A Lecture

ON THE

X-RAY DIAGNOSIS OF RENAL CALCULUS.

Delivered at the Sick Children's Hospital, Great Ormond Street.

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In the following lecture I shall endeavour to treat the above subject from the point of view of the general practitioner, as I have found that the average general practitioner does not fully understand or realize the difficulties or fallacies of renal radiography. I may almost say that in connexion with knowledge of this subject general practitioners may be divided into three classes:

1. Those who have no knowledge of the x rays beyond knowing that it is possible to take a photograph of the bones and some of the internal organs.

2. Those who have a slight knowledge of x -ray phenomena, but who believe that any stone may be easily demonstrated by the application of the rays in a general sort of way.

3. Those who have a wider knowledge of the subject, and who understand and fully realize the difficulties to be overcome in obtaining reliable results.

Since Professor Roentgen published his account of the discovery of the x rays, and described their power of penetrating certain substances, perhaps the most popular application of these rays has been towards the discovery of foreign bodies in the human frame. With foreign bodies such as needles, pins, and bullets, etc., the results are comparatively easy to obtain on account of the greater opacity of such substances compared to the tissues in which they may be embedded. But the application of the rays to the discovery of the presence or absence of pathological deposits—such as calculi in the kidney, ureter, or bladder—is much more difficult and much more unsatisfactory. The results obtained have given rise to a great deal of adverse criticism, and in some respects have caused this method of diagnosis to meet with a great deal of opposition. Unfortunately there has been, and still is, good reason for such a state of affairs; but the great improvement which has recently taken place in x -ray apparatus and methods of procedure warrants, in my opinion, this method being allotted a high place in the diagnosis of renal calculi. Perhaps before proceeding further it would be as well to roughly outline something about the properties of the x rays and the method of their production, as this will give a better understanding why they may be of use in the diagnosis of renal calculi.

I do not intend to go very deeply into the scientific aspect of the many different forms of rays, but before describing anything about the x rays it is necessary to mention something about the "cathode" rays. Both x rays and cathode rays can be produced from what is technically known as a Crookes's tube. This form of tube is a glass bulb of a certain definite shape and which has platinum wires let in at each end. The platinum wires are intended to carry currents of electricity, and, as the passage of such currents generates heat and causes expansion of the wire and glass, platinum is chosen because the coefficient of expansion of glass and the coefficient of expansion of platinum are almost identical. Metal discs—usually aluminium or platinum or both—are fixed to the ends of the wires. The ends of the bulbs are then carefully sealed and the tube exhausted by some very powerful pump till there is a very high vacuum. The ends of the wires are then attached to the positive and negative poles of a strong induction coil, and when the current is turned on it forces its way across from the positive to the negative pole, and causes a series of phenomena which result in the production of the x rays. The current thus passes from the positive to the negative pole in the tube, and when it reaches the negative pole it there produces the cathode rays.

The cathode rays are particles of electricity which are shot off from the negative pole; they travel in straight lines, and are shot off with tremendous speed—a speed which has been computed to be equal to one-third the speed of light, or about 20,000 miles per second. The most interesting property of the cathode rays is the power which they possess of producing the well-known x rays.

Whenever the cathode rays come in contact with a solid

obstacle the x rays are produced. In a Crookes's tube used for x -ray production the obstacle for the purpose of causing obstruction to the cathode rays is the platinum disc which forms the positive pole, and when the cathode rays strike this disc the x rays are generated. When the cathode rays strike the positive pole they are not reflected, but what happens is, that as each negative corpuscle which constitutes the cathode rays strikes the target, there is emitted by this sudden stoppage a single wave of x rays. With regard to the uses of the x rays as a diagnostic agency, this depends entirely on the power of the x rays to penetrate certain substances. In connexion with another form of energy, namely, light—the terms transparency, translucency, and opacity are used, denoting the degree to which light is able to pass through certain media and affect the retina of our eyes. For instance, we call glass transparent and gold opaque, but at the same time a sufficient thickness of glass and a very thin film of gold behave in quite a reverse way; and if we break up white light by means of a prism into its constituent parts and take any one colour, such as red, we find that such rays will not pass through green glass, because the glass absorbs them, and thus, even in thin films, glass must be considered opaque to this form of light. Now, the x rays have the power to behave in exactly the same manner—that is, they can pass through certain substances and be so little absorbed that that particular substance may be said to be transparent to the rays, whilst other substances absorb the rays, and therefore appear to be opaque. The uses, therefore, of the x rays as a diagnostic agency depend upon this property, and it may be as well to point out that an x -ray photograph—say, of the hand—does not show the bones themselves, but only an image of the shadows of the bones.

The x rays are invisible to the unassisted eye; but when a tube is in action it appears greenish in colour, due to the rays causing the glass to fluoresce. The action of the rays is very closely akin to that of light and ultra-violet light on silver salts, and this action is made use of in taking x -ray photographs. In the photographic plates which are most suited to the action of the x rays silver bromide is combined with gelatine, and the rays decompose the bromide into the sub-bromide, which, by development, is reduced to black metallic silver. Now, when it is remembered that the rays pass through the flesh to a greater degree than through the bones, it will be readily understood that by placing the hand over a silver bromide plate and exposing to an active x -ray tube, the rays which pass through the fleshy part will have a greater effect on the silver bromide than the rays passing through the bones, and thus, on reducing the sub-bromide to black metallic silver by development, the result will be a negative showing a contrast in shadows of the different parts. Bearing this in mind, it will be easy to understand why the x rays may be useful in demonstrating the presence of a calculus. As I have already remarked, the x -ray diagnosis of renal calculi has not in all cases proved satisfactory; and this applies more particularly to adults than to children, because in the latter the rays are more able to penetrate, and thus a clearer image is obtained.

The object of the method is to obtain a photographic negative of the kidney region, with a view to seeing whether or not there is evidence of the presence of a stone.

The most important factors in determining this point are:

1. The size of the stone.
2. The composition of the stone.
3. The size of the subject under examination.
4. The condition of the kidney.

I intend to discuss the above four factors separately, but it must be clearly understood that the taking of a successful x -ray picture does not depend on them alone, because there are many other factors which can be discussed more conveniently when describing the technique of the method.

Size of the Stone.

Renal calculi vary in size to a very wide degree. Some are only about as large as a small seed, and some may be so large as to weigh about 2 oz. or more. A small stone offers very much less resistance to the rays than a large one, and therefore the shadow may be so slight and so small as to be easily missed, even although such a shadow is actually present in the negative.

Composition of the Stone.

Renal calculi may be conveniently divided into three groups—(a) acid group, (b) alkaline group, (c) bacterial group. The acid group contains the uratic and oxalate of lime stones; the alkaline group contains lime phos-

phate stones; and the bacterial group contains the ammonio-magnesian phosphate stones. Pure uric acid stones offer very little obstruction to the rays, and therefore are far the most difficult to detect. Fortunately, a pure uric acid stone is extremely rare, and usually has a sufficient covering of oxalate or phosphate of calcium to cause sufficient density to throw a shadow. The uric acid stone (combined with the oxalate or phosphate of calcium) is said to be the most frequent kind of stone, and it is unfortunate that it should not be the most opaque to the rays. The oxalate of calcium stones throw the densest shadow, and pure phosphatic calculi are the most difficult to see, while the urates come somewhere between.

Size of the Subject.

This has to be taken into account much more particularly in connexion with adults than with children, on account of the greater resistance of the parts in adults. As the production of a shadow of a stone upon a negative depends on the strength of the rays which pass through the body and affect the plate, and as the strength of the rays which reach the plate depends upon the resistance offered to their passage from the tube to the plate, it follows that a fat adult's body will cause more obstruction to the rays than the body of a child, and therefore the action on the plate will be correspondingly less in the case of the adult.

Calculi embedded in the kidney are surrounded by the kidney tissue, abdominal contents, abdominal walls, and blood, all of which offer resistance to the rays, and, in fact, nearly approach the opacity of the stone itself. In other words, the ratio of opacities between body plus stone and body minus stone approaches more nearly to unity the greater the thickness of tissues through which the rays have to pass. Thus it will be seen that the thinner the patient is the more active are the rays which pass through to the plate, and the result on the plate is therefore correspondingly greater. Probably this is one of the main reasons why renal radiography is more successful in children than in adults.

Condition of the Kidney.

In certain cases calculi may be embedded in the kidney and cause more or less induration of the kidney tissue by setting up chronic interstitial nephritis. This tends to increase the opacity of the kidney to the rays and may even obscure the stone altogether. Again, in cases where there is much pus the stone may be entirely obscured by the dense shadow which pus causes. Another point to be remembered is that the nearer the object is to the plate the greater will be the contrast in the negative. Thus in taking a negative of a patient with suspected stone, one's object is to get the kidney as near as possible to the plate. The average distance of the kidney in the adult is about 2 in. from the posterior abdominal wall and a good deal less in a child, and the greater the distance is the less defined are the outlines of the shadow produced. This is another reason why renal radiography is more satisfactory in children.

Having explained the main causes of the difficulties I shall now discuss the question of technique, and I do not speak too strongly when I say that the question of technique is a most important one, and that individual cases almost entirely depend for good and reliable results on attention to the detail of technique. The first important step is the preparation of the patient. Every case before being photographed should have a strong purgative, as it is essential to have the bowels as thoroughly emptied as possible of gas as well as solid matter. In hospital it is better to give every case an enema a couple of hours before the photograph is taken, but this is not absolutely necessary and is difficult in private. The empty bowels offer great resistance to the rays, and when full this resistance is greatly increased, so that one may almost say that no case ought to be photographed until this matter has been attended to. Gas in the bowel may be the cause of a mistake in diagnosis, because the rays pass through the gas much more easily than through the solid contents, and therefore affect the plate more strongly, and this has the effect of giving the negative a blotchy appearance which may totally obscure the shadow of a stone.

All clothing should be removed from the part of the patient's body which is to be represented on the negative. This is necessary because clothes would offer a certain amount of resistance, though slight, and this is better avoided. There is also the danger of buttons, etc., causing a shadow, which might be mistaken for a stone. For a reason already explained, the plate must be brought as close to the object to be photographed as possible, and several methods have been recom-

mended to bring the kidney as near the plate as its position will allow. The plate may be placed flat on the table, and the patient placed in the exact position over the plate, and the Crookes's tube is placed in front. This position, with a flannel binder round the abdomen to restrict the breathing as much as possible, is quite suitable for children, because the exposure necessary is so short that the slight breathing movement possible does not have time to cause any material effect on the result.

In adults, however, especially when stout, breathing movements are very liable to cause a blurring of the negative, and for this reason it is essential to try to eliminate, or at least to diminish, such movements as much as possible. It has been shown that the kidney moves very much during respiration, and this is another reason why every precaution must be taken to restrict breathing during exposure, as any movement will tend to cause a blurring of the kidney region on the negative. One method—which, however, is by no means perfect yet—is to use an automatic arrangement which only allows the tube to generate rays during the respiratory pause. This will undoubtedly become a useful method in large, stout patients when the automatic arrangement is simpler and more perfect. In children the abdominal binder is convenient, and answers the purpose if the exposures are short. A very good method is to place the patient face downwards on a canvas-topped table, and place the plate on the back, and have the excited tube underneath. The canvas offers practically no resistance to the rays. To get the back as straight as possible and thus allow the plate to get into close apposition to the back as is necessary, an air-tight cushion is placed between the canvas and the abdomen, the cushion offering practically no resistance to the rays. Thus in this position the weight of the patient to a great extent acts by keeping the respiratory movements within bounds. Having placed the patient in one of the described positions, the x-ray tube has to be arranged with the anti-cathode—that is, the positive pole—directly over the middle line at the level of a point between the umbilicus and the lower end of the sternum. I make it a rule in every case to take in both kidney regions and both ureters in each negative, because it has occurred that the stone has been in the opposite kidney to the one suspected. With the tube, patient, and plate in the selected position, the negative will show a shadow of the vertebrae, transverse processes, the lower ribs, and the pelvic bones. The size of the plate must be large enough to take all this in. In children a suitable size is 12 in. by 10 in. After exposure, which varies according to many circumstances, the negative is ready for development. Care and attention to detail during development is undoubtedly one of the great factors in obtaining good results, and in all cases of suspected stone I think the development should be done personally, as much information may be gained during the process. I do not propose to discuss the question of development in this article, as it is so important that it is better discussed separately. If, when the negative is developed, a stone shows well or is suspected, it is important to take a photograph again two or three days later under as nearly similar conditions as possible.

I have already referred to stereoscopic photography in connexion with radiography, and I consider that all cases of suspected stone should be examined by this method. The method is not a difficult one, but it requires a good deal of extra work and is also more expensive, but the results are well worth the sacrifice.

In the non-stereoscopic negative the object under examination is seen with regard to two dimensions only, namely, length and breadth, and no information is gained with regard to the third dimension—depth or perspective—and therefore the advantage of a method which will show the object in the three dimensions will be obvious to all. The method is as follows: Some form of plate holder is necessary which will allow the negative in its envelope to be securely held, and which will allow the negative to be easily removed without moving the patient and another one placed in exactly the same position. The tube holder is graduated so that the tube may be easily moved a distance of $2\frac{1}{2}$ in. without disturbing the position of the patient. The distance of $2\frac{1}{2}$ in. is the distance between the centres of the two eyes. The tube, patient, and plate are now placed in one of the described positions for an ordinary photograph and the exposure made. The negative is then carefully removed and another one placed in exactly the same position without moving the patient or tube. The tube is now dis-

placed to the side for a distance of $2\frac{1}{2}$ in. by moving the tube-holder to the point already ascertained. Another exposure is then made, and the two negatives are then developed. They are reduced to a convenient size and mounted on ground glass or opal, and when thus prepared and examined with a good stereoscope a view of the object is obtained showing the true perspective. In the diagnosis of fractures and dislocations this method is invaluable. A good negative for a suspected renal calculus should show a clear definition of the transverse processes of the vertebrae, the last two ribs, the crest of the ilium, and the outline of the kidney and the psoas muscle.

Certain conditions have given rise to fallacies, and this fact has led to the performance of an operation in several instances, when no stone was discovered. Perhaps one of the commonest causes of a fallacy is a flaw in the film of the plate, but this can be avoided by exposing two plates one on the top of the other at the same time. In this way two images are obtained, and if the same shadow shows on the two plates at exactly the same spot, and of the same shape, one can reasonably say that such a shadow is not due to a flaw in the film.

Another cause which I believe has led to at least one serious error in diagnosis was due to the shadow of a button appearing in the region of the kidney, but of course this can be easily avoided by making it a rule that all clothing should be removed from the part to be exposed.

Another possibility which might give rise to error is a mark which sometimes appears on a plate as the result of development. I have heard of at least one case where this has been mistaken for the shadow of a stone, and this only emphasizes my remark that development is a very important factor towards good results, and should be done personally.

Perhaps the most serious cause of a fallacy, and the one which offers the greatest difficulties in overcoming, is the presence of calcareous glands in the neighbourhood of the kidney and ureters. In a recent number of the BRITISH MEDICAL JOURNAL Mr. Hurry Fenwick showed several photographs which very distinctly exhibited the shadow of what appeared to be a stone in the ureter. The case was again carefully photographed, but this time with a metal catheter lying in the ureter, and when developed the negative showed that the so-called stone in the ureter lay outside the ureter and not in it. The shadow was afterwards proved to be due to calcareous glands. Some cases have been reported where the physical signs caused the impression that a stone was present, and although repeated photographs gave no evidence of a stone, an operation disclosed a small accumulation of gravel.

From my experience of actual cases I feel that I am in the position to deduce the following conclusions:

1. That the method is an extremely useful auxiliary to the ordinary methods of diagnosis.
2. That the method should be resorted to in every case of suspected stone, and that no operation should be decided upon until the case has been carefully photographed.
3. That the method entails a great responsibility and should in every case be carried out with the greatest possible care, for the patient's sake as well as for the operator's reputation, as a mistake may lead to such serious consequences.
4. That the great increase in the power of the apparatus used, and the increased knowledge of how to obtain the best results, will soon enable x-ray specialists to exclude all doubt in the interpretation of a negative.
5. That in cases where the negative shows the shadow of a stone and an operation is decided upon, the patient should be rephotographed under as nearly as possible similar conditions a day or so prior to the operation. I consider this necessary, because in one case a patient was photographed and a diagnosis of renal calculus was made. The operation took place some time afterwards, and no stone was found in the kidney. Another photograph was taken shortly after the operation, and the stone was again seen, but this time it was in the ureter. During the interval between taking the photograph and performing the operation the stone had moved downwards.
6. Lastly, I think every case should be taken stereoscopically at least once.

SURGEON-LIEUTENANT-COLONEL C. R. KILKELLY, C.M.G., M.B., late Grenadier Guards, has been appointed House Governor and Medical Superintendent of the Convalescent Home for Officers at Osborne, in place of Commander Powell, resigned. Mr. Edgar Hoffmeister, M.B., has been appointed a member of the Consulting Staff.

FURTHER REMARKS ON THE TREATMENT OF RINGWORM OF THE SCALP BY THE X RAYS.

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In a recent issue of the BRITISH MEDICAL JOURNAL (July 1st, 1905), I discussed the treatment of ringworm of the scalp by the x rays, and my remarks were based on an experience of about 60 cases so treated at Charing Cross Hospital and elsewhere. In that contribution, which was written about two months before its publication, I described the technique we employed, and pointed out wherein it was defective, the chief difficulty at that time being the measurement of the dosage sufficient to produce a defluvium of the hair without destroying the hair papillae and so preventing regrowth. For this purpose we depended almost entirely on Sabouraud and Noire's pastilles of platino-barium cyanide.

Fig. 1.—X-ray stand for the treatment of ringworm, etc.

At the time when the paper was written we were fortunate in having at the hospital two regulating tubes which under the relatively constant conditions of having a current of half a milliampère in the secondary circuit and a spark gap of about $3\frac{1}{2}$ in., and with the patient at a distance of 15 cm. from the anticathode, produced the desired effect on the scalp, with an exposure of about fifteen minutes. Unfortunately, a few