned. Of these, 79 occurred in boys.

Side affected.—In my earlier series I did not note the side. One case, a boy aged 10 years, had disjunction of the radial epiphyses of both sides. Of the 9 recent cases, 6 were on the left, two on the right, and one was bilateral.

Implication of Ulna.—In my first series, skiagraphs were taken in five, and, in one of these, the ulnar styloid was seen to be fractured. In the later series, skiagraphs were taken in eight, and the ulnar styloid was seen to be broken off in no less than five. In the bilateral case, the ulnar styloid was fractured on both sides, and the ulnar epiphysis (in addition to the radial) was disjoined on the left (*see* Fig. 1). This epiphysis, in addition to having its styloid process fractured, was displaced outwards and turned edgeways so as to be incarcerated between the radius and ulna. The ulnar styloid apparently remained attached to the internal lateral ligament,

[1] *Colles's Fracture and other Fractures and Disjunctions at the Lower End of the Radius and Ulna*, p. 38.

[2] *Traumatic Sep. of Epiphyses*, p. 481.

PLATE XXXV.

Fig. 1. *Disjunction of radial and ulnar epiphyses. Note position of displaced ulnar epiphysis. A portion of diaphysis is torn off with radial epiphysis.*

PLATE XXXVI.

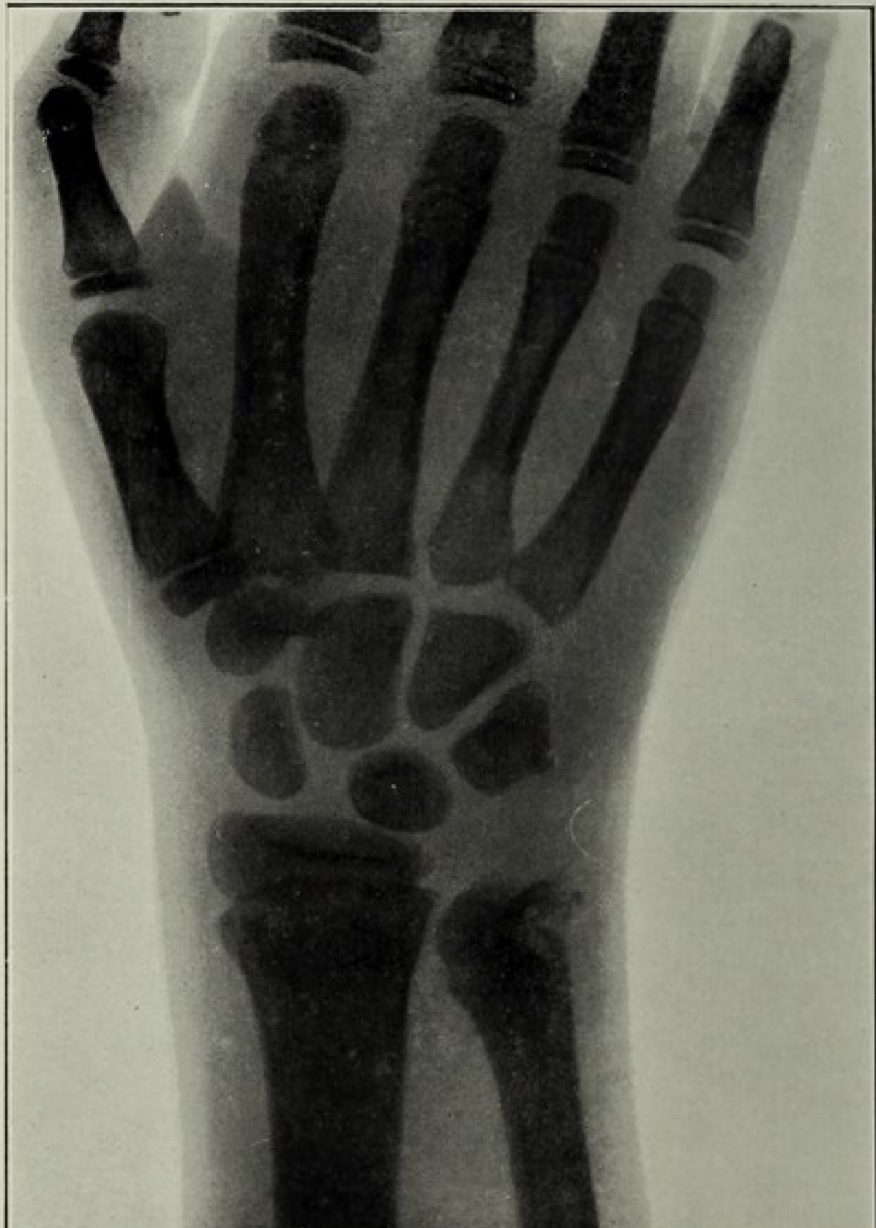

Fig. 2. *Case of disjunction of radial and ulnar epiphyses after treatment.*

Plate XXXVII.

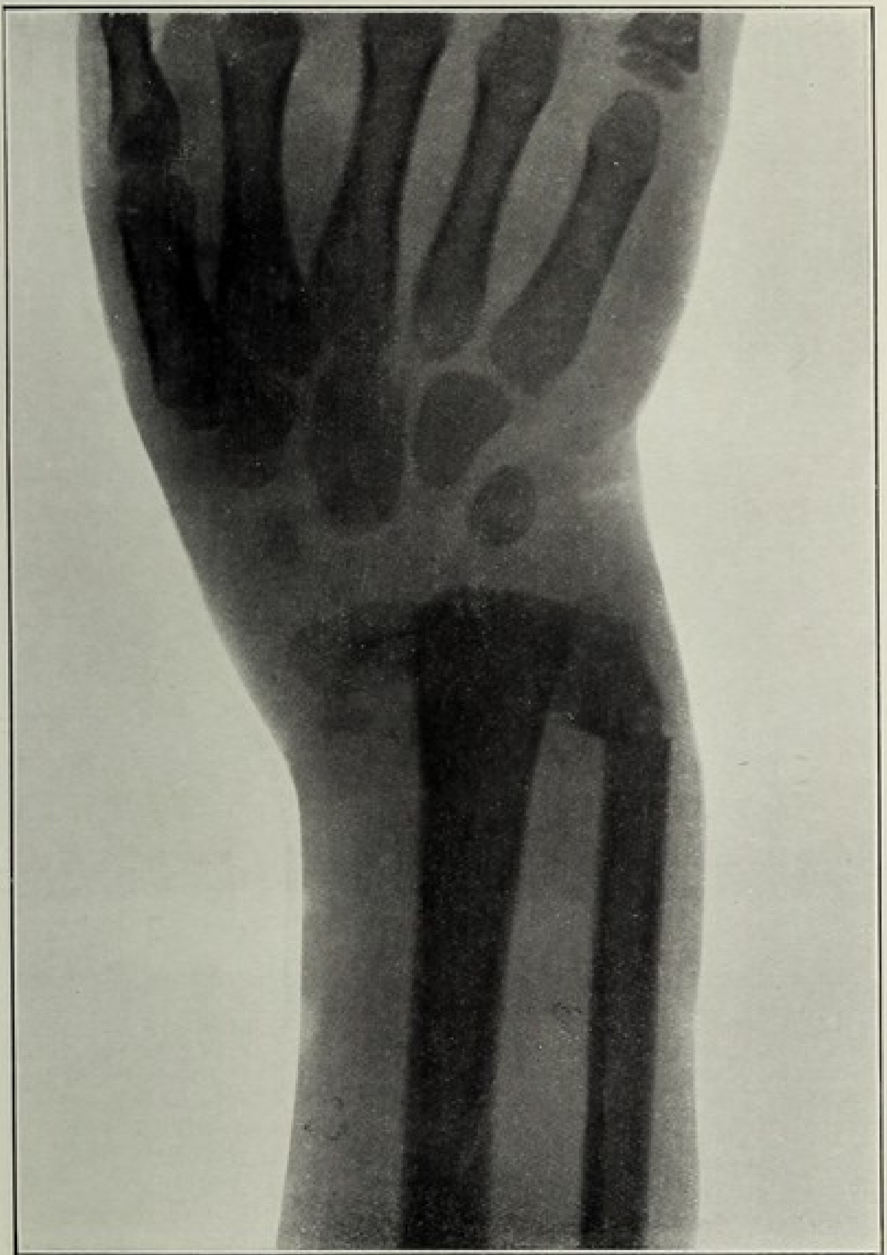

Fig. 3. *Note fracture of ulna in addition to disjunction of radial epiphysis. Much outward displacement. A portion of diaphysis is torn off with radial epiphysis.*

PLATE XXXVIII.

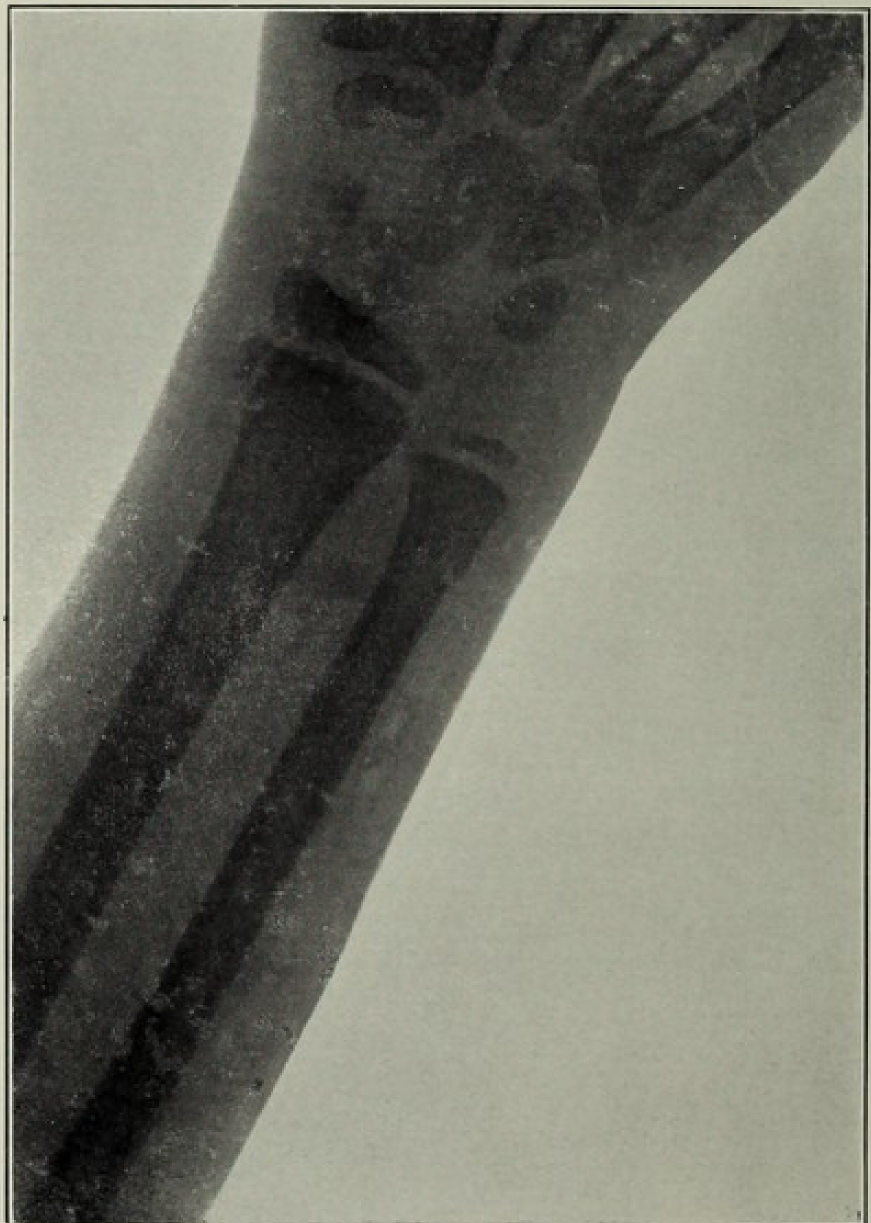

Fig. 4. *Same case as Fig. 3 after treatment. Note fracture of lower and outer part of radial diaphysis.*

PLATE XXXIX.

Fig. 5. *Disjunction of lower epiphysis of radius with dorsal displacement and rotation on transverse axis.*

PLATE XL.

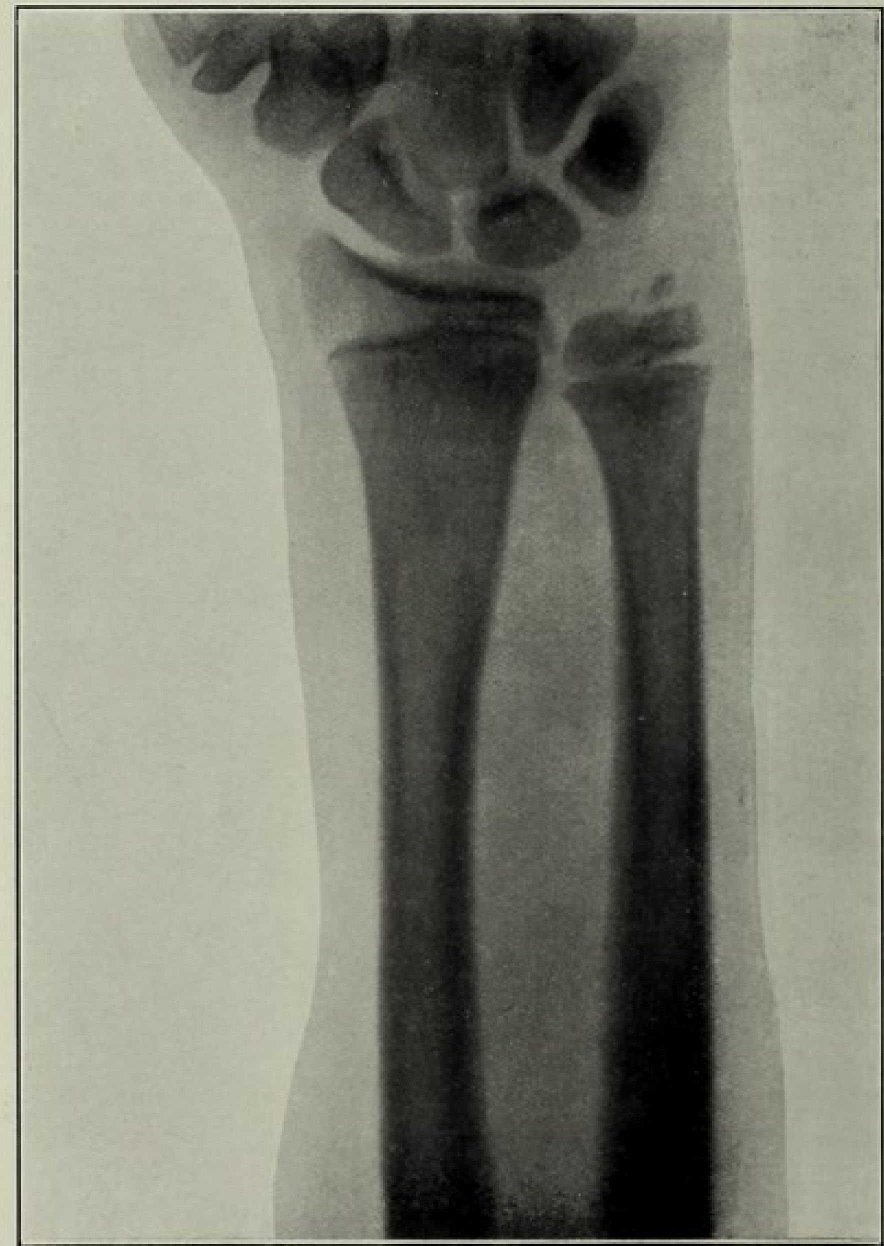

Fig. 6. *Same case as* Fig. 5, *showing absence of outward displacement. Note fracture of ulnar styloid process.*

and did not follow the rest of the epiphysis. As stated in the account of my earlier cases, I am of opinion that the ulnar epiphysis suffers more frequently than would appear from the accounts usually given of the injury under consideration. This is evident from the swelling of the epiphyses of both radius and ulna, which, in a considerable proportion of cases, follows in a few days.

Involvement of the Diaphysis.—By studying a considerable number of skiagraphs of these cases, it will be seen that the accident is not always a pure separation, but that a portion of the diaphysis is frequently torn off by the periosteum, which is stripped up from the bone (*see* Figs. 1, 3, and 4). This is due to the fact that the periosteum is closely and firmly adherent to the epiphysis, and follows it in any displacement.

Displacement.—Dorsal displacement is, as might be expected, the most frequent deformity. In one of my cases, that of a boy aged 14 years, there was forward displacement, a very rare form. It occurred on the right side. The ulnar styloid was not fractured. In some of the cases, a slight amount of radial displacement occurred, and in two, Figs. 1 and 3, this was marked. In these two cases there was also dorsal displacement, and the separation was complete in Fig. 3. In one case there was slight *inward* displacement of both radial and ulnar epiphyses of one side as well as backward displacement. In the description of the former series of cases, I quoted Poland as follows: "There is no rotation or tilting of the epiphysis on its transverse axis." I cannot, with further experience, fully endorse this statement, as I have recently seen several cases in which rotation, quite as marked as occurs in Colles's fracture, was present (*see* Fig. 5). In fact it is often impossible to distinguish between these two conditions, especially when a shred is torn from the diaphysis, giving rise to coarse crepitus in disjunctions.

Deformity.—The deformity depends of course on the displacement, and resembles very closely, in the large majority of cases, that of Colles's fracture. In the most usual or dorsal form, there is a well-marked prominence on the back of the forearm just above the wrist, and the hand appears lengthened. The projection of the diaphysis in front is more marked than in Colles's fracture, owing to the sharp projecting lower end of the bone (*see* Fig. 5), and there is greater liability of the accident becoming compound.

Radial displacement of the hand is present in some cases, and was well marked in the case from which Fig. 3 was taken. It is absent in Fig. 6, but present to a moderate extent in Fig. 1. In the case represented in Fig. 3, the limb had a marked sigmoid shape, and the lower end of the ulna projected beneath the skin internally and in front.

Causation.—In nearly all my cases, the patient fell from a considerable height and put out the hands to save himself. The boy, from which Fig. 1 was taken, fell 12 or 14 feet from a bank. The boy of Fig. 3 fell downstairs. Fig. 5 boy fell off a staging. The boy with forward displacement fell with his hand flexed and "doubled in under him." It would appear, therefore, that considerable violence is necessary to produce this accident.

Treatment.—Owing to recent accounts of fatalities with ethyl chloride, the anæsthetic which I previously used, I have lately tried reduction without an anæsthetic. The deformity can be reduced in a few seconds by strong thumb pressure over the projection with the hand strongly flexed. In the case represented in Fig. 1 I had to resort to anæsthesia, after an abortive attempt without. I was able finally to get perfect reduction (*see* Fig. 2). The ulnar epiphysis slipped into position while I was manipulating the more obvious deformity produced by the displaced radial epiphysis.

Results.—It is too early to speak of the ultimate results in many of the cases mentioned in this article, but I feel certain that most, if not all of them, will have normal growth of the limb. It is rare to see deformity due to arrest of growth from this accident. None of these 20 cases have, as yet, reported themselves as having any abnormality in the development of the injured limb.

FRACTURES AND DISLOCATIONS OF THE CARPAL BONES.

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Late Resident House Surgeon at Aberdeen Royal Infirmary, and Junior and Senior Resident, Oldham Infirmary.

[With Plates XLI.—XLIX.]

I.—FRACTURES.

Probably nowhere is accurate skiagraphy, or, what is of more importance still, accurate reading of skiagrams of more importance than in connection with injuries around the wrist joint. The term "sprained wrist" is one we meet with daily, and has for a long time been used to cover a multitude of unrecognised and inaccurately diagnosed injuries, with not the uncommon result that the joint has become permanently impaired, as I have often seen it stiff and ankylosed, and, in many cases, useless.

The text books almost unanimously agree in describing both fracture and dislocation of any of the carpal bones as matters of the extremest rarity. Hamilton says that all the cases of fracture of the carpal bones he ever met with were either compound, or so complicated as to result, either in the loss of the hand, or in rendering it absolutely useless; and accordingly he thinks it proper to assume that simple fracture of these bones cannot occur, or, he says, supposing that they do occur, they will demand very little surgical interference, and it is possible that they may unite without any bad results and without much displacement. Such views I consider fatal in the extreme, and, since the introduction of X-rays, I think that anyone, who has had but a moderate "accident experience," and has followed up any of the so-called cases of "sprained wrist," which have refused to yield to ordinary treatment, will admit that fractures and dislocations of the carpal bones are common, in fact more common than one is at first inclined to believe. Accordingly, when we find the history of a recent injury, followed by extreme pain on any attempt at movement, and the pain referred to one particular spot in the carpus, it may be with very little obvious deformity; or when we find, a thing more common still, the history of an old injury followed by permanent more or less complete impairment of function of the wrist, with still probably very little loss of normal outline, there exists, in almost all these cases, either fracture, or dislocation, more or less complete, of one or more of the carpal bones.

My attention was first drawn to this by a paper by Drs. Haughton and Holt, in the *R.A.M.C. Journal* for September, 1904, in which they described several cases, giving skiagrams, as well as a detailed account of how to skiagraph such cases to the best advantage. Their method is as follows:—They take a print of both wrists on the same plate in the following positions:—

(i) Both prone—palms to the plate.
(ii) Both fully supinated—dorsum to the plate.
(iii) Both semi-prone—palms together and ulnar border to the plate.
(iv) Both fully pronated—backs together, radial border to the plate.

Now in difficult cases this may be necessary, and especially in legal cases this ought to be done, but for ordinary everyday practice I have found that one carefully taken skiagram, palm to the plate, is all that is required.

Injury to the carpal bones in males predominates over that in females, in the proportion of ten to one, while cases of injury to the right wrist exceed those to the left by a much smaller margin. And again the time of life, during which this injury most frequently occurs, is estimated at between 25 and 35 years of age.

The violence, necessary to produce these injuries, is not necessarily extreme, and may vary in nature, some of the commonest causes are:—

(*a*) Falls on the hand, or extended wrist.
(*b*) Direct violence, *i.e.*, blow.
(*c*) Blow on the knuckles.
(*d*) Forcible hyper-extension of the wrist joint.
(*e*) Severe squeezing together of the bones, *i.e.*, Holt's case, in which a strap, encircling the wrist, squeezed it.
(*f*) Hyper-adduction.

Carpal injuries, however, may occur combined with injuries to the other bones, such as fracture-dislocation of the wrist; fractures of the radial or ulnar styloid; Colles's fracture; fracture of the metacarpals, especially that of the thumb; or with fracture of either bone of the forearm, especially the radius.

No carpal bone is exempt from injury, although there is a great variation in frequency. Codman and Chase give the following order of relative frequency:—Scaphoid, semilunar, pisiform, os magnum, trapezium, trapezoid, unciform, and cuneiform.

Diagnosis.—As late as 1890, Ricard makes the following statement:—"Clinically, one may say, simple fractures of the carpus do not exist, the only sign that has any value whatever, and permits of affirmation of fracture, is crepitus."

Carl Beck, in his *Treatise on Fractures*, 1900, states that abnormal mobility and crepitus are absent, while pain and functional disturbance are the main things to be looked for.

Stimson, in 1900, hinged his diagnosis of simple fracture of any of the bones of the carpus on the presence of crepitus, while most other writers refer to tenderness as a means of localisation.

Ecchymosis is only mentioned when the injury is accompanied by severe general crushing of the hand. Painful motion and loss of function are looked on as existing conditions, and not as a means of diagnostic localisation. Tumour has been a common observation, accurately localised, but frequently misinterpreted.

Before the use of X-rays, the diagnosis of carpal fractures was based upon crepitus, and tumour in case a bone or fragment was displaced. In the absence of these signs, "sprains" and fractures of the lower end of the radius were frequent errors. Blau states that, in the absence of crepitus and tumour in no recorded case previous to the use of X-rays, does he believe that a correct diagnosis has been made of a simple fracture of a carpal bone. Hofliger, 1901, wrote, "in fresh injuries palpation, if carefully done, usually succeeds in establishing a diagnosis relying on the feeling of crepitus."

These bones are not exposed to extreme degrees of displacement, but the effect, on the functional power of the hand, of even a slight displacement is not to be under-estimated. Trifling changes of relation between the bones of the carpus have an influence on the position of the metacarpal bones, and are manifested also in certain limitations in the movements of the fingers. There may exist also slight subluxation of the radio-carpal joint. Occasionally, the metacarpal bones are involved in the fracture to the extent of their being notched at their basis, as seen in one of the cases recorded below. They may also be displaced forwards, or backwards, and, in rare cases, may be rotated on their long axis, and displacement of a metacarpal thus arising, causes, temporarily, a certain awkwardness of movement, in the corresponding finger.

In the case of fracture of the bones of the carpus without displacement, functional power is only temporarily impaired, unless the injury is a severe one involving several bones, as when the wrist is crushed and mangled. In the latter case, we often find the wrist remaining permanently ankylosed. In a case of fracture of the trapezium, which I saw for another practitioner, the symptoms resolved themselves into restricted movement of the thumb and sensitiveness of the ball of the thumb to pressure, with slight swelling of the carpo-metacarpal joint, accompanied by a weak grasp and inability to hold anything for any length of time.

Compound fractures are very apt to be complicated by injuries to the nerves, and, if the hand should get septic, grave functional disability of the wrist is very apt to follow, and too often this is of a permanent nature.

Treatment.—Hamilton considered that simple fracture of the carpal bones required no treatment, and, if the fractures were compound, the treatment was directed to the wrist in general, and not to the injured carpal bone. In 1890, Ricard thought that there was little gravity in the way of complications of the synovial articulations and tendons, and accordingly suggested immobilisation for 15 days in splints, followed by massage. In 1900, Beck advised a palmar-wire splint for carpal injuries, massage after 10 days, and then active movement.

Stimson advocated immobilisation for two or three weeks, and, in compound cases, the removal of the bone. Scudder, in 1900, considered the possibility of scaphoid fracture being mistaken for rheumatism, or sprained wrist and the painful limitations of extension, and, accordingly, advocated the use of splints for one week, followed by massage. Friederich agrees with Beck in his treatment, while Blau immobilises the wrist for four weeks, and considers the course of recovery, following mechanical treatment, as by no means smooth, but frequently interrupted by exacerbations. Bardenheuer, in fresh cases, advised splints for eight days, followed by four days of light movement and eight days of massage and gymnastics. Hofliger doubles the time of fixation in splints, and considers that, when the fragments are in apposition, recovery always follows with union of the bones. In old cases he advises resection of the bones, which Holt advises even in recent cases. Kaufmann always removed the scaphoid, when that bone was fractured, and Pagenstecker also does the same.

From the cases I have had, I have come to the following conclusions:—

If the patient is seen immediately after the injury, I believe that, by fixation of the joint, for a proper period, *i.e.*, from seven to ten days, it is possible to obtain union between the fragments. If, however, the wrist is not fixed for the first three weeks, union does not so easily occur, and the treatment has to be more extended; then fixation for at least one month has to be resorted to, followed by massage for another month, and, if at the end of that time no encouraging improvement in function is seen, then resort to operation and removal of the fragments. Apart from the hopelessness of obtaining union in those cases, I find that excision of the bone is necessary to relieve the mechanical irritation, caused by the slipping of the fragments on one another, thus setting up chronic synovitis and secondary joint changes. Thus the joint, instead of improving with use and massage, tends to get worse rather than better. And again, if the fracture does not unite, the permanent disability is so great that it interferes, not only with the comfort of the patient, but, in the case of a working-man, with his wage-earning capacity.

Although all the bones of the carpus have been known to be fractured, the one most commonly injured is the scaphoid. Kaufmann, Hofliger, Pagenstecker, Stimson, Holt, Russ, and Ely have all recorded cases, while Codman and Chase published a compiled record of 18 cases.

As an example of my own cases, I have selected the following :—

Mary H., æt. 53, was set upon by a drunken brother and, amongst numerous bruises, she complained very much of pain at the wrist, and, when questioned, said that, in attempting to protect herself while he was kicking her, she put out her hand, and received a kick from a pointed clog in the palm of her hand. The radial portion of the dorsum of the hand was very much swollen, and there were pain and tenderness over the scaphoid bone, along with inability to move the wrist and the first two fingers, without a great deal of pain. I could not make out crepitus, but the pain was very much localised to a spot. I had the hand skiagraphed (*see* Fig. 1), and this showed fracture of the scaphoid bone, with almost no separation of the fragments, whilst the spot of greatest tenderness corresponded with the site of fracture.

I put the hand up on a palmar splint, with a thick pad of cotton wool over the dorsum, and fixed it thus for eight days, by which time all swelling and tenderness had gone; then I started hot baths and passive movement, following that on by active movement and massage, and, at the end of one month, the hand was as good and useful as ever.

The second case I record is that of fracture of the trapezoid, with comminution of the articular end of the second metacarpal. The accident happened thus :—H. R., æt. 31, an ironworker, was engaged in driving some bolts, when the head of one of them flew into pieces, one sharp piece catching him on the back of the hand, piercing the skin over the base of the second metacarpal bone, and going right down to the carpo-metacarpal joint without injuring any of the tendons. When I saw him the hand was very dirty, covered with blood, oil, and iron dust, and I spent about one hour thoroughly cleaning it, and I did not consider the time wasted. After thorough disinfection, I passed a probe into the wound, and could make out a comminuted fracture, but was unable to say of what, until I had examined the hand with the fluorescent screen. Then I discovered that the trapezoid, along with the articular end of the second metacarpal, had been fractured. A

Plate XLI.

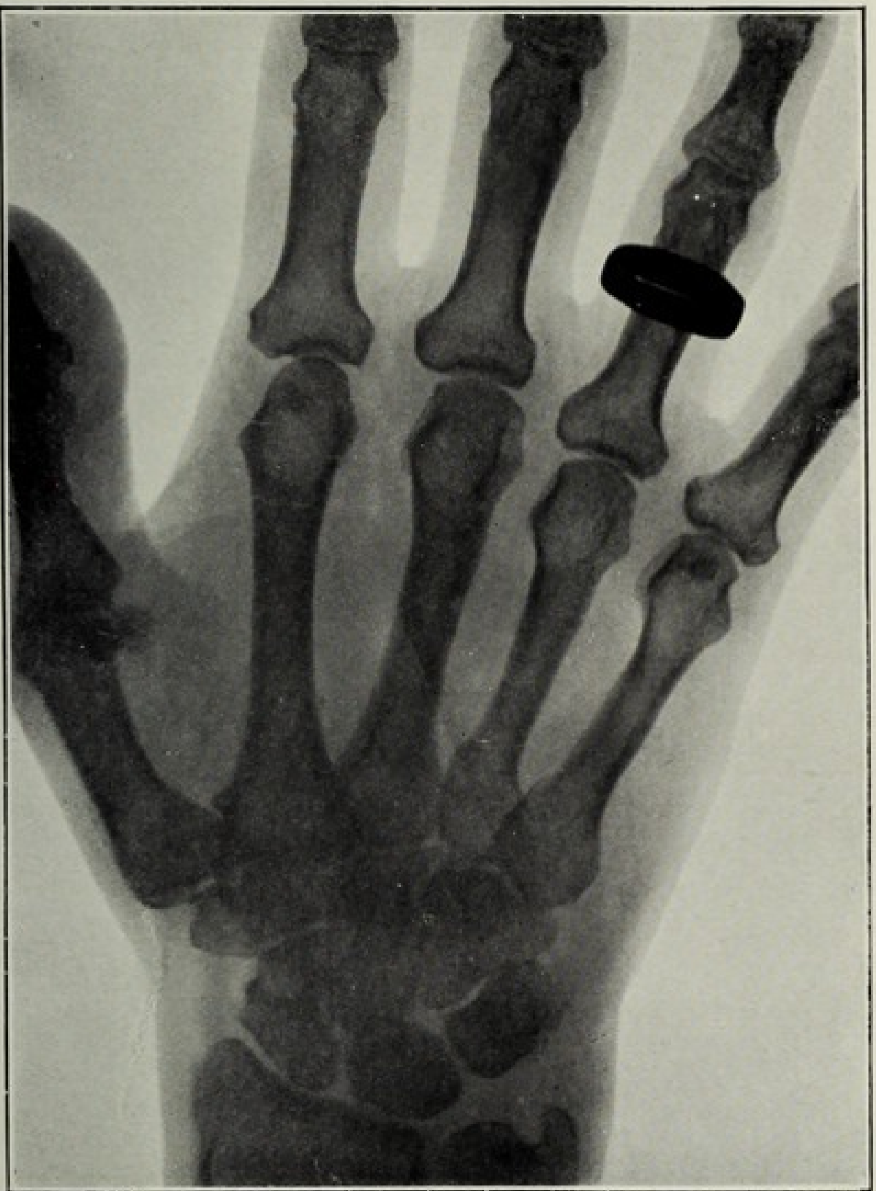

Fig. 1. *Fracture of scaphoid.*

PLATE XLII.

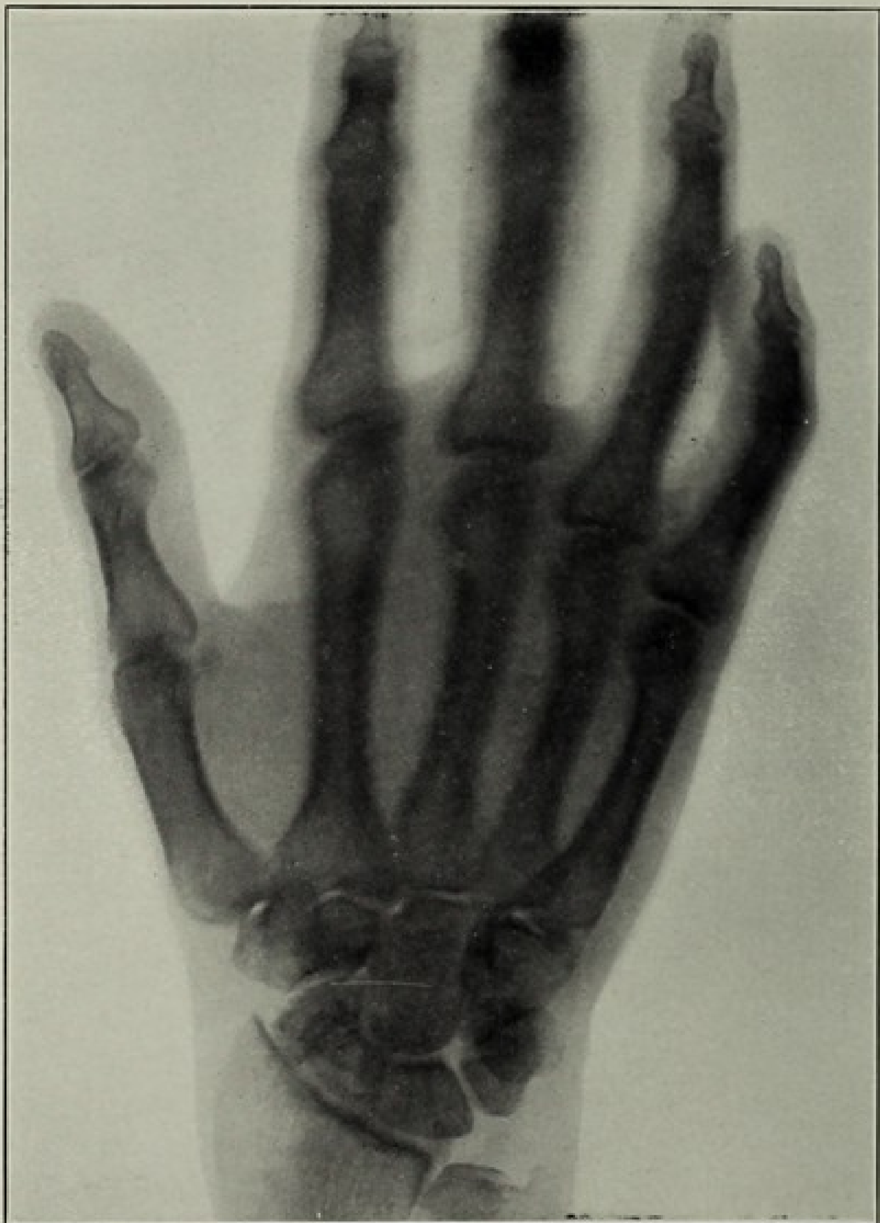

Fig. 2. *Another case of fractured scaphoid from direct violence, i.e., bolt striking the hand.*

skiagram was taken, and, after washing out the wound once more with hydrogen peroxide, I applied a sterile gauze dressing, and put the hand up on a handle splint, and, with a pad of wool over the dorsum, I bandaged the hand firmly in that position. The wound remained aseptic, and, on the thirteenth day, I discontinued the splint, starting massage and passive movement. Callus was thrown out fairly freely, but, at the end of six weeks, the man was back at his usual work with a perfectly useful hand. (*See* Figs. 2 and 3.)

II.—DISLOCATIONS.

Since the carpal bones are bound together on every side by strong ligaments, and enjoy only a very limited degree of motion amongst themselves, dislocation of any of them becomes less common than dislocation of bones like the radius, nevertheless such dislocations are more common than at first supposed.

Dislocation of a carpal bone may be the only lesion present, or it may occur with other lesions, such as fracture of the radius, or "sprain" of the wrist, and may be partial or complete, so that, in order to understand the mechanics of dislocation, it is necessary to go briefly into the motion of the wrist joint. It has been proved that the distal row of carpal bones is so firmly bound together in one block by the inter-osseous ligaments, that there is practically no motion between its individual components. The proximal, or intermediate, row is, however, quite movable, and the motions of extension and flexion of the wrist take place entirely in the two joints above and below the intermediate row. That is, in order to accomplish an arc of 180° from complete flexion to complete extension, each of these joints is movable through an arc of 90°.

Thus, if the wrist in complete flexion is looked at from the side, the axis of the semilunar bone would point at an angle of about 45° to the vertical axis of the radius, while the long axis of the os magnum, which is continuous with that of the middle metacarpal, stands with the axis of the semilunar at an angle of 45° ; thus the axis of the os magnum would stand at right angles to the vertical axis of the radius. The same is true in complete extension.

Now in complete extension, if the hand is still further forced backwards, there comes a point at which the pressure ruptures the ligaments attached to the posterior horn of the semilunar, so that the latter bone is squeezed forwards, and the articular surface of the os magnum slides behind the semilunar and approaches the articular surface of the radius. In the meantime, the semilunar, being still partially held to the radius by the ligaments attached to its anterior horn, rotates, so that the concave surface becomes directed forwards. In this position, it is obviously impossible for the normal arc of motion to be again secured, 90° of motion, the prerogative of the semilunar, being lost, while the os magnum, in its new position, can scarcely take up more than 50°—60° at most.

Partial dislocations are often caused by the violent contact between the bones, incident to a fall on the hand, or by traction in endeavouring to free the hand when it is caught and held fast. The ligaments connecting the carpal bones are more or less torn at the time of the injury, consequently they become lax, and allow the carpal bones to become displaced.

The bones are more likely to get displaced backwards, since the anterior ligaments are much stronger than the posterior, and also because the arch, formed by the bones, has its convexity backwards.

Hamilton says that the pisiform is the only bone not displaced backwards, but I find that Tilton records a case of the semilunar forwards, while Hessert, Dubar, Richon, Stimson, Quervian and Oberst record cases of anterior dislocation of both scaphoid and semilunar, and Gamgee, Auban, Delbert, Urban, Potel, Berger, Folet, Ely, Hofliger, and Sulzberger all record cases of anterior dislocation of the semilunar.

Gulebiewski also records dislocation of the trapezium forwards.

Diagnosis.—As in the case of fracture of the carpal bones, the patient is usually a male, and the age when dislocation is most common is 25—45. There has been a severe injury to the wrist joint of more violent character than causes fracture, usually a violent twisting or wrenching motion, as well as hyperextension. Immediate and excessive pain and tenderness, with ecchymosis, follow, and many times I have found Colles's fracture diagnosed, although "severe sprain" is the more common term applied, and until lately the diagnosis of dislocation of a carpal bone was not thought of, but, with the aid of X-rays, that point is soon cleared up. When seen some weeks after the injury, the patient is found to have limited use of his hand, varying according to the bone dislocated. The usual thing is to find the wrist stiff, and, the fingers held in semiflexion, incapable of either complete flexion or extension. If passive movement is attempted, pain is severe, while, in many cases, the dislocated bone can be felt as a small rounded mass on the back of the hand, but, if the dislocation is anterior, the tumour is not so distinctly felt. If there is a tumour, pressure over it causes a great deal of pain both locally and referred up the nerves. A glance at both hands, placed side by side, is sufficient to show marked asymmetry, the injured hand looking smaller and shorter, but, as I said before, it is to the X-rays that we turn for an ultimate diagnosis.

In reviewing the recorded cases, and searching for the cause why they were all in men mostly between the ages of 25 and 45, the only conclusion I could come to was that individuals of these ages are more apt to take part in amusements, or occupations, which require severe strain, and which are apt to lead to such injuries. It is also possibly the reason why the lesion is less common below the age of 20, that, at this period of growth, the injury is so great as to lead to fracture of the long bones in the region of the epiphysis rather than to dislocation of the carpals, although such also may occur.

Treatment.—In 1904, Scudder, after recounting mistaken diagnosis, the use of X-rays, and the possibility of the presence of a bipartite scaphoid, says, that, for recent cases of dislocation, the only rational treatment is immediate reduction under an anæsthetic, immobilisation, and passive movement at the end of two weeks.

Sulzberger outlines his treatment as follows:—Manipulation and reduction, splints eight to ten days, massage, followed by exercise. He states that the symptoms of fresh dislocation are clear; where results are unsatisfactory, he considers it due to delay in reduction, considering that reduction should always succeed in fresh cases of carpal dislocation, performed either with or without an incision, and in these cases the functional results are always favourable.

Hofliger, writing on the semilunar, says that the anterior dislocation is the most frequent, and that reduction is not successful, but when successful reduction is accomplished soon after the injury, according to Taaffe, the results are good. In old cases, or those in which reduction is impossible, he argues with Holt that excision is the best treatment.

Friedreich states that, for all the above dislocations, reduction should be attempted by maximal extension for the forward variety, extreme flexion for the backward variety, accompanied by pressure over the dislocated bone and gradual return of the wrist to its normal position.

In the cases I am now about to record, I will detail the treatment adopted in each case, and I never found it necessary to resort to excision, although the treatment had to be varied according to circumstances.

Os magnum.—Dislocation, partial or complete, of the os magnum is most common, seeing that it is the most movable bone, as its head allows most of the movement between the first and second row of carpal bones. The head of the os magnum moves about a transverse axis in flexion and extension of the hand, and about a sagittal axis in adduction and abduction. Like the astragalus of the foot, the bone forms the keystone of the carpal arch, and dislocation is nearly always backwards and incomplete, while dislocation forwards is prevented by its firm ligamentous connection with the neighbouring bones, *i.e.*, the unciform, the trapezoid, and the third metacarpal.

As early as 1805, Richerand, in his edition of Boyer's *Lectures on Diseases of Bone,* described a subluxation backwards of the os magnum in a patient, who, during the pains of labour, seized the mattress and squeezed it. It showed as a circumscribed tumour on the back of the hand, and disappeared on extending the hand and making firm pressure over the tumour. He did not try any treatment, and the result is not recorded. Brasby Cooper mentions that he saw in a young, strong, muscular man the os magnum

PLATE XLIII.

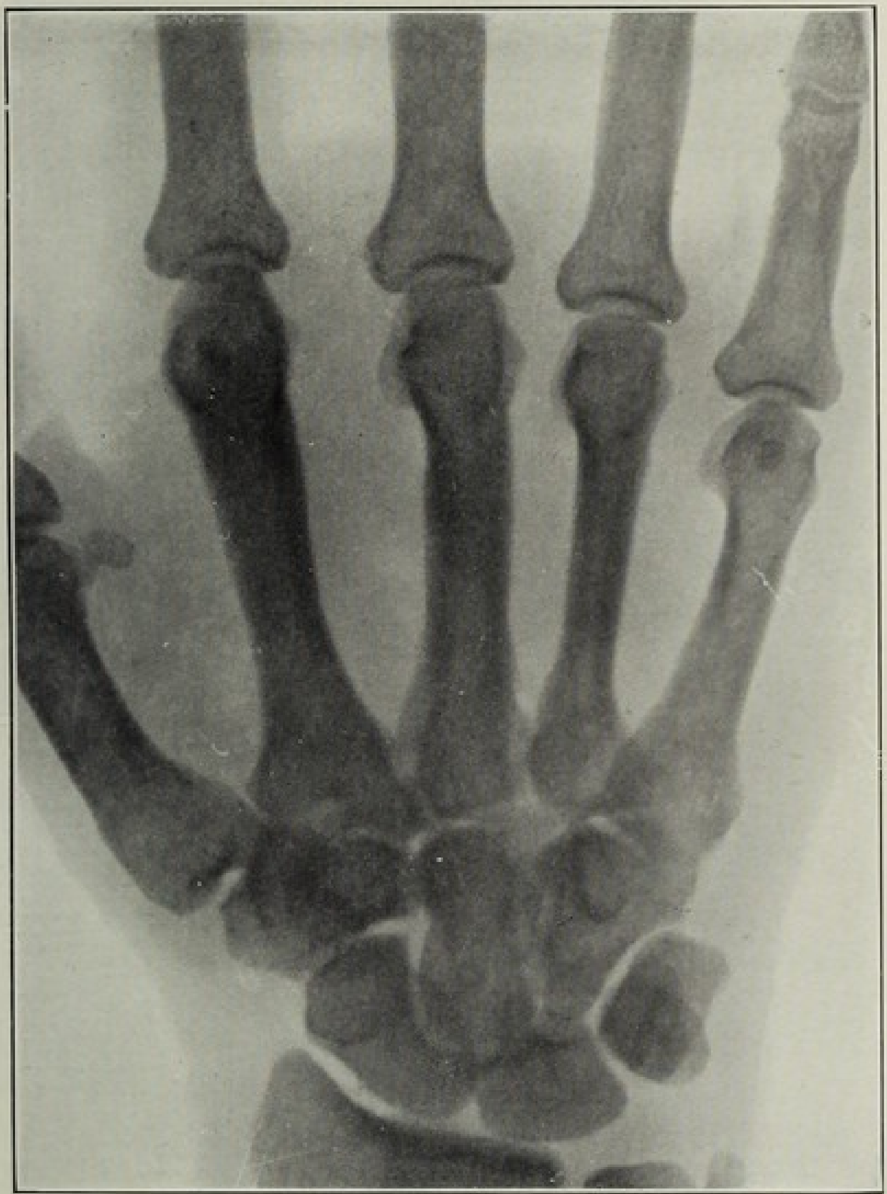

Fig. 3. *Case of fractured trapezoid and articular end of second metacarpal.*

Plate XLIV.

Fig. 4. *Dislocation backwards of os magnum.*

dislocated backwards by a fall on the back of the hand when in extreme flexion. The hand remained slightly bent, and the projection on the back was very distinct. Reduction was attempted by extending the whole hand, along with pressure applied on the displaced bone. This did not succeed, and extension was made from the middle and forefinger only, while pressure was kept up on the os magnum, when suddenly it slipped into place, but, on flexing the hand, the dislocation was reproduced, and a splint and compress had to be applied for some days, until the ligaments had healed sufficiently to keep the bone in position.

Holt thinks that, if the first attempt at reduction does not succeed, the only rational treatment, in order to preserve a useful joint, is excision through a dorsal incision, but I have never found it necessary to go to this extreme.

The following case, of which I show the skiagram (Fig. 4), was simple both in diagnosis and treatment.

H. M., a millworker, æt. 46, fell in the factory with a small bobbin in her hand, which at the time was in extreme flexion. I saw the patient next day, and found a hard, bony swelling on the dorsum of the wrist over the region of the os magnum, slightly tender on pressure. The movement of the wrist was impaired, and the hand showed a tendency to droop. A skiagram showed partial dislocation of the os magnum backwards. Extension of the hand, by pulling on the middle and forefinger along with pressure over the swelling, reduced the dislocation, but it was as easily reproduced on flexion. I put the hand up on a flat splint, with a firm compress over the back, and kept it so for about a week, then beginning massage and passive movement with a very good result.

Partial dislocations of this bone, along with some of the other carpal bones, are frequently met with subsequent to fracture of the radius, and, when some time has elapsed, after the injury, it is not an uncommon thing to mistake them for ganglia, and here radiography is of the greatest use. The reason for their occurring so frequently after fractures of the radius is given as the strain experienced at the time and the subsequent laxness of the ligaments.

Scaphoid. — Lembké, in *Archiv. fur Unfallheilkunde*, Vol. III., describes an outward dislocation of the scaphoid.

Its concave surface lay against the apex of the styloid process of the radius, to which it had become united, while the convex surface was directed outwards. The trapezium and trapezoid were thereby displaced forwards, together with the first two metacarpal bones and the fingers; the semilunar, cuneiform, os magnum, and unciform were all fractured. Extension of the wrist joint could be carried to an angle of 15°, but flexion was altogether suspended. Abduction and adduction were reduced by one half, and the thumb was limited as to flexion; otherwise the movements of the fingers were normal. The cause of the injury in this case was direct violence.

Elkington (*cf.* Cooper), in 1842, recorded a posterior luxation of the scaphoid, along with fracture of the lower end of the radius, in a man aged 60. Pressure produced reduction, and, at the end of six weeks, union of the fracture had taken place, but there were limitations of the movement of the wrist, and diminished power of the grasp. In another similar case he records an excellent result.

Morris, in 1883, records an anterior dislocation of the scaphoid along with the os magnum. This he reduced and treated with splints, beginning with passive movement a few days after the reduction. He continued the splints for four weeks, and then began active movement, with the result that, in three months, there was fair motion of the carpus.

Stewart, in 1888, reports a case of immediate reduction of an anterior dislocated scaphoid, and the result, at the end of five months, was "good motion without much inconvenience."

Hessert, in 1902, recorded a case of anterior dislocation of the scaphoid along with the semilunar; the diagnosis was made only a month after the accident, and, all this time, the hand had been in splints; disability of the hand and wrist, with painful movement followed, and reduction was found impossible. Both scaphoid and semilunar were excised, and, eight months after the operation, considerable improvement had resulted, although the hand as yet was far from perfect. The hand, useless before the operation, was now able to work and grasp objects, becoming stronger and more useful. Both active and passive motion was restricted, while the whole range of motion amounted to about 45°.

Plate XLV.

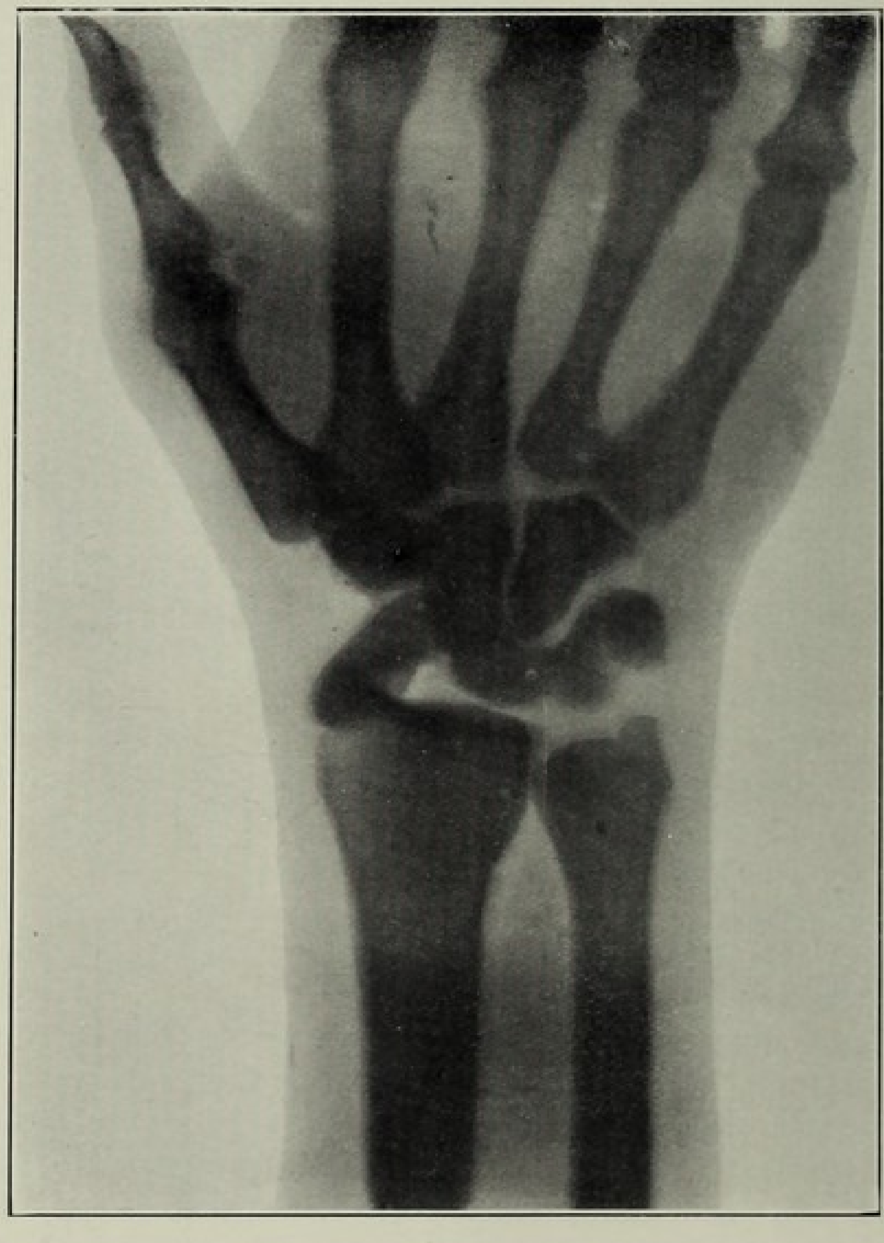

Fig. 5. *Dislocation of scaphoid.*

Dubar (*cf.* Potel), by means of X-rays, diagnosed anterior dislocation of scaphoid and semilunar in a hand six months after the injury. When he saw the case, the hand had been in splints for some time. Movement at the wrist was very limited, pain on pressure fairly severe, and range of motion about 30°. He operated, excising both bones, put the hand in splints, and began passive movement 15 days after the operation. Two months afterwards there was very good active and passive movement, without pain, both in flexion and extension; he looked on the result in this case as excellent.

As an example, I record a case which I had under my care.

W. D., an engineer, æt. 38, while repairing some machinery in a mill, fell 20 feet, alighting amongst the machinery. He received a deep punctured wound in left renal region, and, amongst other injuries, what was at first diagnosed as a Colles's fracture. On examining the wrist I found a dislocation, backwards and upwards, of the scaphoid bone, and a rotation of it on its own axis. Movement of the thumb was almost entirely restricted, as was also movement of the wrist.

Reduction without an anæsthetic I found impossible, on account of the pain, but, under chloroform, by extending and abducting the thumb, and flexing the wrist, I managed by pressure and manipulation of the dislocated bone to force it into place. Ten days on a splint, followed by massage, hot baths, active and passive movement completely restored the use of the wrist. I append the skiagram (Fig. 5).

Semilunar.—In order to understand thoroughly the mechanics of dislocation of the semilunar, I must briefly mention the normal motion of the wrist joint. The distal row of the carpal bones is so firmly bound together in one block by interosseous ligaments that there is practically no motion between its individual components. The proximal, or intermediate, row is, however, quite movable, and the motions of extension and flexion of the wrist take place entirely in the two joints above and below the intermediate row; that is to say, that, in order to accomplish the full arc of 180° from complete flexion to complete extension, each of these joints is movable through an arc of 90°. For example, if the wrist, in complete flexion is looked at from the side, the axis of the semilunar bone will point at an angle of about 45° to the vertical axis of the radius, while the long axis of the os magnum, which is continuous with that of the middle metacarpal, would form an angle of 45° with the axis of the semilunar. Accordingly the axis of the os magnum would stand at right angles to the vertical axis of the radius. The same is true for extension.

Accordingly, if the hand in complete flexion is still further flexed, there comes a point at which pressure ruptures the posterior ligaments, so that the semilunar is forced backwards, and the articular surface of the os magnum slides forward in front of the semilunar, and approaches the articular surface of the radius. In the meantime the semilunar, being still held to the radius by its ligaments, rotates so that its concave surface becomes directed forwards. In this position it is impossible for the normal arc of motion to be again secured, for about 90° of motion, which was the function of the semilunar, is lost; and the os magnum, in its new bed, can scarcely take up more than 50° or 60° at the most. The same is true also for anterior dislocation of the semilunar.

Accordingly, since dislocation backwards of the semilunar is caused by hyperflexion, its reduction must take place by hyperextension and pressure over the bone. The reduction of the anterior dislocation by hyperflexion is done in the following way. Hyperextension is first made to drag the convex surface of the semilunar back into contact with the radial articular surface, and then, while the semilunar is prevented from rolling forwards by pressure of the two thumbs of the surgeon at the anterior lip of the radius, hyperflexion is made over the surgeon's thumbs by an assistant. This allows the articular surface of the os magnum to slip again, over the posterior part of the semilunar, to its original place.

Diagnosis.—As in the case of other injuries about the wrist affecting the carpal bones, the patient is usually a male, and the prevailing age from 30 to 40. The injury is of the nature of violent twisting, or wrenching, coupled with hyperflexion, or hyperextension. There are pain, tenderness, possibly ecchymosis, a characteristic "silver fork" deformity, but no crepitus, so that the surgeon, who, at first sight, calls it a

Colles may be forgiven. Movement at the wrist is restricted, and any attempt at the same causes intense agony. If the case is unreduced and seen some weeks after the injury, the patient is found to have little or no use of his hand. The wrist is perfectly stiff, and the fingers held in semiflexion, while the deformity is very marked, and suggests an old Colles's fracture. If the dislocation is posterior, a bony prominence, found to be the semi-rotated semilunar, is evident on the back of the wrist, while anterior dislocation gives decided tumour amongst the flexor tendons. When the two hands are laid side by side, the injured hand looks smaller and shorter. The inability to flex or extend the fingers is very noticeable, while the shortened appearance of the hand is almost diagnostic. But it is on X-rays that we rely for our ultimate diagnosis, and then also must be borne in mind the fact that, along with dislocation of the semilunar, fracture of the scaphoid is of common occurrence.

The literature on dislocation of the semilunar is fairly abundant. Lembké was the first to describe it, and, in his case, the dislocation was back and accompanied by fracture of radius, os magnum, and unciform. Ericsen, in 1859, described a backward dislocation, produced by a fall with the hand hyperflexed; by extension and pressure, it was easily reduced; but flexion of the hand almost immediately reproduced it again.

Gamgee records an anterior dislocation of the left semilunar. There was pressure on median nerve, and flexion abolished. Manipulation failed to reduce the dislocation, and, four months after the accident, excision was performed with good result.

Auban, Delbert, Urban, Potel, Berger, and Folet have all recorded cases of anterior semilunar dislocation, treated by operation, varying in time from 3 to 18 months after the accident, and, in all these cases, motion of the wrist was restored; while Ely, Hofliger, and Sulzberger report cases in which, by manipulation and splints, even after some months had elapsed since the accident, they obtained a very fair range of movement; but by far the most complete list of cases is that by Codman and Chase, which contains 12 cases.

Treatment.—As in most other injuries to the carpus, treatment varies according to the time after the injury at which we see the patient. Should the case come under observation immediately after the injury, and the dislocation of the semilunar not be accompanied by fracture of the scaphoid, simple reduction is by far the best method of treatment. This can best be shown in the example I give here. A young ironworker, in a hurry to get down the stairs at closing time, fell a few steps, doubling his hand hyperflexed under him. He immediately saw a doctor, who made a provisional diagnosis of Colles's fracture, and sent him on to me. I saw him within an hour of the accident. The hand presented the typical silver fork deformity; movement at the wrist was nil on account of pain, and swelling had not commenced. The semilunar could be felt as a hard painful tumour amongst the extensor tendons. I immediately took an X-ray plate (*see* Fig. 6), and the diagnosis of backward dislocation of the semilunar was confirmed. Under somnoform by traction, hyperextension, and pressure over the tumour, reduction was easy. A handle splint, with a firm pad over the dorsum of the wrist, was applied, and the hand kept at rest for eight days, and, following that, hot baths, massage, and passive movement resorted to. At the end of three weeks, the hand was as perfect as before. Such is a typical example of the ordinary case. But if fracture of the scaphoid, or of any adjacent bone exists at the same time, and possibly part of the fractured bone also dislocated, it is better to excise the dislocated fragment, and reduce the semilunar, or, failing that, to excise both, for by so doing you invariably obtain a perfectly useful wrist.

If the case comes under our notice, however, say, some weeks or months after the injury, we have another phase of the subject to consider. Chase records some cases in which, even a month after the injury, reduction under an anæsthetic was performed with good results. Accordingly, reduction should always be tried first, and, failing that, excision through a palmar or dorsal incision, according as to whether the dislocation is anterior or posterior.

Unciform.—Dislocation of this bone is not so common as is that of the bones already described. South is the only one who, so far as I can find, made any mention of the subject, and he describes one isolated case. I had a typical case in a boy who fell in the card-room with the hand hyperflexed,

PLATE XLVI.

Fig. 6. *Backward dislocation of the semilunar.*

PLATE XLVII.

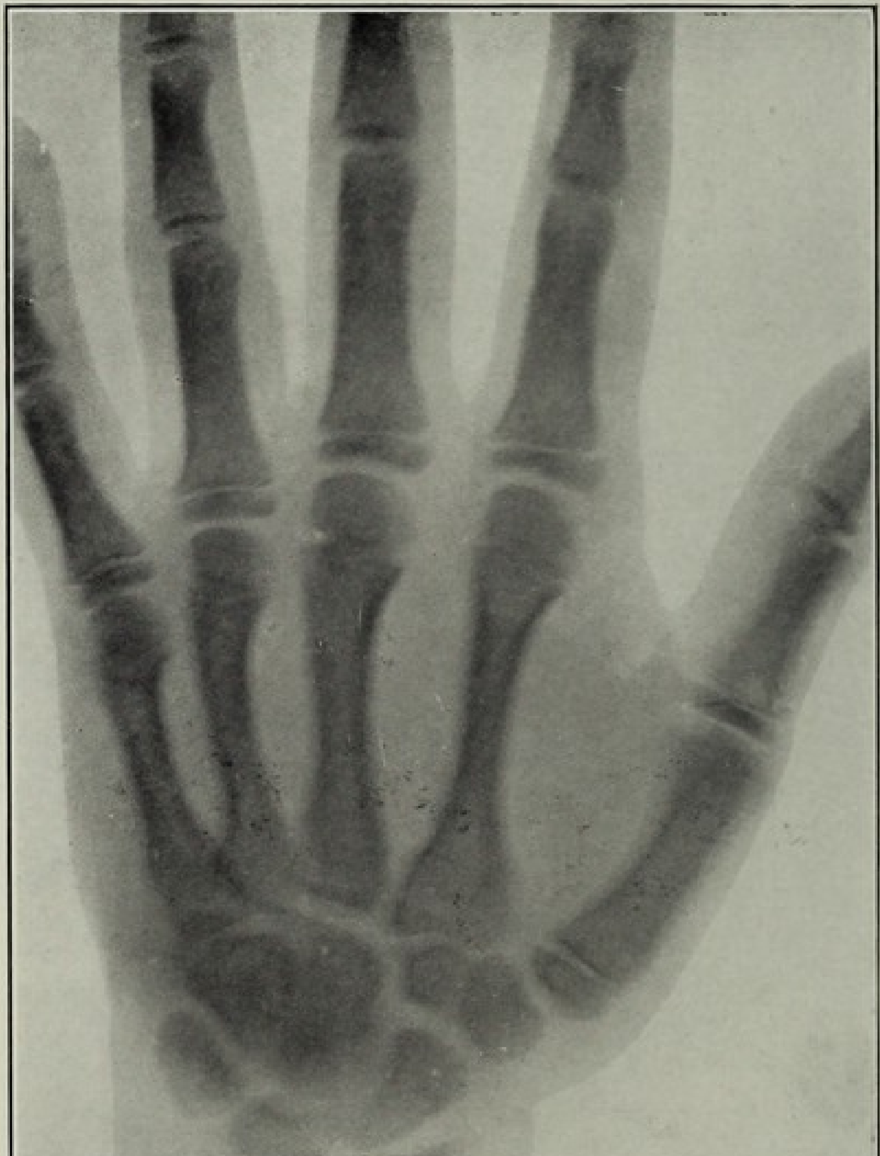

Fig. 7. *Dislocation of unciform.*

and the ulnar border next the ground. When I examined him, within an hour of the accident, the unciform could be felt quite distinctly projecting backwards on the dorsum of the hand, while adduction and flexion of the little and ring finger were impaired. I had the hand skiagraphed confirming the diagnosis (*see* Fig. 7).

Extension made on the little and ring finger, accompanied by pressure on the dislocated bone, reduced it easily, but, on flexing the hand, the dislocation was easily reproduced. I immobilised the hand for 14 days on a splint, then began passive movement, followed by massage and active movement, with a perfect result in 25 days.

Trapezium.—The trapezium is reported by Bailey to have been dislocated forwards, giving swelling and thickening of the ball of the thumb. The thumb was displaced somewhat forwards, and its mobility restricted, and, for four months, the patient was unable to use the hand for grasping and similar movements.

The accompanying skiagram (Fig. 9) shows a case of dislocation backwards of the trapezium in a man, æt. 35, sent by his doctor to consult me. He gave the history of having fallen, some six years before, while under the influence of drink, and of having sprained his thumb, as he thought, at the time. His chief complaint was weakness of grip, unles the thumb was supported at its proximal end. The thumb looked short, and stuck out from the hand in the position of abduction, showing a deep hollow at its articular end between it and the radius, while over the trapezoid a hard bony swelling was well marked. I skiagraphed the hand confirming my diagnosis, and advised the giving of an anæsthetic and an attempt at reduction. This he refused, and showed me how, by supporting the articular proximal end of the thumb, his grip was fairly good. This led me to advocate a leather support, like a glove, for the wrist and upper half of the thumb, an arrangement which answered the purpose very well.

I have failed to find any record of a dislocation of the trapezoid, or cuneiform, and, as I have not come across any myself, I shall pass it over.

Pisiform.—Dislocation of the pisiform seems to be quite common, occurring as the sole lesion, and caused by falls on the hand. South (Note to Chelium, *op. cit.* p. 234) says that Gras was the first to describe this dislocation; and Ferguson (*op. cit.* p. 190) describes a case, in which the bone was detached from its lower connection by the action of the flexor carpi ulnaris. Little benefit can be got from any attempt to keep it in place, but at times somewhat serious after symptoms occur, such as atrophy of the ball of the little finger and of the flexor carpi ulnaris, while adduction of the wrist becomes limited.

In children, however, we find this bone moving very freely on the cuneiform, and, even in adults, it is quite movable, and this mobility may quite easily lead one to mistake it for dislocation.

Dislocation of one row of carpal bones from the other has been recorded. Oberest records a case in a male, aged 25, seen five weeks after the injury. Then there was no motion of the fingers, wrist held in flexion and adduction, while the circumference was increased. The distance from the tip of the radial styloid to the distal end of the first metacarpal was 1 centimetre less on the injured side, as also was the distance from the tip of the ulnar styloid to end of fifth metacarpal. The only treatment he applied was massage and exercise. The result, after one month, was flexion within $\frac{1}{4}$ of normal, but no extension. The shortening was the same, but he was still unable to close his fingers or fist. There was slight atrophy of the forearm, but very little change in the strength of the muscles. The same author records another case of dorsal dislocation of the distal carpal row in a miner, æt. 55. One month after the accident the wrist was held in adduction, the hand shortened, broadened, and increased in circumference. The distance fram the tip of the radial styloid to distal end of first metacarpal, $\frac{3}{4}$ c.c. less on the injured hand. Also distance, from tip of ulnar styloid to distal end of fifth metacarpal, $\frac{3}{4}$ c.c. less on injured hand. The articulation was entirely stiff, and the muscles weakened, but tenderness not marked. After two months' treatment by massage and forced movement, only very little improvement was obtained.

Maisonneuré, Richmond, and Després have also recorded

Plate XLVIII.

Fig. 8. *Another case of dislocation backwards of the unciform.*

Plate XLIX.

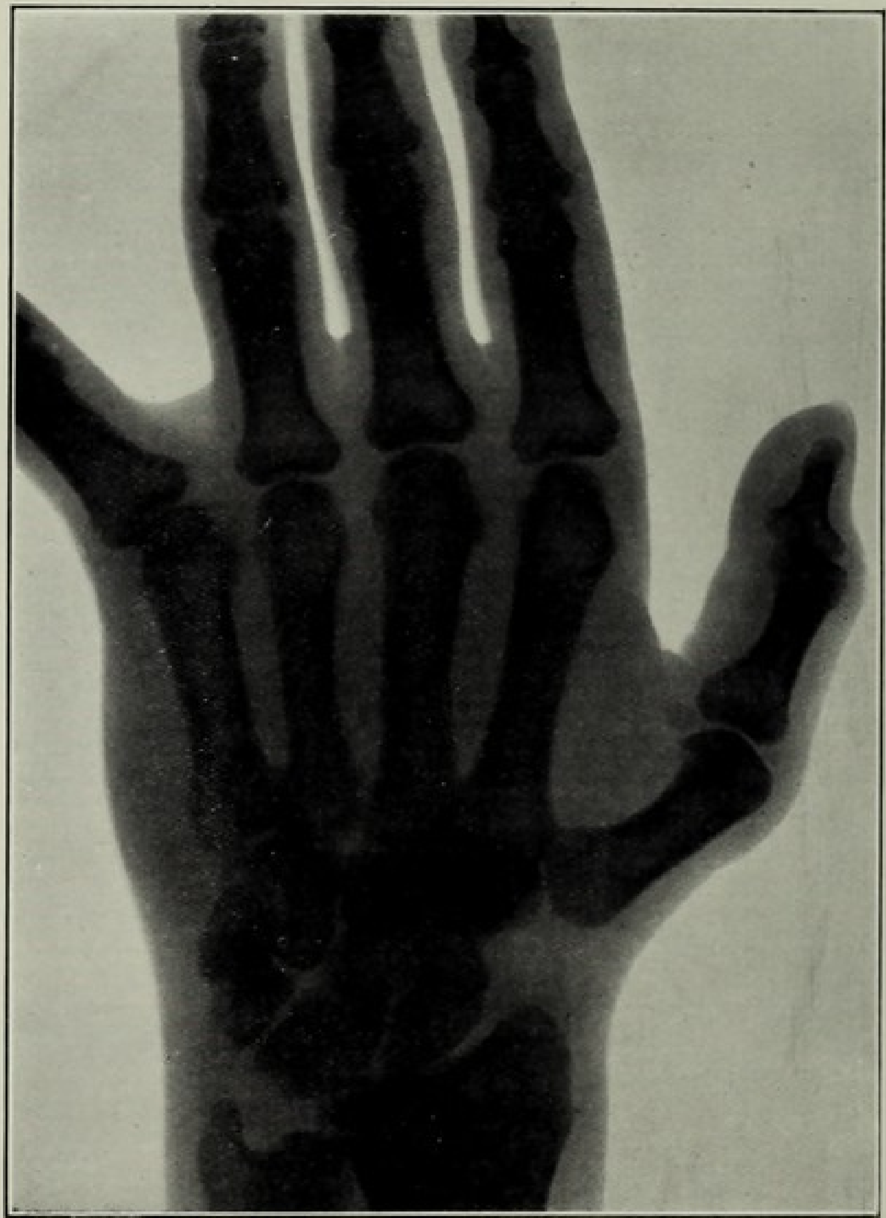

Fig. 9. *Dislocation of trapezium.*

dislocation of one row of carpal bones from another. But, as yet, I have not met with any.

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SKIAGRAPHY IN URINARY SURGERY.

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[With Plates L.—LXI.]

THERE is, perhaps, no branch of surgery which has received more assistance from the introduction of the radiographic method of diagnosis than that of the urinary tract. It may be fairly claimed that this method has attained sufficient accuracy to justify the statement that an exhaustive examination of the whole urinary tract should be made before any operation upon a case of suspected stone.

In a patient weighing less than 15 stone, the presence of a calculus, other than a very minute one, can practically always be demonstrated, and, in still stouter patients, a stone of moderate size can be shown.

The importance of a correct diagnosis is of the greatest importance both to the patient and to the surgeon, whether the diagnosis is positive or negative.

A good radiogram not only shows the presence or absence of a calculus, thereby indicating the cases which should be submitted to operation, but it also shows the number, size, and position of the stones. These details enable the surgeon to perform the operation, when it is indicated, with a maximum of speed and thoroughness and a minimum of injury to the kidney. Furthermore there is a group of cases, which exhibit the characteristic symptoms of renal or ureteral calculus, but in which the offending stone is small. A radiogram will demonstrate this, and, if the symptoms are not severe. expectant treatment is permissible.

In order to obtain correct results, it is necessary to explore the whole urinary tract in every case. This cannot be too strongly insisted upon, since cases have occurred in which a supposed renal stone has been found in the lower end of the ureter. Further, there have been cases, in which there has been a stone in the lower end of the ureter, whose presence was suspected on clinical grounds, while there were unsuspected calculi in the kidney itself. Again, one may be asked to investigate one kidney, which has given rise to symptoms, whereas there may be stones in both kidneys.

It is always necessary to obtain a good skiagram. It is obviously impossible to expect to demonstrate the presence of a stone in a negative which does not show the vertebræ distinctly. A good radiograph of the kidney region should show clearly the last two ribs, the vertebræ, the crest of the ilium, and the outline of the kidney and psoas muscle.

In order to obtain a good skiagram, several points must be borne in mind to prevent error. One of the most important of these is to see that the patient's bowels are thoroughly empty at the time of taking the skiagram. This must be specially insisted upon, and it should be remembered that a single dose of an aperient by no means ensures this result.

I am in the habit of ordering for such patients, where it is practicable, a saline aperient for two days; this is followed by a purge consisting of Pulv. Jalap, Pulv. Scammon. aa grs. 15. This is given on the night before the visit, and, in the morning, a long tube enema is administered. The skiagram is then taken on an empty stomach. These somewhat drastic measures are rendered necessary by the fact that scybala in the bowel cast shadows on the plate, which obscure those produced by calculi, or may even be mistaken for them.

In order to obviate this source of error, still further control skiagrams should be taken after an interval of several days. Any shadow due to a fæcal concretion will by this time have altered its relative position to the crest of the ilium, the transverse processes of the lumbar vertebræ, and the last rib, while that due to a renal calculus remains fixed.

There are other sources of error, the elimination of which is more difficult, and this can only be done by the careful consideration of the relationship of the shadow to the surrounding structures. Such shadows are produced in the renal region by calcified mesenteric glands, appendicular concretions, or irregular enlargement of the tip of the last rib, while, in the lower urinary tract, calcified lumbar, or inguinal glands, phleboliths, or calcified patches in arteries may confuse the diagnosis. It is in the lower ureteral region especially that there is the greatest difficulty, and the exact relationship of the shadow can sometimes only be made out by taking a skiagram with an opaque bougie in the ureter.

Another important factor, which must be borne in mind, is the wide excursion of the kidney during respiration. It is often possible to see a large renal calculus on the screen, and the shadow can be seen to move from 1 to 2 inches in a vertical direction with each breath. The method of overcoming this difficulty is described below, and the apparatus used and the technique of taking the necessary skiagrams are also explained.

The apparatus for exciting the tube consists of a 10-inch variable primary coil worked by the 100-volt continuous main with an electrolytic interrupter.

The tube, a heavy anode regulator (Muller), is enclosed in a box with lead glass, or thick plate glass, sides but open at the ends, enabling one thereby to regulate it easily. The top of the box is rendered opaque to the rays by lining it with a layer of red lead and a thick sheet of rubber, and a circular hole 3 or 4 inches in diameter is cut in such a position that the anode forms the centre of this circle. Above this is fixed an iris diaphragm with leaves of thick brass, which gives any aperture from ½ to 4 inches, and which can be altered by a slight movement of a vulcanite arm attached to its outer ring. This box is placed on a platform on the substage of a canvas-topped couch, and, by means of this substage, the box can be moved longitudinally or transversely.

The lower substage is marked out at 3 c.m. intervals for stereoscopic work.

Technique of taking Skiagram of Renal Region.—The patient is placed on his abdomen on the couch, and a circular air-pillow made of thin rubber, 6 inches in diameter and 2 feet long, inserted underneath him between the lower ribs and the iliac crests. This serves a double purpose of compressing the abdominal contents, and also of making the back flat, so that the plate will lie in accurate opposition thereto in its full extent. The tube box is then arranged with the diaphragm wide open, and the whole area examined with the screen.

Three skiagrams are generally taken, the first with a 3-inch diaphragm using a 10 × 12 plate with the tube centred under the spine taking in both kidneys and ureters, and the other two on 10 × 8 plates, the tube being centred under each side, using the smallest diaphragm that will include the whole kidney. In all cases the anode of the tube is as nearly as possible 20 inches from the plate.

The plate is enclosed in two light-tight bags and placed film downwards on the back, and kept there by placing a weight on it. The patient is then directed to take several long breaths, and then to hold his breath in the position of full inspiration. This phase of respiration is chosen because it brings the upper end of the kidney down, and gets it clear of the ribs as far as possible, and also because the patient is thereby able to hold still longer than in expiration.

An exposure of from 5 to 60 seconds, varying with the size of the patient, is then given at a current of 15 ampères through the primary of the coil. In most cases it will be possible to get the desired exposure in a single inspiration. In the case in which this is not possible, the same result can be obtained by divided exposures, which are made for shorter periods with a rest between each, the current only being allowed to pass through the tube when the patient is in the position of full inspiration. To do this, the operator, holding the commutator or a cut-out in his hand, should fix his head so that his eyes are on a level with the plate, and mark a chalk line on the opposite wall, which will just coincide with the line of the plate on the patient's back at full inspiration; he can thus be quite sure of getting his exposures all at the same phase of respiration.

In order to obviate the difficulty of obtaining the same phase of respiration in divided exposures, I have lately employed the following method. On the photographic plate, a lead plate, from the centre of which projects a rod with a small fork at the top, is placed. From a pillar at the side of the couch, attached to the lower stage holding the tube, projects an arm carrying a dial, on which there is placed an insulated movable contact, and another arm, parallel to this, carries a jointed lever which terminates in a fork.

The lever is carried on a lateral support at right angles to the arm that bears it, and is so arranged that the edge of the dial is between its two terminations. A relay circuit, consisting of small dry cells, a small electro-magnet, and a platinum contact, was first employed, but it was not satisfactory, as the platinum contacts were apt to stick, consequently a mercury contact was substituted. This is inserted in the primary circuit, and connection made with the movable contact on the dial and the lever. The lever is then placed in position in the fork on the lead plate, and the respiratory movements are communicated to it. The movable contact is then adjusted, so that the circuit is completed at the required phase of respiration by the lever touching it. The required exposure is obtained after the patient has taken a sufficient number of breaths, and the time can be recorded accurately by means of a clock-movement in which, by means of a small electro-magnet on a relay circuit, the clock only records during the flow of the current. This method is especially valuable for stereoscopic work, for it ensures identical exposures, and it obviates the overheating of the tube, which occurs when using the electrolytic break continuously for any length of time.

In the illustration the apparatus is shown, with the patient in position on the couch. The small box on the pillar contains the mercury contact and the clock. This apparatus was made for me by Messrs. H. W. Cox & Co.

With regard to stereoscopic radiographs for renal calculus, they are valuable because they sometimes show small calculi, where the diagnosis would be otherwise doubtful.

To take them, close fitting bags, such as Hinton's, should be employed. The same apparatus is used, but the bags have lines drawn on the backs at right angles to their central point. The lead plate is similarly marked. The first plate is placed in position, and the tube box moved 3 c.m. to one side. The lead plate is placed in position with the marked lines coinciding with those on the back, and the lever adjusted. The position for the second plate is then marked on the patient's skin by continuing the vertical line from the plate and by drawing another at right angles along the edge of the plate.

After the first skiagram is taken, the tube box is moved 3 c.m. to the other side of the central position, the second plate placed in position, and the procedure repeated.

In order to take the skiagrams of the lower ureteral region and the bladder, the patient is placed on his back, and the tube centred beneath the upper part of the symphysis. The plate

PLATE L.

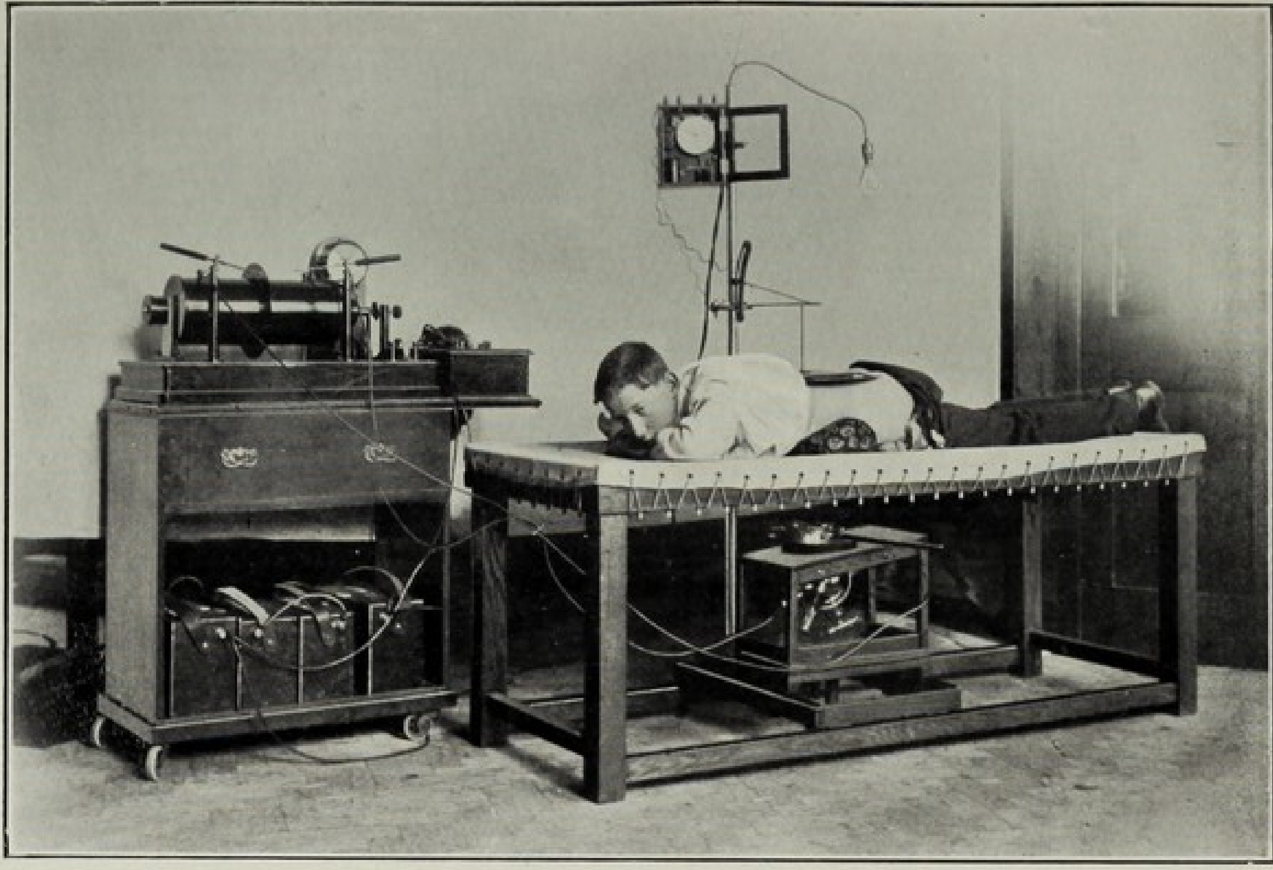

Fig. 1. *Apparatus employed for taking skiagram of renal region. The patient is represented at the position of full inspiration when the current is flowing. When he exhales the lever drops, the contact is broken, and is not made again until the resumption of the full inspiratory position. The apparatus represented is a 10-inch coil excited by four 6-volt accumulators and interrupted by the Mackenzie-Davidson break. The tube box and diaphragm with rod for adjustment can be seen below.*

PLATE LIII.

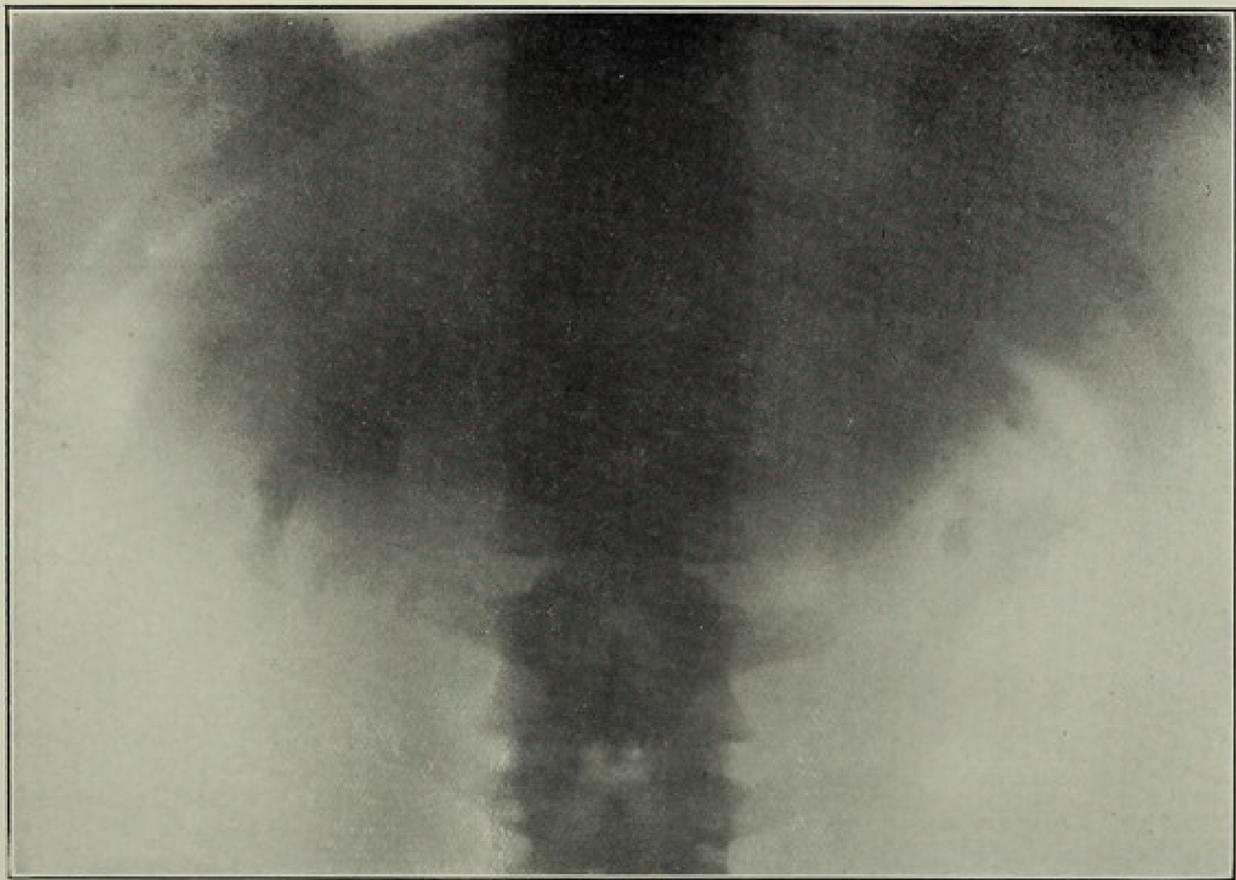

Fig. 4. *Large branched stone in left kidney. Collection of 7 or 8 stones in right kidney. This patient had had a double nephrotomy done, five years previously, on the right kidney, when some stones were removed, and two years previously on left kidney, when no stone was detected. Verified by operation.*

Plate LIV.

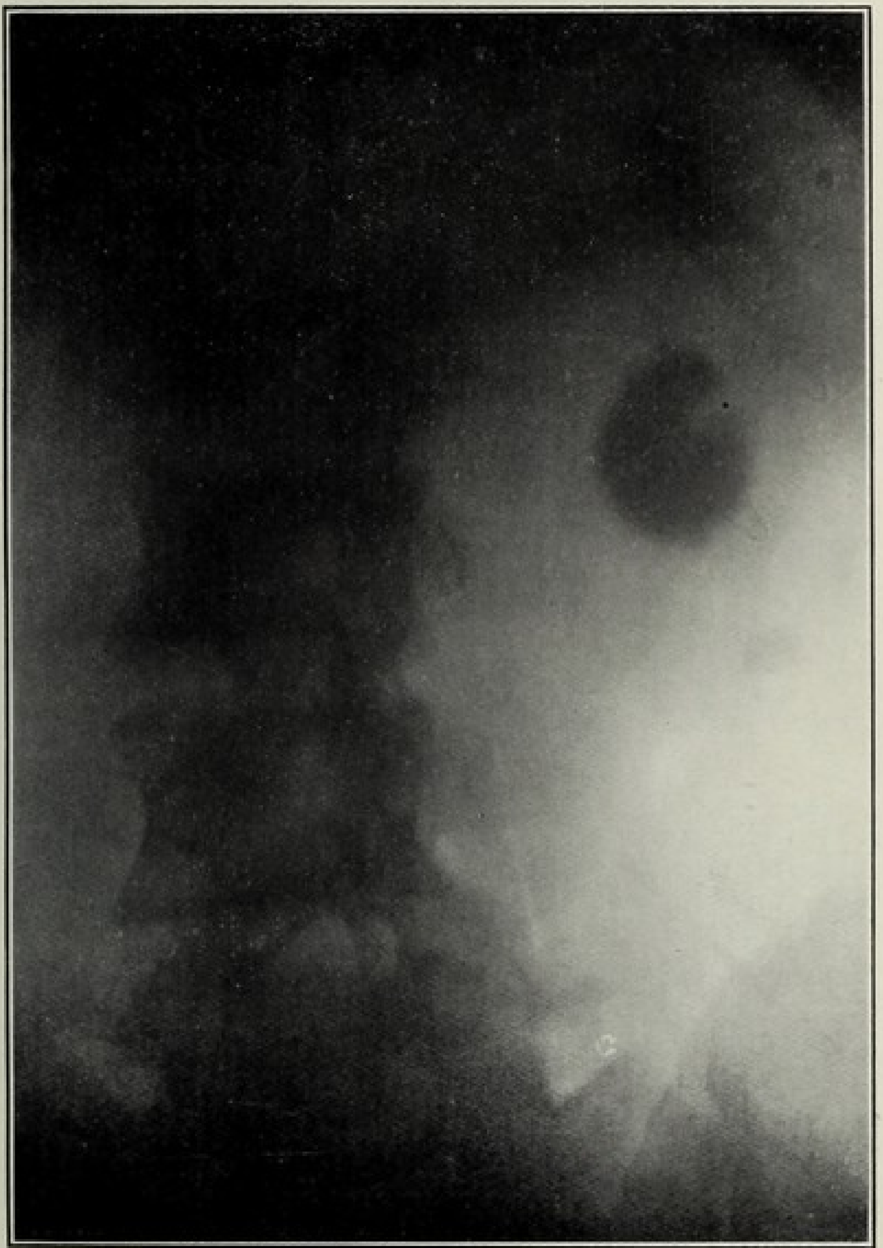

Fig. 5. *Large stone in right kidney. Two smaller ones in substance of the kidney. Verified by operation.*

PLATE LV.

Fig. 6. *Large stone in left kidney. Smaller shadow lower down was given by a small collection of sandy material in lower calyx. Verified.*

Plate LVI.

Fig. 7. *Large collection of stones in right kidney. No symptoms given by these. Patient was not passed for insurance owing to the presence of pus in urine. Verified by operation.*

Plate LVII.

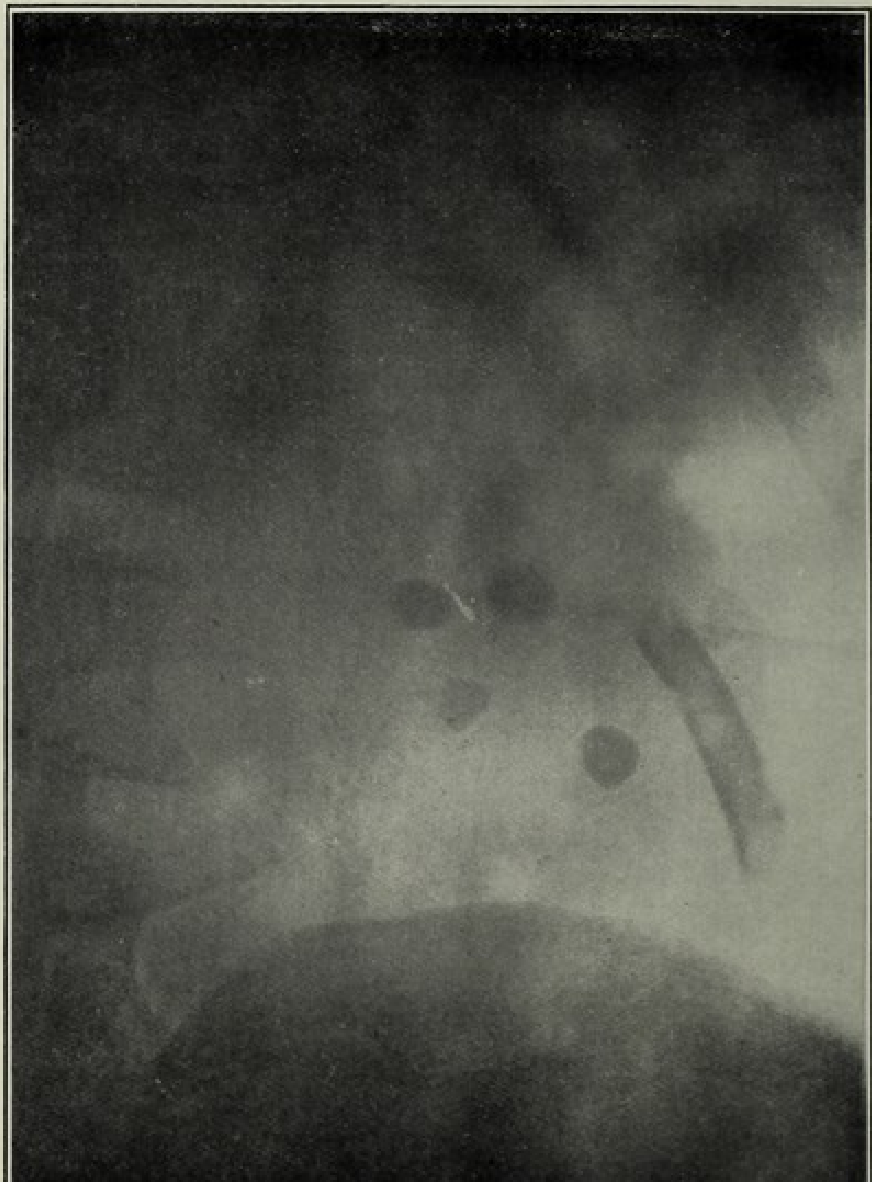

Fig. 8. *Same case as preceding figure six months later. Urinary fistula formed and re-formation of stones. Drainage tube showing. Verified.*

PLATE LVIII.

Fig. 9. *Three stones in kidney in girl of twelve. Middle one easily found. The other two were found after prolonged search.*

PLATE LIX.

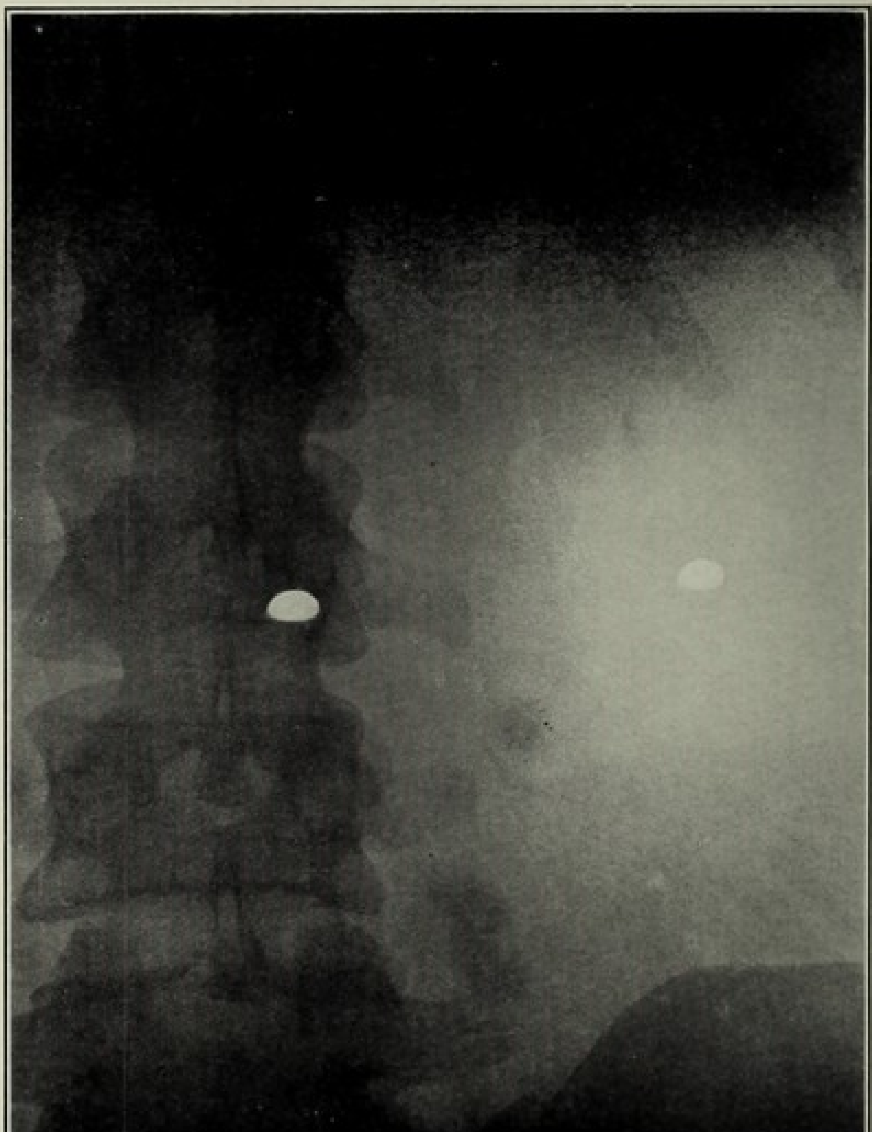

Fig. 10. *Ureteral stone. Not found at operation, but passed three days later.*

PLATE LX.

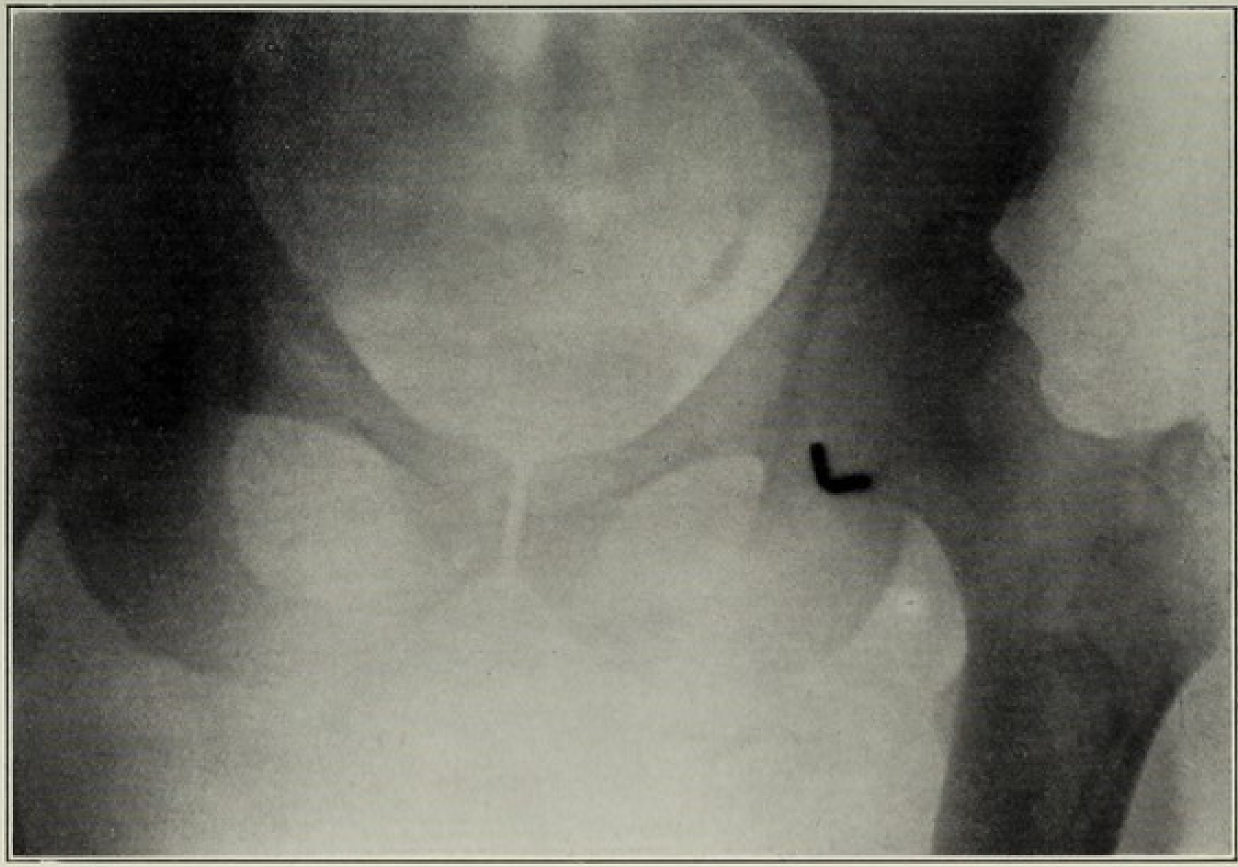

Fig. 11. *Stone in lower part of ureter; passed later.*

PLATE LXI.

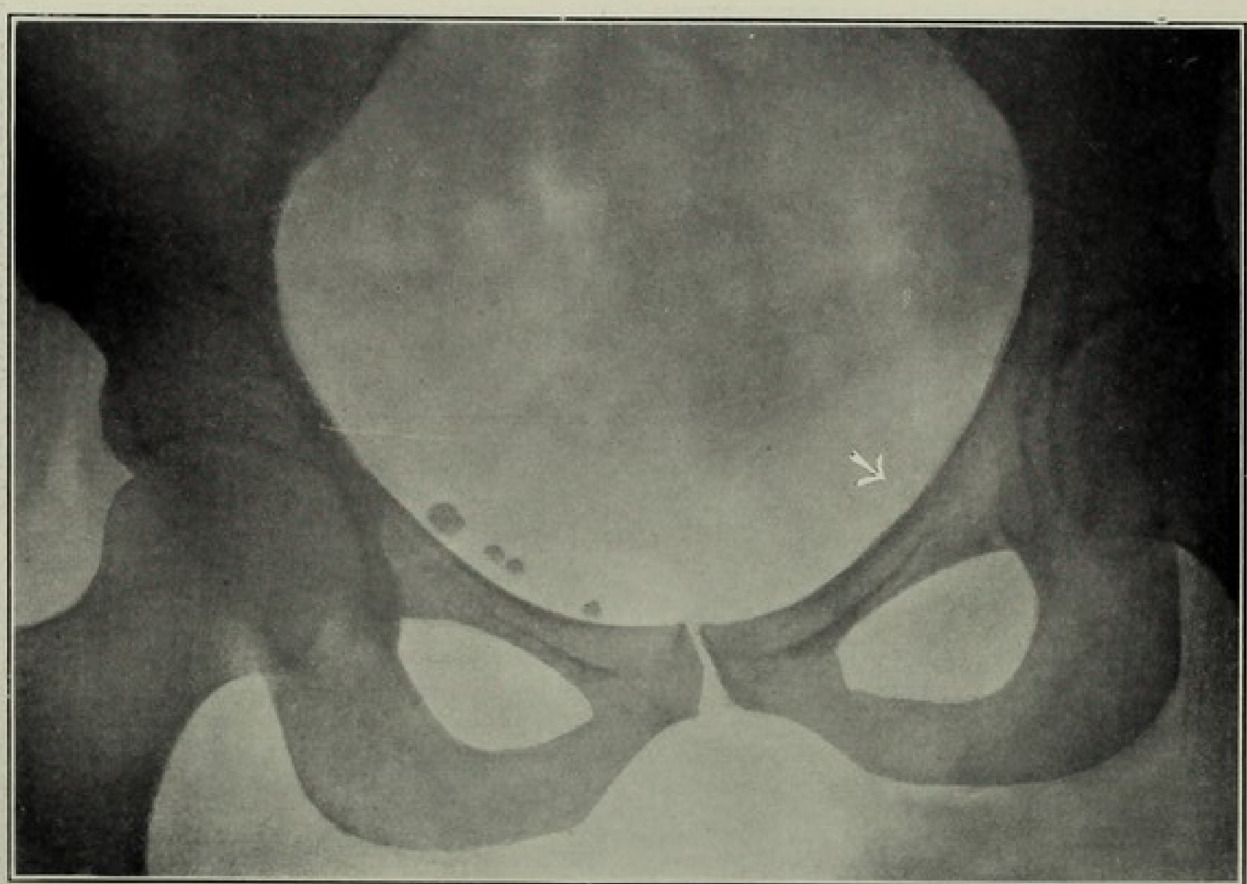

Fig. 12. *Ureteral calculi on right side. Calcified gland on left.*

is placed on the abdomen, with the upper edge at the level of the umbilicus steadied by a weight, or a piece of wood is placed on it, and a bandage passed under the pegs, which hold the rope for the canvas top at each side, and tied down. In this way the respiratory movements are not communicated to the plate. The rest of the procedure is identical with that used for the renal region.

The permanence of an operation for the removal of a renal calculus depends upon every particle of stone, or grit, being removed. When there is only one stone this is easy, but it frequently happens that more than one is present, or a definite calculus is accompanied by a mass of fine gritty material. In order to ensure the removal of everything, which might at a future date give rise to trouble, or form the nucleus of new calculi, I would suggest the use of a small sterilisable cryptoscope, which I have had made. By means of this, the surgeon is able to see any stone, when the kidney has been delivered on to the loin, although, while it was in the body, no stone could be seen on the screen.

The importance of this is readily understood when one considers the difficulties of a second nephrolithotomy on the same kidney.

The practical point at issue is to decide how far the assertion, which was made above as to the accuracy of X-ray diagnosis, is justified.

I have examined over 500 cases of suspected lithiasis during the past three years. Of these, 88 cases have been submitted to operation, and the accuracy, or otherwise, of the diagnosis finally settled. In five cases, three of the kidney and two of the bladder, the X-ray diagnosis was not confirmed. The details of these cases are as follows :—

The two cases of vesical calculus were missed, owing to the arrangements of the surgeon not allowing sufficient time for the controls, and indifferent negatives being obtained.

As regards the cases of renal calculus, in one case, a distinct shadow was found, but the surgeon has as yet found no stone. The shadow is still present, and its nature still remains doubtful. In the second case, the kidney had been operated on, and was dragged out of place by scar tissue.

There was no actual stone, but a small pocket of gritty *débris* was found at the operation.

In the third case, a definite diagnosis was not given, owing to the difficulty of getting a good negative in a stout and nervous patient, and at the subsequent operation a stone was found.

It will be noticed that the number of cases operated on bears but a small proportion to the number of cases examined, and this is perhaps the strongest testimony to the place which X-ray diagnosis of stone in the urinary tract has established for itself. Surgeons are now very reluctant to operate in cases in which the Radiographer has reported that no stone was present. In 33 cases the symptoms have justified operation in spite of the skiagram, and in only two cases has a stone been found. These figures give an accuracy of diagnosis very much in advance of any previous method, and, considering the difficulties of technique, the percentage of error is remarkably small.

The greatest difficulty is encountered in the region of the ureter; three cases, which were examined and no shadow discovered, subsequently passed small ureteral calculi, and several cases, which are at present under expectant treatment, present shadows which may be due to calculi, or to calcified glands.

LOCALISATION OF FOREIGN BODIES BY MEANS OF X-RAYS.

By EDWARD W. H. SHENTON, M.R.C.S.,

Radiographer to Guy's Hospital; Hon. Radiographer to St. Peter's Hospital for Stone.

In dealing with the subject of localisation, it is well to forget the existence of systems and apparatus, and to centre one's thoughts more directly upon a plan shorn of mathematical details and formulæ.

Somewhat analogous to the imbedding of an object in human tissue is the burying of a treasure in the earth. In the latter case, it is certainly to the advantage of the seeker to be led to a spot, and told that beneath it, at such and such a depth, lies the object of his search. Similarly in the former case, I maintain that, by the assistance of X-rays, we can direct the would-be extractor of a foreign body from human tissue to the spot beneath which it lies, and say how far beneath that spot it is. The use of mathematical formulæ can serve us no better than that.

Since, then, the success of the subsequent operation depends upon the discovery of the point under which the object lies, what we want is a good source of X-rays as a means of securing this easily and certainly.

For this purpose, as for many others, I have had made, in accordance with my designs, a table, and, if I briefly describe the principles of this, it may suggest possible adaptations of existing apparatus; at any rate, it will show one way in which the operator can completely and quickly control his light in relation to his patient.

A wooden table—wood in preference to metal to lessen short circuit, of material square in section, to prevent lodgment of dust—with a removable canvas top. This top, which consists of a wooden frame with easily removable canvas stretched tightly across, has four pull-out handles, by means of which it is converted into a stretcher.

Beneath the table is an X-ray proof box, carrying the X-ray tube, which can be moved lengthwise, from side to side, and up and down, by three handles facing the operator. The mechanism is of the bicycle chain-wheel and roller chain variety, extremely strong and simple. The top of the box is covered with a diaphragm, which may advantageously be of the iris diaphragm variety.

Along the front and lower part of the couch runs a foot-board, connected either end with a large switch, and so arranged that, when depressed, the right switch is closed while the left opens, or conversely, when the board is lifted, the right is opened while the left closes. Room lights are connected with the right, and the primary wires of the X-ray coil to the left.

Wherever the operator stands, upward pressure with his toe turns on the rays, and turns off the room lights, while, by pressing with his foot, the room is lighted, and the X-ray apparatus turned off. The operator has thus the control of the position of his tube, and command of the rays and the room lights, and is therefore in a position to examine, to full advantage, any part of the body lying upon the canvas stretcher before him.

Let us assume that we are required to assist the surgeon in the extrication of a bullet from the leg. The first thing is to find the whereabouts of the bullet, and this is easily effected by an examination with the open tube, and without using a diaphragm. It may be here noted, for the guidance of those unfamiliar with modern X-ray apparatus, that it is a matter of no difficulty to find a bullet of any size, in any part of the human body, and this upon the screen, or, as it is technically called, "at a fluoroscopic examination." This also applies to other metallic foreign bodies, and it is not incorrect to say that no surgeon would attempt to remove any metallic foreign body which present day X-ray apparatus failed to demonstrate clearly upon the screen.

The locality of the bullet having been ascertained, a diaphragm is then fitted over the tube. I will not here stay to discuss this useful piece of apparatus, as there are several different forms of it. It is essentially a piece of thick metal, with a circular hole in it. Mr. Harry Cox has recently provided me with a more elaborate diaphragm, which opens and closes upon the "iris" system and has much to recommend it.

Whatever diaphragm is used, I would suggest that it should be a small one, say, in the case under consideration, 2 inches across.

The tube is then manipulated so that the bullet assumes the centre of this circle in the screen, this latter being laid on, or held firmly above the limb by suitable apparatus, which is provided on the table above described.

A metallic pointer, a probe, for example, is now passed between screen and leg, and its tip placed upon the bullet shadow, or perhaps it would be more correct to say that the shadow of the point of the probe is watched, until it coincides with the shadow of the bullet, these shadows of course being upon the screen, and the probe itself touching the patient's skin. The probe is held steadily, the footboard depressed, and the room lights thereby turned up. Remove the screen, and mark the skin with ink, or other suitable material, exactly where the point of the probe is touching it.

This is the point immediately over the bullet, and it is manifest that an incision made exactly over this, and carried to a correct depth, must liberate the object sought for. It remains, therefore, to find the depth of the bullet from the skin, and this may be accomplished in two ways. The former is by means of a simple surgical probe, or piece of wire, and a small piece of lead foil, or soft wire; the second is by means of slightly more elaborate apparatus.

Let us consider the former method. Take a straight probe, and twist a piece of lead foil around it, so as to make an appreciable bulge.

Turn the leg on its side, *i.e.*, at right angles to its former position; then place the tip of the prepared probe on the spot marked upon the skin, letting the probe be horizontal to it, or, in other words, parallel with the screen.

Next, slide the piece of lead foil along the probe until its distance from the point is equal to that of the point from the bullet. The accompanying illustration will explain this. We are, of course, watching the screen, and can therefore measure these distances on its surface, and adjust A so that AB shall equal BC.

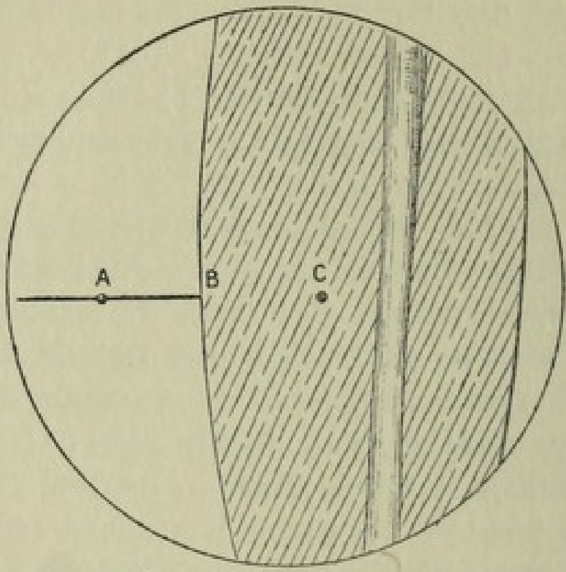

Fig. 1. A. *Piece of lead foil wrapped round probe.*
B. *Point where probe touches skin.*
C. *Bullet imbedded in thigh.*

When it is remembered that A B and C are all on the same plane, it is quite evident that the measurement AB, permanently recorded upon the probe, is the depth of C from B, or the depth of the bullet from the skin. It is advisable to make the point B roughly the centre of the luminous circle.

The exact spot under which C lies and its exact depth from this spot have been discovered, and, with such data, the surgeon cannot fail to find the foreign body. The X-ray operator cannot be responsible for the subsequent operation, but he will not feel entirely satisfied until this has been carried to a successful conclusion. He need not feel the least anxiety, however, as to the result if he has the confidence of the surgeon. I have, in this way, assisted at many hundreds of searches for foreign bodies, and have never seen a failure when attention to the simple data has been given. I must, however, remark that some surgeons are peculiarly gifted in rapidly reaching the object of their search, and I attribute this to the mental picture they form of its whereabouts after one has put the matter clearly before them—"immediately under this spot at such a depth." This peculiarity is as much a gift, as being a born "shot," and others, though equally good as surgeons, will invariably go wide of the mark, and delay matters a little at the outset. It is, therefore, unfair to praise or blame the Radiographer for the shortness of the operation or the reverse. The Radiographer, who works for several surgeons, will find himself able to gauge beforehand to a nicety the duration of the operation according to the operator.

Let me here most emphatically denounce the radiogram, by which I mean the X-ray photograph, as an aid to the extraction of a foreign body. There is no surer means of defeating the end in view than by the production of a few radiograms at an operation. It has been my lot to witness some of the worst exhibitions, in a surgical sense, the causations of which were directly attributable to radiograms. I need not give the painful details of any of these, but would mention one rather striking case which is fresh in memory. An officer, who was shot in the thigh, was "X-rayed"—a horrible expression to my mind, and usually, in these cases, synonymous with the taking of a collection of deceptive and worthless skiagrams. These radiograms were responsible for two hours of profitless raking about in the neighbourhood of the femoral artery, and some evident interference with nerve structures, which caused chronic pain in the leg after the wound had healed.

When the patient came to me, I treated him just as I have detailed above, and just as anyone, who has carefully followed my remarks, would be in a position to do. I was present at the next operation, which was performed by Sir Alfred Fripp, and made the statement that the bullet lay $3\frac{1}{2}$ inches directly under a certain mark.

Three minutes after the first cut the bullet appeared, and the striking feature of the whole matter was its "magnificent simplicity." The next worse thing to giving a surgeon a radiogram is to try to describe the anatomical situation of a foreign body. Do not allow yourself to be drawn into this. However good an anatomist you may be, you will be wofully astray if you attempt to say what anatomical structure lies so many inches under a given point. Of course you may with advantage say that the object sought is near the femur, in the chest wall, between the metatarsals, etc., but do not suggest that it lies in Hunter's canal, or reposes in the pituitary body.

It may please the surgeon to hear such suggestions before operation, and, on the extremely rare occasions, when events prove that you are right, you will no doubt be pleased with yourself, but I am convinced that, on the whole, it is not worth while, and certainly in principle it is wrong, to make such suggestions. It is merely for you to state its relation to external objects, and to let the operating surgeon find out, or form his own estimate of, the exact anatomical structures with which he will be concerned.

Assuming that this common-sense principle, of marking the spot and finding the depth, has been accepted, I will briefly describe the second method, to which I referred above, that will sometimes be more convenient than the probe and lead foil, though it necessitates a little piece of special apparatus. This method is for finding the depths in those cases in which the limb cannot be turned. The instrument, which I have called a localiser, in deference to the feelings of the instrument maker, but which is really a little depth gauze, is depicted in the illustration.

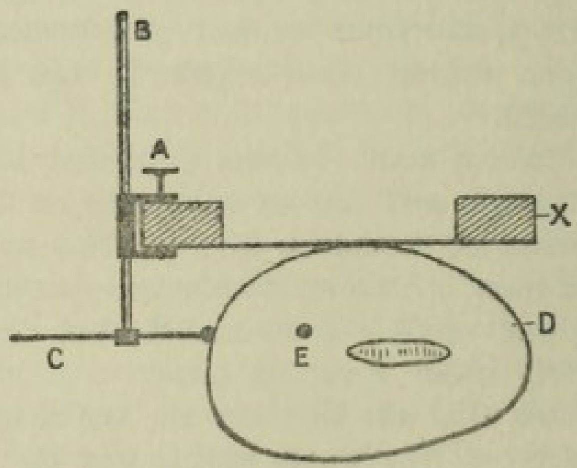

Fig. 2. A. *Small clamp on edge of screen* X.
B. *Graduated rod sliding in guide in clamp.*
C. *Pointer sliding at right angles to* B.
D. *Part being examined (a section).*
E. *Bullet imbedded in* D.

This little affair clips on to the screen by a thumbscrew clamp A. B, a graduated rod, slides in a guide in A, and C, a pointer with a knob, slides in the end of B, keeping a right angle with it.

C is therefore always parallel with the screen surface.

Having secured the first mark, *i.e.*, the one immediately over the bullet, the rod B is pulled up so that C touches the screen. The tube, by means of the couch mechanism, is now moved from side to side, and the movements of the shadows upon the screen watched. The shadow of the tip of C does not move when it touches the screen, but the shadow of the bullet moves in a contrary direction to the tube. Pausing for a moment, one can easily embrace the facts that the nearer the object is to the screen the less distance will its shadow move, and that two objects, in a plane parallel with the screen surface, will move an equal distance. Putting this in another way, the shadows of any two objects, moving the same distance upon the screen, must be on the same plane.

Now, while the tube is moving to and fro, push B down until the tip of C, the probe, moves at the same rate as the bullet. This means that these two objects are on the same plane, and that, therefore, the distance of the probe from the screen is the same as that of the bullet from the screen. This measurement is given in actual figures on the sliding scale at X.

These two principles, that of the probe and leadfoil and the oscillating tube, I have now had in constant use, ever since I first published them over eight years ago, and with many slight modifications, I have been able to locate every variety of foreign body which the X-rays have been capable of showing.

One modification is necessary in the case of imbedded needles, since it is essential to locate both ends ; but the way to accomplish this is manifest to anyone who has followed the idea of the bullet localisation.

THE VALUE OF X-RAYS IN DIAGNOSING AND LOCALISING FOREIGN BODIES IN THE EYE.

By H. WILLOUGHBY LYLE, M.D., B.S. (Lond.), F.R.C.S. (Eng.),

Assistant Surgeon, Royal Eye Hospital; Ophthalmic Surgeon, Royal Ear Hospital; Lecturer on Physiology in King's College, London.

In considering the value and importance of X-rays as a means of diagnosis and localisation of foreign bodies which have entered the eyeball the three following cases, which have been under my care, will, I think, prove instructive.

Case 1.—A. B., age 22, a stonemason, was admitted to the Royal Eye Hospital at 11 a.m. on October 20, 1905, when he gave the following history: At 8 a.m. he was in the yard of the works in which he was employed, cutting a piece of granite with a chisel and hammer, when he suddenly felt something hit him in his left eye. He went straightway to his doctor, who sent him at once to the hospital, where he arrived three hours after the injury. On examination, a small penetrating corneal wound was seen opposite to that which would be between ten and eleven on the clock face. Behind this wound the iris was injured and somewhat discoloured; there was a little blood in the aqueous chamber. After a drop or two of atropine solution of the strength of four grains to the ounce, and cocaine, four per cent. solution, had been instilled into the conjunctival sac, a wound in the anterior portion of the capsule of the lens, and a rapidly developing traumatic cataract could be seen. The patient was unable to distinguish light from darkness with the injured eye. He said that neither the chisel nor the hammer had been examined after he received the injury, so that it was impossible to ascertain whether the foreign body in the globe was a piece of steel or a chip of granite. The patient was sent as soon as possible to Dr. A. D. Reid, Radiographer at King's College Hospital, in order to have the diagnosis of a foreign body in the eyeball confirmed, and also to have it localised if possible. Dr. Reid's report was that there was a foreign body about two millimeters long in the globe. Its position was 16 millimeters back from the central point of the cornea, five millimeters below the optical axis of the eyeball, and five millimeters towards the nasal side. It took a considerable amount of time for these exact measurements to be made, thus rendering it quite impossible to attempt to remove the foreign body on the same day. The next day, however, the patient was placed under a general anæsthetic, the conjunctiva was dissected back and the sclera incised as nearly as possible over the surmised position of the foreign body; the point of the small hand electro-magnet was introduced through the scleral wound into the vitreous chamber, and an attempt made to attract the foreign body. After repeated attempts, in various directions in the vitreous through the one scleral wound, had failed, it was decided to excise the eyeball. This was accordingly done at once. The globe was then carefully bisected, and the foreign body (steel) was found embedded in the vitreous surrounded by organised lymph, there was also a well-defined streak of lymph extending from the posterior portion of the capsule of the lens right up to the foreign body. It will be seen then that the foreign body was not only diagnosed to be in the eyeball by the means of the X-rays, but it was also accurately localised, but that it could not be removed from the globe, because it was completely surrounded, and held firmly in position by the organised lymph. The conclusion to be drawn from the above experience is that, in order to successfully remove pieces of metal from the back portion of the eyeball, the patient must be seen almost immediately after the accident; the diagnosis and localisation must take place at once, and the earlier an endeavour is made to remove the foreign body (if metal) by the small hand electro-magnet the better. In some cases, however, after the foreign body has been removed, septic iridocyclitis makes itself manifest in the anterior part of the globe, especially in the neighbourhood of the original penetrating wound, and, in such circumstances, it is better to remove the eyeball at once.

Case 2.—C. D., aged 29, a fitter, was admitted to the Royal Eye Hospital on January 26, 1906, when he gave the following history :—Twenty-four hours previously he was "hitting some hot steel when it splintered into his face." On carefully examining the patient's right eye, in the dark room, by oblique ocal illumination, an exceeding fine wound was seen in the cornea opposite to 11 upon the clock face. Behind this the iris was slightly discoloured, and a minute bead of lymph was seen upon its anterior surface, exactly behind the corneal wound. There was also some slight injection at the circum-corneal zone opposite to the corneal wound. The aqueous chamber appeared to be quite normal and there was no blood present. The pupil reacted quite well to light. The opacity in the cornea appeared to be more like a linear abrasion than a penetrating wound. Atropine drops were instilled into the eye when the pupil enlarged somewhat irregularly ; there appeared to be something preventing full dilatation in the neighbourhood of the local injection in the circumcorneal region. On very careful examination by oblique focal illumination, there appeared to be a fine whitish point of something projecting through the iris behind the corneal wound, as if some small body had pierced the iris, and the fine point of it was lying in the posterior portion of the aqueous chamber towards the peripheral part of the anterior portion of the lens capsule. The lens appeared to be quite normal, and the capsule seemed to be in no way damaged. The patient's vision was good. The eye was kept under the influence of atropine and a pad and bandage applied. He was submitted to very careful examination by the means of X-rays, but the report by the Radiographer was that there was no foreign body present in the eye. The patient was, however, kept in hospital in bed upon his back, atropine drops were instilled into the eye night and morning, and a pad and bandage kept constantly on. As the inflammation in the circumcorneal region opposite to the corneal wound in no way lessened, on February 1, it was decided to operate upon the eye. A solution of cocaine was instilled into the patient's right eye. A small incision was made, with a Taylor's knife, through the corneoscleral junction opposite to the corneal wound ; fine iris forceps were then introduced, closed, into the aqueous chamber, and a small piece of iris picked up, including the previously seen bead of lymph. A hard body was at once felt in the blades of the forceps. This piece of iris was very carefully withdrawn and cut off with iris shears. The patient made a complete recovery and the vision is quite normal. A small piece of steel, measuring 1·5 millimetres long and ·5 of a millimetre broad, surrounded by lymph, was found embedded in the iris; the fine point of it, surrounded by lymph, was approximate to the anterior part of the lens capsule. In this case, it will be seen that, although a very careful examination of the patient's eye was made by an experienced Radiographer, no shadow could be seen which might indicate the presence of a foreign body in the eyeball. I take it that the reason that it was missed was because it was so very minute. At the same time, it is interesting to note that, as it was hot, it penetrated the cornea as a *clean* foreign body, and, although it remained embedded in the iris for seven days, it set up no septic process there.

Case 3.—E. F., aged 36, an engineer, was admitted to the Royal Eye Hospital on April 3, 1906, with the following history:—On the morning of April 3, he was going his round at the generating station examining the machinery, especially the pressure gauges. While looking at one of these, his face being within 1 foot of it, the glass pressure gauge, which was partially enclosed in brass, burst. His face was slightly cut, glass lodged in his hair, and both eyes were damaged. Directly after the injury, he plunged his face into cold water, and opened his eyes, in this way freeing himself as completely as possible from glass dust. Within 20 minutes of the accident, he was brought to the hospital, immediately put to bed, and his eyes carefully examined. The cornea of the right eye had the epithelium off in one place, but this eye soon recovered. In the left eye, there was a large penetrating cornea wound, as nearly as possible opposite to seven on the clock face, and through this the iris was protruding, there was no aqueous chamber, due to the fact that its contents had escaped through the cornea wound. Under cocaine, the iris was withdrawn, carefully freed from the margins of the wound and cut off with iris shears. Atropine was then instilled into the eye, and the patient kept quiet in bed; the eye being continually kept under the influence of atropine and cocaine. The pupil dilated sluggishly and incompletely; the lens then became rapidly opaque and further pressed the iris forwards. The eye was then found to be injected in the ciliary region all the way round suggesting a general iridocyclitis, and as this persisted in spite of treatment, it was thought advisable to have the eye carefully examined by means of X-rays. Three negatives were then taken by an expert Radiographer, and the plates carefully developed. In none of these was there any sign of a shadow produced, and the opinion expressed was that there was no glass in the eyeball. The eye was still kept under the influence of atropine and absolute rest in bed was secured for the patient. Under this treatment the eyeball still remained injected and the tension became full + 1, it was decided to allow some of the swollen lens material to escape. This was done under the influence of cocaine, by means of the introduction of a small, short Taylor's knife at the corneoscleral junction just above the original cornea wound. The knife was carefully and slowly depressed, and a considerable amount of lens material allowed to escape. Although the tension of the eyeball became normal, and the eye improved somewhat for a time, yet it did not progress satisfactorily and repeated examination suggested that there was possibly a piece of glass lodged in the cataractous lens after all. The iris now became dull in appearance and the pupil less widely dilated, moreover the cataractous lens did not absorb at all. It was then decided to ascertain whether the cataractous lens did contain any glass or not. The patient was placed under a general anæsthetic, and a small incision made above just in front of the corneo-scleral junction with a long Taylor's knife ; this was thrust into the cataractous lens, and a hard substance felt there with the point of the knife. As the knife was withdrawn the incision was considerably enlarged to the left. A silver scoop was then introduced through the incision well behind the lens, and the remains of the cataractous lens withdrawn together with a piece of glass, which was afterwards examined and found to have the following measurements, 7 millimeters long, 4 millimeters broad at the widest part, and 2 millimeters deep. This proves to be a case, in which a piece of glass of very considerable dimensions was situated in the anterior part of the eyeball, and was not detected by the X-rays, although three different plates were exposed. Dr. A. D. Reid undertook to examine the portion of glass which was extracted from the eyeball, and to endeavour to find out why it was not detected by the X-rays. He reported, however, that lead-glass produces a distinct shadow, which is easily seen, but that soda-glass gives rise to a faint shadow only. This patient has been good enough to submit to me various pieces of "Jena" glass, which is used in the making of these pressure gauges, and also the broken pressure gauge itself; these have been examined by Mr. Stanley Collins, B.Sc., A.I.C., Demonstrator of Chemistry in King's College, London, and he finds that all the samples submitted to him consist of soda-glass. Here then we have the reason why the piece of glass lodged within the lens capsule of the patient under consideration was not detected. At the same time, Mr. Collins pointed out that the piece of broken glass from the ruptured pressure gauge was not clear, and had been *devitrified;* consequently it had become more brittle. This, I am informed, usually takes place after the new clear pressure gauges have been in use for twenty-four hours, and is due to the great heat and high steam pressure to which they are subjected. It is obvious that, in these circumstances, greater precautions than at present should be taken to prevent the inevitable scattering of small portions of glass when such explosions as that referred to, and which are not infrequent, occur.

From the three typical cases quoted, I think we may safely conclude that there may be foreign bodies embedded in the eyeball, which cannot be detected by X-ray examination, either because they are too minute, or because they are not opaque enough to cause a definite shadow; in this latter class soda-glass is included. On the other hand we may detect by means of X-rays pieces of flint and metal, provided that they are of sufficient size to produce a shadow. In the former case, it is practically useless to attempt to localise the foreign body and to remove it, for, as a rule, the eyeball becomes early infected and is soon destroyed as a result of iridocyclitis or panophthalmitis. In the latter case, if the metal is hot when it enters the globe, it may be successfully diagnosed and localised, and, if the eyeball is operated upon within a few hours of the metal entering it, the foreign body may be successfully removed by means of the small hand electro-magnet, and blindness consequently averted.

SOME PRINCIPLES AND FALLACIES OF X-RAY INTERPRETATION.

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Medical Officer, H.M. Prison, Bristol.

[With Plates LXII.—LXIII.]

In every case of a foreign body, whether known to be present or merely suspected to be so, and in every case of an injury to a bone or a joint, the practitioner in charge will be wise early to have his patient X-rayed for timely diagnosis, because if he does not have it done sooner while X-raying is good, somebody else is pretty sure to have it done later. He must understand clearly the nature of the lesion (depicted it may be by a non-medical Radiographer) consistently with the results of more ordinary clinical examination of the case and with its progress; and must be prepared to explain the appearances to others, perhaps in a Court of Law. The responsibility towards his patient and his patient's friends for correct interpretation must remain with the professional adviser, and may not be transferred to any lay person; the latter can only be held responsible for technical faults in exposing, developing, and printing the radiographs so far as blemishes to the plates can be avoided. Towards his medical brethren, and more especially towards his surgical colleagues, the medical Radiographer is under further heavy obligations not to mislead by guesswork, nor to be found in error at the operation table. While he may look forward to some day forming and giving a confident opinion without personal examination of the patient, he can even now often give his surgical friends very definite information not obtainable by any other method of investigation.

Practically the interpretation of that collection of opaque and transparent shadows, constituting a radiograph consists in determining from it (and from the knowledge brought to the task of the parts and processes involved) the order of distance or relative position of nearness and farness—the third dimension—of the parts depicted. In an ordinary photograph

PLATE LXII.

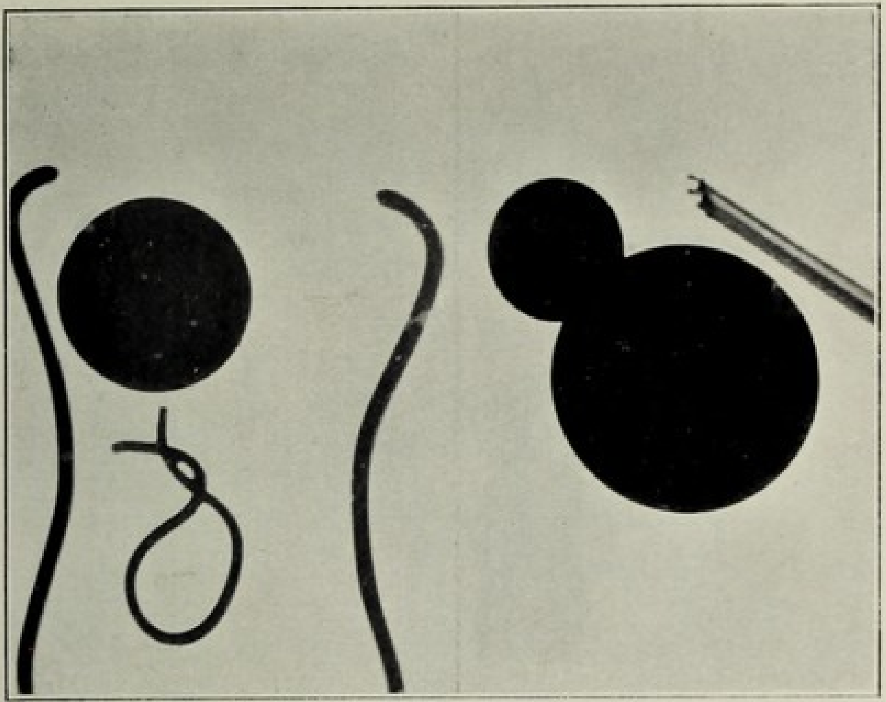

Fig. 1. *Radiographic ambiguity.*

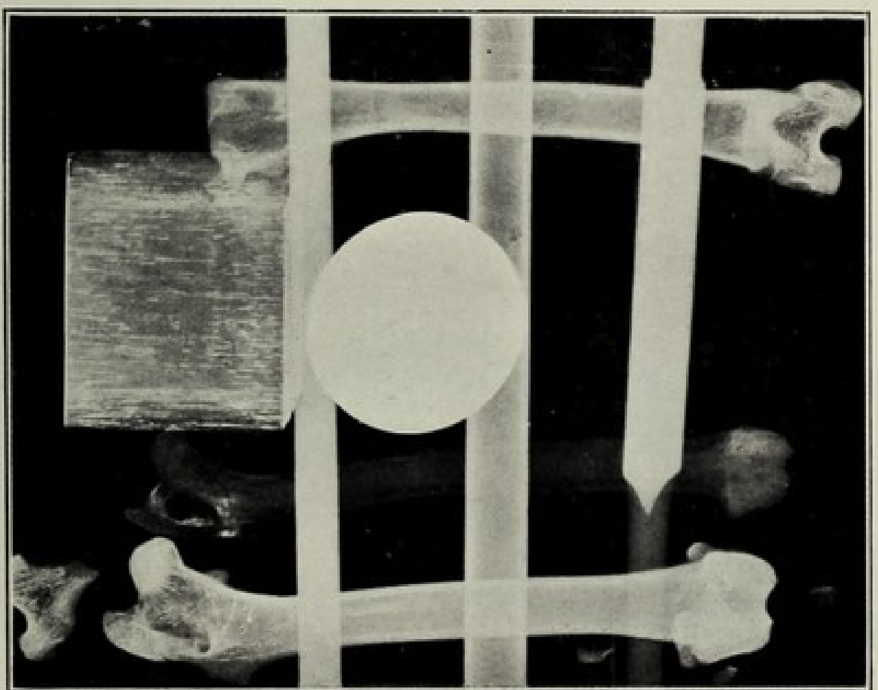

Fig. 2. *Radiographic ambiguity.*

PLATE LXIII.

Fig. 3. *Reduced projection.*

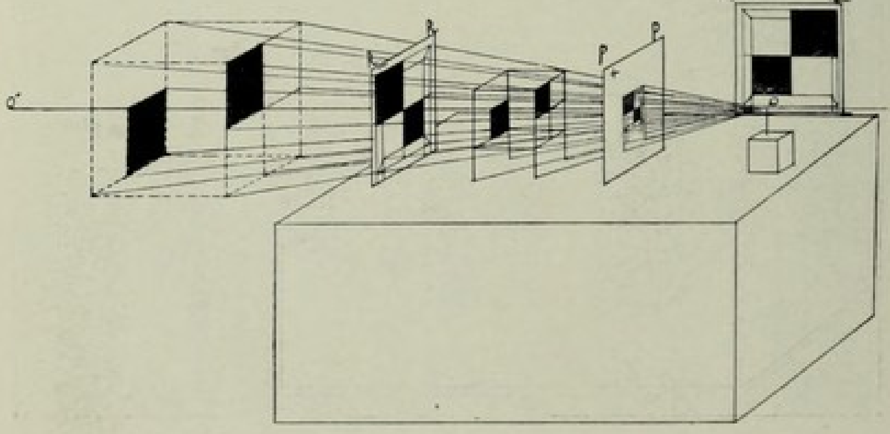

Fig. 4. *Graphic and radiographic projection.*

or drawing, and in actual vision, our judgments of the relative distance from the eyes of the objects viewed is largely due to the fact that opaque bodies partially cover the more remote from the observer, while transparent bodies obscure them. Whereas there, as Helmholtz (in speaking of "Form" in a lecture on "The Relations of Optics to Painting") says, "nearer objects partially conceal more distant ones, but can never themselves be concealed by the latter,"[1] it is not so in the back of beyond region of shadow projection. Here opaque bodies eclipse everything opaque or transparent both between them and the source of illumination and on their far side therefrom, while transparent bodies indifferently obscure each other, one through another. There is thus in every radiograph an essential ambiguity to be solved of near and far, which can be solved mainly by the appreciation of Perspective and its stereoscopic development, and subsidiarily by the indistinctness and distinctness of the objects depicted.

Thus in Fig. 1, the overlapping outlines of two coins and a piece of twisted wire mutually disappear, a mode of representing things not unknown to caricaturists and advertisement designers. Thus also, by an effort of will, the bony shadows of Fig. 2 can be visualised as being either in front of, or behind, the transparent bars lying across them. These conditions are schematically shown in Fig. 1 alongside of the respectively corresponding images in ordinary drawing. In Fig. 2, again, the opaque disc appears to be in front of two of the transverse bars, whereas in the actual experiment the disc was placed over the one and under the other. This fallacy of X-ray representation is an unfailing trap for the unwary surgeon. Although, according to ordinary graphic convention, the fragment of a needle in Fig. 3 must be nearer than the bones, there is no warrant for such a conclusion under the conditions of Radiography in any single radiograph by itself alone; the only valid conclusion from the solitary radiograph being that there is a foreign body in a certain ascertainable direction. The ambiguity of the position of the foreign body in such an example, when its real dimensions are unknown, can be resolved only by stereoscopic or allied methods.

In Fig. 4, an endeavour is made to demonstrate (so far as is possible from a single diagram) some of the chief relations of a projected shadow with an ordinary image (using the word image in the draughtsman's sense of the word image) in the case of an easily recognisable geometrical figure at once visible and portrayable by X-rays. This common object is a wire framework of cubical shape with two opposite sides distinctively marked as shown. O is, in the first instance, the station point either of the anticathodal centre of emission of a focus tube, or of a small flame in a dark room. Beyond the object from O is the screen RR, on which a prominent shadow of the object has been thrown; this screen is a radiographic or shadowgraphic plane of delineation. Next (the luminous body being removed), an observer (with one eye at O) could draw, or have photographed with camera lens at O, an image of the object on an intervening screen PP—a photographic or graphic plane of delineation. Now it is found that, so long as these two planes are parallel and however they may be moved, the shadow projection on the further one differs from the image on the nearer in size and not in proportion, the two images being geometrically *similar* to each other, and of course both in strict Perspective. The shadow on the farther screen is, as regards outlines, an enlargement of the image on the nearer, and the image on the latter is a reduced copy of the image on the former.

Thus, to those who find it confusing to think out the relations of a radiograph as a shadow of objects originally between the plane of the radiographic plate and the focus tube, objects since removed, two alternatives present themselves. In the first place (as has been done in Fig. 3), the radiograph may be diminished in size by photographic process to a graphic plane, and may then be considered as the image of the original object on the farther side. Otherwise (according to the illusion sought by the shadow-graphist when the spectators sit between the artist and the white sheet on to which he manipulates the shadows of his fingers) the image on RR is not merely the shadow of a real object between RR and O, but may also be legitimately considered the image of an enlarged ideal, virtual, or imaginary model of the original object somewhere in the position and somewhat of the dimension of the dotted cube to the left of the diagram Fig. 4.

In either case, according to knowledge otherwise derived of the normal structures of the human body, the outlines of the bony parts depicted can be pencilled in correctly, those parts being considered to be nearer or farther from the plane of the observer as were originally nearer or farther from the plane of the focus tube at the time of taking; the nearer outlines being drawn in continuous and the farther ones in broken lines, according to a useful convention of technical drawing. Other things being equal, in this procedure the skilled draughtsman of the human skeleton ought to excel.

It is probable, from its being an enlargement, and from the tendency there is to hold it closer for inspection to the eye than need be, that a primary unreduced radiograph gives an exaggerated idea of the extent of a lesion, as if, for instance, one were to enlarge a small photograph of a boil to half or whole plate size and then to trim the edges of the resulting print to quarter plate once more, thus conveying to the mind the idea of a carbuncle. It is advisable, for this and other reasons, not to show to one's patient the radiograph of his injury till he is well on the road to recovery.

Yet again, in our diagram, Fig. 4, if the graphic image on P.P., viewed from the side towards O, is a photograph, then it is a photographic positive or print (+) correct in form and tone (black on white); likewise the image on R.R. viewed from the side towards O, is obviously in the matter of form the primary radiographic negative (—), the tone (white on black or black on white) depending respectively on whether R.R. is a developed sensitive plate or an ordinary screen. In other words, it is the Radiographic Negative that corresponds with the Photographic Print (or drawing) in the matter of form. If, therefore, our cube is called a "right-handed" cube, and the cross-wired side is called its back, then the two screens, when viewed from the side nearer O, are pictures of a right-handed cube viewed with the back nearest. In the same way, viewed from the far side from O (from the side nearer O′), the two screens would represent a left-handed cube viewed from its back, not a right-handed cube viewed from its face, which would have a very different appearance. The argument is simply (*a*) that the other side of a picture—the reversed image —is not the picture of the other side of the object depicted, and (*b*) that what is sauce for the photographic goose is sauce for the radiographic gander. To the right of the diagram behind O (marked R.R. +), is drawn the appearance of the far side of R.R. remote from O, practically the image formed on the fluorescent screen, correct in tone but reversed in form. With the fluorescent screen there is only Hobson's choice, there not being sufficient clearance to view the screen from any side but the side remote from the focus tube while the objects are being X-rayed, and the image of course vanishing with the removal of the objects. It is quite probable that the use of the X-ray print, as correctly representing the object behind it, is entirely a mistake; and it is not difficult to see how the mistake arose. If we liken the appearances on a fluorescent screen to the shadows of intervening objects thrown on a window blind by a bedroom candle which can be viewed only from the outside, it would be found, if the blind were pulled up, that the outlines and aspect of the objects portrayed would be very different, not only in size but in proportion, from a drawing or photograph made by the outsider, though no doubt he would try in some way to odds it even between his ideas and the reality, as most Radiographers have been doing up till lately. We have in fact been working from the wrong or fluorescent screen side of the Radiographic Plane, that is the side that would not consistently correspond with the visual appearance if the objects were visible.

I would respectfully, therefore, submit Fig. 4 to those interested in the subject, asking them to mentally substitute the translucent skeleton of a right hand with its back towards O in place of the cubical framework of wire, and to work through the different cases of right and left and back and front. It might, of course, naturally be objected that it really does not matter whether we X-ray an object from back or front, say, a hand or thorax; surely the two resulting (opaque or transparent) silhouettes could by some twisting and turning be got to coincide. A glance at Fig. 5 will show the fallacy of this opinion. The object to be taken here is a hand with two small sesamoid bones on the surface of the index and little fingers, and a small bullet, Q, towards the back. The hand is first X-rayed from O_1 on plate R_1, and subsequently from O_{11} on plate R_{11}, the distances in both cases being the same. Q has purposely been shadowed along the normal axis of projection O_1 to O_{11}; the sesamoid bones, however, came out on different

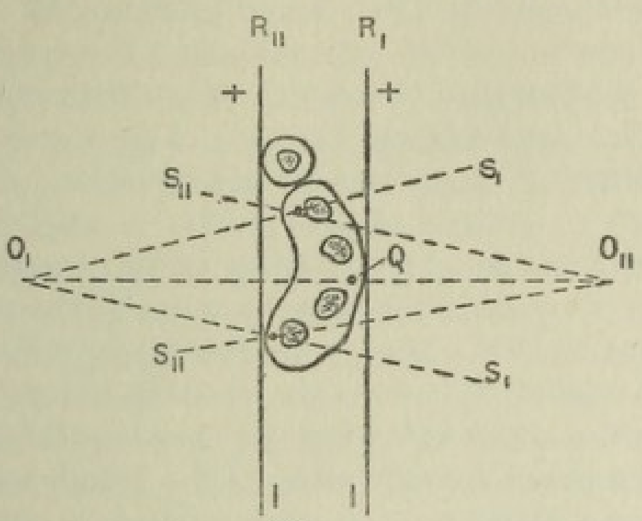

Fig. 5.

levels upon the developed plates, namely, as S_1 and S_{11}, and s_1 and s_{11}. Now it is evident that, unless the hand was infinitely thin, or O_1 and O_{11} infinitely distant, however we may place R_1 and R_{11} against each other, the shadows of more than one point at a time can never be got to coincide accurately. Unlike solar, radiographic projection is radiating, and not parallel nor "orthographic."

The use of an X-ray photograph viewed from the side opposed to that of the focus tube, that is, of the print, leads to error in determining, from a single radiograph, the direction in which to search for a foreign body, *e.g.*, in Fig. 6 is shown

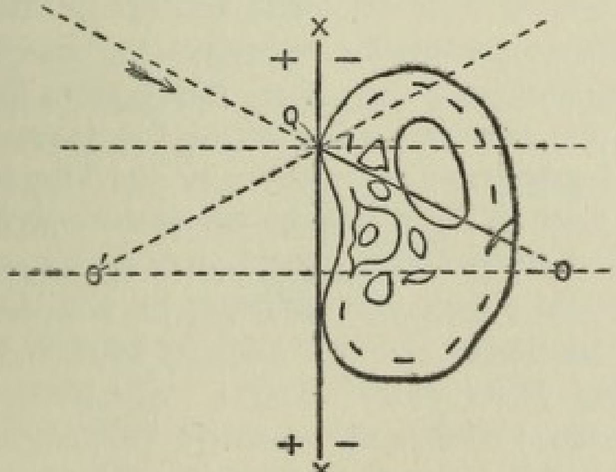

Fig. 6.

a portion of a patient's trunk being X-rayed on a plate, XX, by a focus tube at O. On this plate at Q is developed the shadow of a foreign body, say, a small bullet. All we know is that somewhere within the patient along a line (really a cone) joining the shadow with the centre of emission that was, is a foreign body, but to anyone viewing the photograph from the side away from O (say, from O′ corresponding to O) there would happen an entirely erroneous idea in what direction to search for the bullet. Trying along O′ Q, a surgeon would entirely miss his quarry unless it lay close to Q, or unless Q were adjacent to OO′. He would also disconcertingly fail in attaining his object if he were to try along the perpendicular to XX at Q, the arrow indicating the only hopeful direction to search for the bullet, namely, along Q O. I may mention here that Mackenzie Davidson's bi-polar method of localisation—really a stereoscopic method involving a double exposure—depends, for correct reconstruction of the position in space of the foreign body, upon working carefully on the negative side of the radiographic plane.

It is evident that, for a radiograph to be of full value as a witness of fact, certain elements are requisite to be known, namely, (*a*) whether it is a positive or negative, that is, a reversed or a direct image; (*b*) the position of the point of sight or point where the normal ray, or ray perpendicular to the plate, cuts it; and (*c*) the part of the patient nearest the centre of the plate. All these might very well be registered on the plate at the time of taking, so as to be indelibly impressed, together with the name and age of the patient and the date. These particulars, excepting the second, are most elegantly recorded by writing them direct upon the light-tight envelope of the sensitive plate facing the tube, with an ink composed of subnitrate of bismuth, or the like, suspended in gum. The point of sight may be simultaneously indicated by a small cube of wood placed square on the plate, with metallic strips along the edges perpendicular to the plate, at once guiding the interpreter to the vanishing point of lines perpendicular to the plane of delineation. The point of sight, of course, does not coincide, unless accidentally, with the centre of the plate, as it does, as a rule, in ordinary photography. Such devices are illustrated in Fig. 3, which represents a radiographic negative reduced in size to a graphic plane, and corrected in tone by the simple expedient of photographing the original radiographic prints and reversing the plate of the reducing camera before printing finally. The object taken was a right hand X-rayed from the dorsal aspect. I usually now employ a simpler piece of apparatus, an accurately cut wooden cube about an inch in the side, thickly dusted with bismuth powder.

The general theorem of radiating perspective is: "Things grow smaller in appearance the farther off they are. Moreover, this lessening is progressive and uniform. Therefore, if objects of equal height are to be represented as they " should " appear to the eye, they must be drawn of different heights, the nearer higher than the more remote; and the same applies to width." [2] The present problem is to determine from a given radiograph the relative distance of the object depicted. Thus, in the X-ray outlines of Fig. 7, when once an assurance

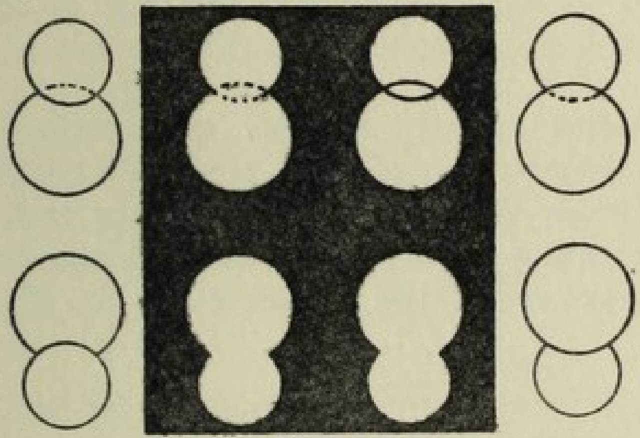

Fig. 7.

is given that the discs represented are equal in diameter, it is at once known that the apparently smaller must have been farther from the plane of the focus tube at the time of taking than the other. On the same principle, when two fairly cylindrical bones of unequal size parallel to the plate are of equal dimensions, as measured with the divider on the plate, then the more slender bone must have been nearer to the plane of the focus tube than the other when the radiograph was made. In like manner, of two spherical bullets the same size, the apparently smaller must then have been nearer the plate. In the case of a fracture, the two opposite sides of the fissure must be of the same dimensions; the apparently larger end, when that can be satisfactorily determined, *i.e.*, when we are pretty certain that no considerable rotation has taken place of a somewhat irregular shaft on its long axis, must have been nearer the plane of the focus tube when the limb was X-rayed. I do not know whether Fig. 8 (a tracing of an actual radio-

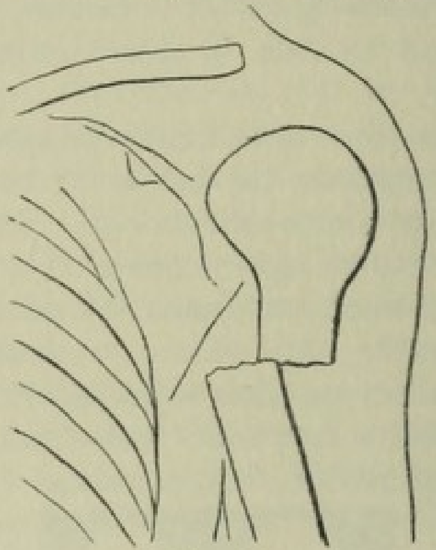

Fig. 8.

graph published recently without any details given as to side of the body or aspect)[3] is a print or a negative; but it is almost certain that the lower end of the broken head of the humerus was originally farther from the radiographic plane than the upper end of the broken shaft. In Fig. 9, I have

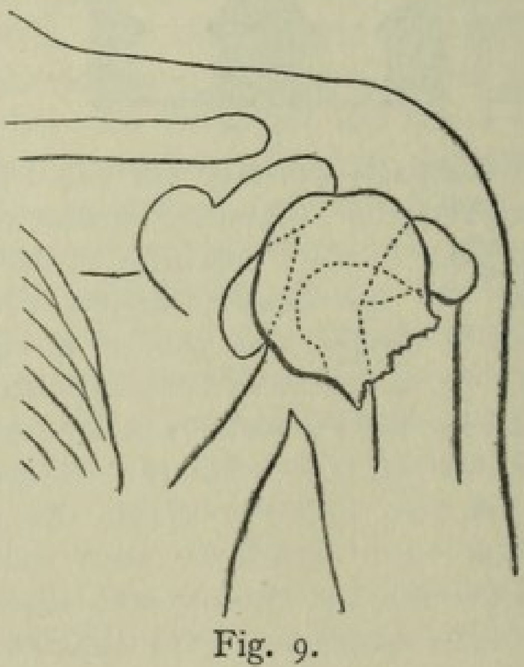

Fig. 9.

ventured further ; assuming the reduced radiograph published[4] to be the reduction of a radiographic print, then clearly this patient had a "fracture of surgical neck of the" left "humerus with displacement outwards and backwards of the shaft." If this tracing is held up to the light and looked at through its back, then the representation as pencilled becomes one of a right fractured humerus, viewed in both cases from the anterior surface of the shoulder. I may say that the plane of the fracture, as represented from above downwards and forwards, is somewhat conjectural, and warranted from surgical rather than from perspective considerations.

Under the ordinary conditions of the time and range of exposure, parts nearer the plate come out more sharply outlined than parts more remote. This phenomenon is a very intricate one, but it is mainly due to the fact that the radiographic centre of emission is not a minute point, but a small surface of sensible area, radiating from every minute point of that area. I have attempted to elucidate the matter in Fig. 10. The sketch under O_1 indicates what

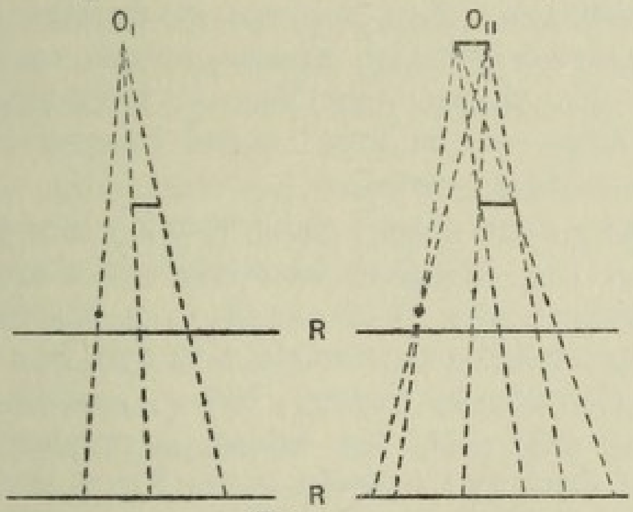

Fig. 10.

might be expected to happen if the radiographic centre were a small point ; that under O_{11} what does actually happen in X-raying, for example, a small bullet and a small disc on Plates R and R at different distances. In radiographing a thorax (Fig. 11) the wall next the focus tube, in this case the anterior wall, actually becomes indistinguishable, and we have a vague shadow of the heart superposed upon comparatively sharp outlines of the vertebral bodies and spine.

and the heads of the ribs. In this figure, as in Fig. 4, P.P. stands for the graphic and R.R. for the radiographic planes,

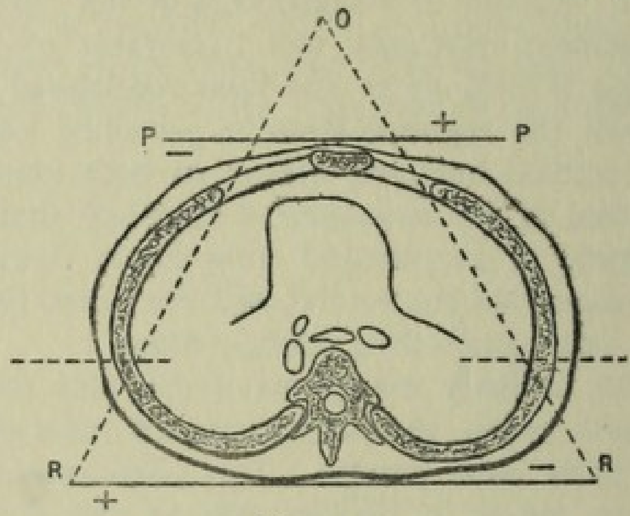

Fig. 11.

and the signs + and – indicate the existing nomenclature of the near and the far sides of these planes respectively. The outlines of the equilateral triangle indicate the limits beyond which perspective becomes exaggerated, or what is erroneously styled distorted, namely, outside an angle of 60° at O. If this thorax were X-rayed from behind, in the resulting radiograph the spine would become obscure and the cardiac outlines sharper.

I may here conveniently quote from a recent paper of my own :—" . . . . According to recognised clinical methods, the percussion outline of the heart in a big man is fairly *similar* to and reliably comparable with that in a small man, apart from alteration by disease. But . . . unless the distance of the focus tube from the subject is proportional to the thickness of these two individuals, the X-ray shadow outline on the chest of the one man is not truly *similar* to or comparable with that on the other. And further . . . the percussion outline and the X-ray shadow outline of an internal organ do not appear to be even mathematically *similar* or directly *inter se* comparable," the respective symptoms of Projection being entirely different.

The sub-title of this paper might very well be "An Introduction to the Use of X-ray Stereoscopy." Examined through a lenticular stereoscope, Fig. 3 exemplifies the advantage of the method, namely, the immediate visual appreciation of all parts native and foreign in their actual relative positions. In this particular example, there are not merely partial and total silhouette outlines, but some indication of surface contour and of the grosser structure of the bones. To say, after tedious and complicated mathematical reasoning, that a fragment of glass is so many millimetres from some arbitrary and inconstant mark in the skin is one thing; to describe its position in relation to permanent bony landmarks in ordinary intelligible surgical language is another. And this is the great advantage of stereoscopic over other methods of localisation. In viewing this reduced stereoscopic example we see, not the original hand, but a diminished model of it nearer the observer.

To sum up :—

(1) In every radiograph there is inherent an ambiguity of near and far which cannot be solved by inspection alone.

(2) So far as it is an enlargement, a radiograph is an image of an enlarged model of the actual object, and may be usefully reduced to ordinary graphic proportions, that part being looked for as nearer the plane of the observer as was originally nearer the plane of the focus tube at the time of taking.

(3) The radiographic negative corresponds with the photographic print in being a direct image; the radiographic print, or fluorescent screen of ordinary usage, as such gives a reversed image like the back side of a drawing, and may lead to erroneous estimates of direction and relative distance.

(4) The Perspective is similar to that of ordinary drawing, and the original position of the focus tube is the correct station point of the observer's eye.

(5) Every radiograph ought to have automatically registered on it certain elements at the time of taking.

(6) In certain cases, the essential ambiguity of the single radiograph may be resolved by knowledge of normal structure and arrangement, by perspective rules, and by relative distinctness of parts depicted; but in all doubtful cases an appeal lies by stereoscopic methods to binocular judgment.

For the originals of Radiographs in Figs. 2 and 3, I am indebted as usual to Mr. Thomas Clark. They were produced by an Electrical Influence Machine, designed and constructed by himself, as described in the *Archives of the Röntgen Ray,* for November, 1899.

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[4] *British Medical Journal,* June 16, 1906.

X-RAY DERMATITIS, ITS PREVENTION AND TREATMENT.

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THE uninitiated find it difficult to understand that the apparently feeble emanations, which proceed from an X-ray tube in action, have a potency for good, and evil, which experience only has taught us to respect. Want of experience, together with an under-estimated value of the properties of the rays, has been the cause of many serious accidents in the past, and, as a result, many have been maimed for life, who might have escaped injury if we had had, in the early days, the knowledge which we now possess. Even now our knowledge is very limited, but it is sufficient to protect ourselves and our patients from running serious risks, provided that the rays are applied in a scientific manner.

It is a well established fact that every therapeutic agent which is capable of producing good results, is, if improperly used, also capable of producing harmful ones. Indeed it may be said that an agent, which, when wrongly administered, cannot produce ill results, cannot bring about good ones, no matter how it is administered. In the scientific administration of harmful therapeutic agents, results are obtained which could never follow from the giving of drugs which produce no effects, good, bad, or indifferent.

In the X-rays, we have at our disposal an exceedingly powerful therapeutic agent, the effects of which can only be guided by an intimate knowledge of their properties, by scientific administration, and by experience. The production of ill results in the early days was due to wrongful administration through lack of knowledge.

During these early days, I must admit that fortune favoured me in one respect, inasmuch as the only X-ray dermatitis I produced (excepting in a few cases in which it was purposely developed) came home to myself, but I freely admit that, in the light of our present knowledge, I escaped doing serious injury to several kind friends who allowed me to radiograph them. Ten years ago, I gave several exposures of an hour's duration with a Jackson's tube fixed within a few inches of the unprotected skin; using a coil capable of giving a 15-inch spark, through the primary of which 8 ampères of current, at a pressure of 12 volts, passed. With our modern tubes and apparatus, such an exposure would be criminal, yet only a few months back my attention was drawn to a severe case of dermatitis due to the administration of such a dose. I attribute my not producing a dermatitis in the cases mentioned above to the fact that I used a large coil, as it has recently come to our knowledge that a small coil and tube are more dangerous than the larger outfits.

X-ray dermatitis is divided into two classes: "acute" and "chronic." These differ widely from each other both as regards symptoms and methods of treatment. The acute form is nearly always produced upon patients, whilst the chronic form is only seen upon operators. I have never yet seen a case of chronic dermatitis upon a patient, although some have been subjected to a very large number of exposures. An acute dermatitis may be produced upon any part of the body, whilst the chronic form is but rarely seen anywhere but upon the backs of the hands. It does not follow from this statement that the chronic form cannot be produced anywhere, and it may be that, in some rare instances, a chronic X-ray dermatitis has been produced upon patients, who have been subjected to treatment. The reason why chronic X-ray dermatitis rarely appears anywhere but on the hands is obvious, and is due to the fact that they are constantly placed near the tube and receive the most intense radiations. It is not my intention here to enter into any discussion upon the question of the particular rays which, emanating from a Crookes tube in action, produce deleterious effects. It is known that, by careful filtration, ill effects can to an extent be avoided, but it has not been proved that this filtration does not also cut out those rays which do good, in other words we have good reasons to believe that the rays, which produce deleterious effects, are those which also produce good ones. We have reasons for believing that, what we call the X-rays, are not a beam of rays exhibiting measurable properties, but a bundle of rays, each capable of exhibiting immeasurable and diverse properties. These rays have still to be sorted out, and we may find that, in the future, we shall be able to produce the results we require at will. The fact that the X-rays affect a photographic plate, whilst they fail to produce any effect upon a "printing-out" paper is a significant one, which proves that their action is very different from that of the sun's rays. In this paper, in speaking of X-rays, I include all the rays which emanate from an X-ray tube in action.

Acute X-Ray Dermatitis arises as the result of too prolonged, or too frequently repeated exposures within a limited space of time. By a prolonged exposure at a short distance from an excited tube a sufficient amount of damage to the tissues can be brought about to culminate in the death of the patient.

Granted that the exposure is long enough, and that the parts are placed near to the tube, an acute X-ray dermatitis can be produced upon anyone, notwithstanding the fact that idiosyncrasy plays an important part in its production.

It has been said, by some writers upon the subject, that an acute X-ray dermatitis may show itself during, or immediately after, a prolonged exposure to an intense radiation. I have never seen, in my experience, any signs of injury present themselves during an exposure, and, in only two instances, have I noticed a slight erythema occurring a few hours afterwards. In both of these cases, the patients were in an exceedingly feeble condition owing to prolonged illness. In several cases, I have given a lengthy exposure for the purpose of producing a marked dermatitis, and, even in these, no symptoms have manifested themselves until from 7 to 21 days after radiation. Freund gives the time in which the hairs fall out after a strong radiation as varying from 3 to 14 days. As hair, however, can be removed without the production of a severe dermatitis, which need not necessarily produce the results of an ordinary burn of the second degree, the exposure given to produce epilation is not sufficiently large to cover the whole field of X-ray burns, which I wish to include in my category.

The pathological changes in the superficial tissues, which follow prolonged exposure, are exceedingly complex and ill-understood, and, in order to enter into a discussion upon them, it would be necessary to cover the whole field of radio-therapeutics; I will, therefore, content myself by mentioning the easily recognised symptoms of over-exposure, still bearing in mind the factor of idiosyncrasy. The visible effects upon the skin are:—

1. Pigmentation.
2. The shedding of hair.
3. The production of a mild erythema.
4. The destruction and shedding of epithelium.
5. The formation of an ulcer.
6. Complete destruction of the skin and necrosis of some of the underlying tissues.

The severity of the symptoms produced by prolonged exposure depends (apart from marked idiosyncrasy) upon:—

1. Nearness of the tube to the exposed part.
2. Length, number and frequency of exposures.
3. The condition of the tube. (Hard or soft.)
4. The general health of the patient.
5. The efficient protection of the parts around the area rayed.
6. Previous applications of the rays.

The effects, first noticed after an abnormal exposure, and which make their appearance at a variable interval afterwards, are tingling, itching, turgescence, pigmentation, redness, increased temperature, shedding of hair, smarting, and burning. The patient usually complains of one or other of these symptoms a few days, or hours, before a severe burn makes its appearance. Later the parts may become inflamed and exceedingly painful, and may ultimately slough and produce an ulcer, which is not only exquisitely painful, but most difficult to heal.

This ulcer may be only superficial, or it may involve the whole thickness of the skin and some of the tissues beneath. If such an ulcer is deep enough to have passed through the skin, it sooner or later (unless the most stringent precautions are taken to prevent it) assumes chronic characteristics which point to its method of production. The surface becomes covered by an exceedingly tough and adherent wash-leather coloured deposit, which is most difficult to remove, the slightest touch upon the surface of which produces the most intense pain. The difficulty of removing this leathery deposit is so great that, in two cases under my care, I have administered an anæsthetic, and applied acid nitrate of mercury over the whole surface. After such an application, a slough separates in a week or two, and, if great care is taken, a healthy granulating surface may take its place. The pain experienced from the ulcer is great, and nothing appears to entirely relieve it. Exclusion of air, however, renders the sore much more bearable. In a series of four cases (in none of which the ulcer exceeded 2 inches in diameter) over twelve months' constant care and attention were necessary to bring about complete healing. During the last five years I have not produced, either accidentally or intentionally, a sore of this class, but, if I did, I would try the effect of scraping the whole surface under an anæsthetic, and subsequently treating it upon strictly antiseptic principles. Most of the severe ulcers I have seen have been produced purposely, only a small area of the skin being attacked, the greater part having been protected during the exposure. I have seen one or two cases of accidental burns, in which a large ulcer resulted; in one instance it covered the whole of the front of the chest and the upper half of the abdomen. I am sorry I cannot say how this case ended; I saw it only once, and have since been unable to obtain any news of it.

In these large accidental X-ray burns, the ulcer is not, as a rule, very deep, and the leathery deposit, previously mentioned, may not show itself. They are covered with yellow, unhealthy, granulating tissue, and freely secrete a large quantity of very thin pus. In a large burn, which has been produced at a very short distance from the tube, we may get a deep necrotic ulcer in the centre, gradually merging into an area of very superficial ulceration, and, outside this, an area of erythema with an edge of pigmented skin. I always look with suspicion upon an ulcer said to have been produced by the X-rays, from an unprotected tube, in which the surrounding skin is healthy, and shows no signs of pigmentation, or of having received damage.

Most of the cases of acute X-ray dermatitis, which I have seen, have been produced during the process of radiographing for the purpose of diagnosis. At the present time, with up-to-date apparatus, the patient should run no risk whatever from the operation of taking a radiograph. The length of exposure, necessary to take a radiograph through the thickest part of the body, is so short, that no harm can be done even to a patient who has a marked idiosyncrasy to the Roentgen rays. With my apparatus in perfect working order, I find that an exposure of from ten seconds to two minutes, the tube being placed at a distance of from fifteen to twenty inches from the skin, amply sufficient; and, even when the apparatus is not working well, I never exceed an exposure of three minutes. I have never known such an exposure produce harmful effects, and, in only one instance, have I seen any symptoms result. This occurred in the case of a very stout gentleman whom I radiographed for renal calculus. Owing to the existence of a persistent cough, the radiograph was not so good as I could have wished, and I had to request him to visit me again. Some weeks later he called upon me, and I was surprised to find upon his abdomen a well marked circular patch of pigmentation, which corresponded with the opening in my diaphragm-compressor. The patient had not noticed it himself, neither had he had any symptom to complain of. This case goes to show the presence of a very marked susceptibility to the effects of the rays, and points to the fact that, even under the most perfect conditions, one must proceed with the greatest possible care.

The production of an acute X-ray dermatitis, during the process of making a diagnosis, can only be brought about by the rays having been improperly applied as the result of either negligence or ignorance.

There is a very great difference between an acute dermatitis produced upon a healthy surface and that produced upon a diseased area. I have seen no trouble arise from the production of a limited dermatitis upon a diseased skin. In two cases of ringworm, for instance, I have produced rather more reaction than desired, without ill results; while in two cases, in which a slight dermatitis was produced upon the chin in an attempt to remove an abnormal growth of hair, a lengthy course of after treatment was necessary.

It is worthy of notice that an X-ray burn, produced upon skin immediately over bone, is exceedingly difficult, and in many cases impossible, to cure. The greatest care should therefore be exercised in applying the rays in such positions.

Acute X-ray dermatitis is absolutely avoidable, when the rays are used only for the purpose of diagnosis, and, should it occur, the operator has only himself to blame. A full knowledge of the apparatus at his command, combined with experience, should enable him to steer clear of all danger, and, in the near future, acute X-ray burns, as distinct from a limited erythema, should be unknown.

The results of even a slight erythema upon the healthy skin persist for a lengthy time, especially in cases in which pigmentation is also present. I have known several cases in which the area attacked could be clearly defined months after all inflammatory symptoms had passed away, and in one or two instances, the ring formed by the hole in the protective screen is now visible, although between two and four years have elapsed since X-ray treatment was discontinued.

Treatment of Acute X-Ray Dermatitis.—For a simple erythema, I find nothing so effective as the frequent application of an evaporating lead lotion. If this is applied immediately the first symptoms manifest themselves, and, if it is constantly applied for several days, no serious results will follow, provided that the overdose administered is not a large one. Should the dose be sufficiently large as to produce a burn of the second or third degree, the persistence in this treatment for so long a time as possible, will tend to minimise the ultimate results, and will comfort the patient. Should a superficial ulcer occur, every effort must be made to protect it from the air, otherwise the patient will obtain no rest, day or night, from the severe pain. Very superficial ulcers, in which the epidermis only is shed, are best treated as are ordinary scalds, or burns, from which however they differ very greatly, in being far more painful, and far slower to heal. They require constant care, and every effort should be taken to keep them as aseptic as possible. A severe dermatitis, such as results in the formation of bullæ, should be treated with lint, soaked in lead lotion and opium, this being covered with guttapercha tissue, or oiled silk. The only commonly used dressing, which has in my hands produced bad results, is boracic acid; this I never use to dress either X-ray or light burns, unless it is necessary to keep up irritation. When an ulcer does not exhibit the characteristics, which I have previously described as being those of a well-defined X-ray burn, I have obtained good results from dressing it, in the first place, with carbolic lotion (1 in 60) and later with lotio rubra.

The treatment of X-ray ulcers, which have penetrated through the skin, and which have assumed the characteristics of chronicity, is exceedingly difficult and unsatisfactory. Provided that the patient's health is good, and that the ulcer is situated in a suitable position, I would advise the administration of an anæsthetic, the removal of the wash-leather deposit by means of a Volkmann's spoon, a thorough cleansing of the parts, and subsequent antiseptic dressing, great care being taken to exclude air. Our experience of this class of ulcer is so small that it is next to impossible to lay down any hard and fast rules for treatment, in several cases, however, which have been brought to my notice, twelve months' constant care and attention were necessary to bring about a complete cure.

The Prevention of Acute X-ray Dermatitis.—As I have previously stated, there should be no danger whatever from an exposure such as is necessary to produce a radiograph for the purpose of diagnosis, provided that an efficient apparatus is used. The only recent accidents, which have been brought to my notice, have resulted from using a small coil and tube for the radiographing of thick parts, for which such an apparatus is unsuitable. I have known several burns result from a lack of photographic knowledge on the part of the operator. It is a matter of common knowledge that novices at photography frequently mistake over- for under-exposure, and, as a consequence, lengthen their exposures instead of shortening them. As no satisfactory result follows such a procedure, the part is not infrequently radiographed three or four times, with the result that the total exposure has overstepped the safety limit, and a dermatitis results. An X-ray apparatus in the hands of a surgeon, who has no knowledge of photography and electricity, constitutes a great public danger. It is now pretty generally recognised that a special training is necessary in order to fit a man for the successful carrying out of X-ray work, and the sooner that a knowledge of electro-therapeutics is made a necessary part of medical training the better for the public and profession alike.

In order to avoid accidents, when using the X-rays for diagnosis, the following points must be kept in mind :—

1. The coil should give at least a 10-inch spark, and be used in conjunction with an efficient interrupter.
2. The tube should be specially chosen to produce the result required.
3. A soft tube should never be used to radiograph through parts which require more than a few seconds exposure.
4. The tube should never be placed nearer than 12 inches from the skin.
5. The most rapid plate obtainable should be used for all but the thinnest parts of the body.
6. Never take more than two radiographs through a thick part at a sitting. A soft tube gives the best results in radiographing thin parts, such as the hand, wrist and toes; but it should on no account be used for the thicker parts.

In speaking of the most rapid plate, I do not refer to the extra rapid plates known to the photographer, but to the special plates prepared only for X-ray work. In my experience, the ordinary "Extra Rapid" plate is frequently far slower than the "Ordinary" plate; thickness of film being a desirable quality for our work. There are many brands of special X-ray plates on the market, but I refrain from giving any one a gratuitous advertisement, because there is ample room for improvement in all of them.

To formulate rules for the guidance of other workers as to the length of exposure necessary to produce a given result, is a matter of impossibility unless the exact conditions, under which each individual operator is working, are known. There are so many factors, connected with each installation, which differ from every other, that it is absolutely impossible to form an opinion without having a full statement of facts laid before one. Under the most favourable conditions, however, the necessary exposures should not greatly exceed the following :—

Hand and toes - -	10 seconds.
Wrist - - - -	15 "
Ankle - - - -	20 "
Arm and leg - -	30 to 60 seconds.
Knee and lower part of thigh -	1 minute.
Shoulder - - -	2 minutes.
Hip - - - -	2½ to 3 minutes.
Head - - - -	3 minutes.
Chest - - - -	2 to 3 minutes.
Renal calculus - - -	3 minutes.

These exposures are only intended as a guide to those using an efficient apparatus, and special "X-ray" plate, when dealing with a normally developed adult subject. Should they not be exceeded little or no danger can arise from giving a single exposure with any apparatus which is capable of doing the work required of it.

It has been stated on good authority that the placing of an earthed aluminium plate, or a thick piece of leather, between the tube and the part to be radiographed does away with all risk of producing a dermatitis. That both aluminium and leather filter out some of the rays I have no doubt, but from a radio-therapeutic point of view, I have grave doubts as to whether or no these filters do not cut out the very rays which produce the results we require. We have much to learn on this subject. It may be taken as an axiom that, in taking a radiograph for diagnosis, the shortest possible exposure compatible with the production of good results, is to be aimed at.

Chronic X-Ray Dermatitis occurs only in operators who are constantly exposed to the X-rays, and who take no precautions to protect themselves from their deleterious influences. The present sufferers are to be found amongst the early experimenters, whose ignorance of the properties of the rays led them to unduly expose themselves to their influence. It occasionally comes on as the result of an acute attack aggravated by subsequent exposure, but, as a rule, it has come on gradually, commencing with a slight erythema, which was attributed to other causes, and which, on these grounds, failed to impress the enthusiast with the danger he was running until it was too late to take the necessary precautions.

The disease generally occurs upon the dorsum of the hands, and, as a rule, arises from the common practice of many operators of employing the hand in front of the fluorescent screen as an aid to judging the penetrating power of the rays. Apart from this the hands are, as a rule, brought nearer to the tube than any other part, and, moreover, they are not protected by clothing. During these exposures, which end in such disastrous results, the operator experiences no signs that he is damaging himself until the dermatitis makes its appearance, when it is too late to rectify matters. Next to the hands the face suffers most. The skin, as a rule becomes red or tanned, but, beyond slight symptoms of itching or warmth, I have only in one instance seen anything occur. In this particular case, an ulcer was produced upon the chin, and, as showing that clothing protects to a slight degree only, a severe burn also occurred on the front of the chest.

Several cases, in which the vision has been impaired, have been recorded, and one of my colleagues developed a mild acute ophthalmia from examining a hand with the screen for about ten minutes; the patient developed no symptoms from the examination.

The effects of chronic X-ray dermatitis differ considerably in different individuals, the symptoms, however, remaining much the same. It is one of the most persistent, painful, and disfiguring maladies with which it has been my misfortune to meet, and although, in the light of our present knowledge, it is avoidable, there appears to be little or no hope for those who have contracted it.

The disease, so far as the hands are concerned, generally makes its first appearance in the form of a mild erythema around the roots of the nails. When this symptom first appeared, in my case, I wrongly attributed it to the effects of the metal I was using in my developer, never dreaming that it was the direct effect of the rays themselves, and consequently I took no precautions. This erythema gradually becomes more marked, and, as the nails grow, they are marked with transverse and longitudinal lines; they become excessively brittle, and the quicks dry up and exhibit a tendency to separate from the nails. The nails commence to thicken, and their substance to degenerate, until they become shapeless masses. The skin becomes uniformly red, and, later, small warty growths make their appearance. These gradually increase in size and number, whilst the skin generally becomes dry and wrinkled. At this stage, apart from the disfigurement, the patient suffers no inconvenience. The warty growths continue to increase in size, especially over the knuckles, and unless they are kept down by the aid of fine sand-paper, or, by constantly cutting them with a razor, the skin loses its elasticity to such an extent that it cracks with the slightest extra exertion. These cracks are very painful and difficult to heal. Pain of an almost indescribable character, which appears to come from the bones, and which is aggravated by holding the hands in a dependent position, is felt. Loss of power in the arm muscles is also experienced. At this stage the skin between the warty growths exhibits marked telangiectasis, is considerably thickened, and is tied down to the subjacent tissues. There is an ever present sensation of burning and extreme itching, the latter being so bad at times that it requires no small amount of control to keep from scratching. The bases of some of the larger warts become inflamed, and the thickened mass may come away, leaving an ulcer which takes months to heal. These ulcers are so tender and painful that words fail to convey any idea of the suffering of the patient. They occasionally refuse to heal, become gradually larger, and may assume malignant characteristics, which demand operative procedure. In several cases which have been brought to my notice, fingers and hands have had to be amputated, and two or three cases in which death has resulted have been recorded.

Personally, I have suffered from chronic X-ray dermatitis for over eight years, and, notwithstanding all methods of treatment and precautionary methods, I am gradually becoming worse. I have not had a moment's freedom from pain for three years, two fingers are perfectly useless, and, in the cold weather, I am unable to dress myself, and on occasions cannot write. I mention these facts, in the first place, to deter others from running risks, and in the second, in the almost vain hope that some suggestion for treatment may be forthcoming which will give relief.

Dr. John T. Pitkin, in a paper read before the "American Roentgen Ray Society," December 10th, 1903, thus describes the pain and suffering of this terrible disease: "For a "description of the pain and suffering, hyperæsthesia and "paræsthesia, no language, sacred or profane, is adequate. "The sting of the honey-bee, or the passage of a renal "calculus, is painful enough, but they are comparative "pleasures, because, being paroxysmal, they have a time "limitation. Extreme tenderness to the slightest touch, hot "and cold waves and flashes, warmth, tingling, pricking, "throbbing, stinging, crawling, boring and burning sensations, "as if the parts were on fire and contained bugs, and other "living things; feelings, as if the anatomical structures were "being removed from one position to another: all of these "sensations are proportionate to the depth of the inflam-"matory process." When this disease is once contracted there appears to be no relief obtainable. Giving up the work, for even a lengthy period, appears to make little difference, and protecting the hands does not appear to improve matters, although it may prevent them from getting much worse. The disease is, apparently, not only incurable, but is progressive, hence the best advice which can be given to beginners is, from the first to protect themselves, and so to avoid it.

Treatment of Chronic X-ray Dermatitis.—Inasmuch as, in the light of our present knowledge, this disease is entirely preventable, and incurable, it would be waste of time to detail the various methods of treatment, which have been tried, or suggested, for obtaining relief. Suffice it to say, therefore, that nothing gives relief to the pain, and that the skin never afterwards regains its normal condition.

Before entering into details of the various methods which should be adopted, for the protection of both the operator and the patient, I would like to say a few words upon another danger, which lurks behind the indiscriminate use of an unprotected X-ray tube. It has been proved that guinea-pigs, rats, and mice can be rendered sterile by the exposure of the testicles to the rays, and it has been asserted that several workers with the rays, have been affected in like manner. The changes which take place in the structure of the testicle have been carefully observed and are well understood, and there can be no doubt as to the effect which is likely to be produced should these parts not be protected. This danger is one which calls for the attention of the whole profession, as the X-rays in the hands of untrained and unscrupulous persons may constitute a grave public danger. Taking into consideration the dangerous nature of the rays when improperly used, I have no hesitation in stating that legislative measures should be enacted, confining their use entirely to properly trained qualified medical men.

Preventive Measures.—All preventive measures to be complete must protect the operator as well as the patient. The best device I know of for this purpose is Belot's shield. This shield is constructed upon scientific principles, and can be used for every purpose which comes within the scope of X-ray work. In addition to the shield a lead-glass screen, sufficiently high to protect the whole of the operator's body, should be placed on either side of the tube holder, and the necessary switches for manipulating the apparatus should be behind the screen.

Opaque gloves and an opaque apron should be worn during the whole time that the tube is in operation. The operator should on no account allow anyone to look through any part of his body with the fluorescent screen, and should never change the adjustment of a tube, or the position of a patient, while the apparatus is in operation. As an additional precaution, it is well to wear glasses, when making an examination with the screen, or perhaps an even better method is to have a sheet of lead-glass fixed in front of the screen, as, in addition to affording protection, this device lengthens the life of the screen, and prevents its surface from being injured by the nails or gloves. Always keep as far as possible away from an excited tube, even when you are protected in the manner I have described.

My last piece of advice is, do not run risks, or allow anyone else to run them, otherwise you may have, for the remainder of your life, to regret having done so.