THE X RAYS AND THEIR APPLICATION TO PRACTICE AND DIAGNOSIS.

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WHEN it was first announced at the beginning of the present year that a German investigator had succeeded in so manipulating the energy derived from an electric discharge *in vacuo* as to cause such energy to traverse bodies opaque to ordinary light, and, having traversed them, to affect a photographic plate or fluorescent material placed in their path, the announcement was received, even by those best able to judge, with more or less incredulity. It was soon found, however, by many workers in England, following on the lines laid down by Roentgen, that not only was the statement correct, but that the discovery was capable of receiving far wider application than was at first thought possible.

It has for some time been known that when a high tension current is caused to pass through a vacuum there is developed at the cathode a form of energy having a peculiar character of its own. Cathode rays, as they have been called, have been very fully investigated by Wiedemann, Lenard, and other investigators. Crookes, in England, many years ago investigated their properties, but it was not until Lenard discovered the possibility of causing these rays to traverse the walls of the vacuum tube that even any suggestion of their practical utility was indicated.

ROENTGEN'S DISCOVERY.

Roentgen carried their application a step further, and found that when these cathode rays impinged upon some solid substance (the glass wall of the tube, for instance, or the platinum plate in the later focus tube), there was developed a special form of rays, the properties of which are now so familiar. Thus has resulted a discovery already fruitful of the most beneficent results in the realm of practical medicine, and pregnant with possibilities, the full extent of which it is at present not even possible to suggest. So important is the discovery made by Roentgen, and so many are the fields of physical research which it has already opened up or suggested, that the greatest physicist of modern times has declared that the discovery of the *x* rays is the greatest of the present century. Thanks to the many investigations which have been made (mainly in this country) into the methods and apparatus most suited to the production of the *x* rays, it is now possible to produce them in sufficient quantity to be of practical utility in the everyday routine of medical and surgical diagnosis.

REQUISITE APPARATUS.

The apparatus required consists mainly of a coil or transformer, capable of giving off a continuous stream or current of high-pressure electricity; of a suitable vacuum tube, through which the current is passed, and from which the rays emanate; and of a sensitive surface capable, either directly or indirectly, of rendering the rays visible to the eye. It will be well if I briefly mention some of the practical points which experience has raised, and which it is necessary to observe, in the selection and working of the requisite apparatus. First, as to the source of the electricity. Wherever possible, it is advisable to work from accumulators, and this always involves much trouble. The current as it exists in the mains for household supply is not adapted to the working of induction coils, without considerable expenditure on a suitable transformer. An accumulator should be chosen that will give a uniform rate of discharge, and for bedside work should be as portable as possible. Personally, I have found the lithanode secondary cell give the best result. Its rate of discharge is very uniform, it is simple in construction, and therefore requires little attention, and it is packed in a very presentable case convenient for transport. But although it is advisable to bestow care on the selection of a suitable accumulator, it is far more important to make certain of obtaining perfection in the induction coil. In this country there is no one who has so thoroughly mastered and brought to such a high state of perfection the practical details of the construction of coils as Mr. Alfred Appa. His experience is the result of years of investigation and practical construction, and to anyone desiring to obtain the best results his coils are absolute necessities. As to the vacuum tube, the first form introduced into this country by Messrs. Newton, from a design of Mr. Herbert Jackson, and now universally copied and sold under

the name of the focus tube, is undoubtedly the best. But so many makers have lately succeeded in producing these tubes of high efficiency that it would be invidious to recommend any particular make. The only other apparatus necessary for practical use are the fluorescent screen and photographic plate.

THE CRYPTOSCOPE.

The first substance used for the coating of the fluorescent screen was the platino-cyanide of barium. This was soon superseded by the same salt of potassium on the ground that the fluorescence was far brighter. This is undoubtedly true, but I have lately seen some screens coated with barium salt which, while being nearly as bright as the potassium, seemed to give far greater contrast and distinctness of the shadows. Much probably depends on the method employed in crystallising the salt. Many other substances have been used for coating the screens, such as various tungstates and fluorides, and the organic compound, penta-deca-para-tolylketone. But none of these substances have afforded results in any way comparable with the platino-cyanides. The brand of photographic plates is a matter of importance, but one difficult to advise upon, some people preferring one brand, and some another. Personally I have obtained the best results with Cadet lighting plates, developed with Velox.

PRACTICAL USES.

We come now to the consideration of the practical aids which the new process is capable of rendering to the elucidation of points of medical and surgical diagnosis. It may be at once stated that the process is only of use under those conditions in which we have a substance, or portion of the body which is opaque to the *x* rays, surrounded by tissues which are transparent, and *vice versa*. This definition of practical utility at once limits the applications very considerably, and when it is remembered that the vast majority of the tissues and organs of the body are extremely transparent, and that only the bones and certain foreign bodies are opaque, a very fair idea is obtained of the extent of the new services rendered by the new process. I must take this opportunity of giving a warning. Whenever the advance of science results in a discovery which has immediate practical bearings on medicine or surgery, there is always the danger lest the extent of the aid which such a discovery is capable of rendering be at first over-estimated. During recent years there have been several examples of this, as witness the sensation which was caused on the introduction of tuberculin and various other antitoxins. After enjoying the full confidence of professional opinion for a short time, it is generally found that such new discoveries are not capable of accomplishing all that their promoters claimed. When this is found out, the pendulum of confidence is apt to swing back, and the impression remains that these supposed discoveries are absolutely useless. It seems as if men's minds were incapable of conceiving that a new discovery may do much towards assisting medical and surgical work without doing everything; and thus it is in the case of the *x* rays. It would surely try the patience, if not the sense of the humorous, were I to mention even one-tenth of the absurd and utterly irrelevant questions I have been asked as to the efficacy of the *x* rays. Some go so far as to imagine a therapeutic use for them, and it has even been imagined that they may influence our psychical life.

We proceed now to consider the various cases in which the new process has actually proved itself of immediate use. It would be best for our purpose if we take the regions of the body *seriatim*.

SKIAGRAPHY OF THE HEAD.

In the head, in the region of the skull, its use is practically confined to the discovery of foreign bodies, such as bullets lodged in the brain case. The conditions here are not very favourable, for the soft brain substance, being completely surrounded by the tables of the skull, there is a more or less opaque screen in all directions. But although bone is the most opaque tissue of the body, yet it is not so absolutely to the passage of the *x* rays, and by continuing exposure for a sufficient length of time, it is quite possible to locate the position of the bullet in the brain tissue. In the cervical spine the position of a tuberculous focus can be readily ascertained. For this purpose it is best to skiagraph from the side, so as to obtain a profile view. Working in this way I have been able to diagnose caries with facility.

THE THORAX.

Coming now to the thorax, we enter on the realm about which so much has been recently said concerning the application of the *x* rays to the diagnosis of cardiac mischief. It is quite true that by using a sufficiently large plate a skiagraph of the heart can be obtained. That this is possible is due to the fact that anatomically the heart consists of a dense mass of tissue practically surrounded by an air space. But it must be remembered that a skiagraph thus obtained consists of nothing else but a shadow of the outline of the heart. No indication is afforded as to the condition of its valves or cavities, beyond that which can be indirectly inferred from its shape and size. Consequently the knowledge that we are able to gain from the application of the method to this region of the body is no more than can be obtained in a much simpler manner by the ordinary method of percussion. For the diagnosis of foreign bodies in the trachea and bronchi, or imbedded in the substance of the lung, the skiagraph will reveal all that can be desired, providing such bodies are opaque to the *x* rays. It is especially useful in the all too common cases of children who have swallowed marbles, small coins, etc.

DIAGNOSIS OF SPINAL CARIES.

In the case of thoracic caries a difficulty is introduced owing to the presence of the sternum, and the ribs in front which act as a more or less efficient screen to the rays. But these difficulties can be easily overcome by so adjusting the position of the tube as to direct the rays laterally to the sternum, and so as to traverse an intercostal space. By this means a slightly oblique projection of the spine is obtained, but for all practical purposes the foreshortening is so insignificant as to be negligible.

FOREIGN BODIES IN THE ABDOMEN.

In the region of the abdomen the practical utility of the process is confined to the detection of foreign bodies, the localisation of Murphy's buttons, and the diagnosis of lumbar caries, fracture, or dislocation. When localising foreign bodies in the intestine by this means, it is necessary to bear in mind one or two practical points. Supposing, for example, the foreign body has been detected lying over the right iliac bone. Under these circumstances it would not be unnatural to suspect that the body had lodged in the ileo-cæcal valve. But such an inference cannot be more than the merest conjecture, and if it is decided to operate on the information thus arrived at, it is essential to do so *instantly*, for the body may not have lodged at the valve, but may simply have been lying in a loop of the intestine immediately over it. If any time is wasted in exposing the part, it is quite possible that sufficient peristalsis may have occurred to have completely shifted the body, or even to have misplaced the entire loop of intestine. So in these cases the practical rule must be observed, that the skiagraph should be taken immediately before operation. Much hope was at one time held out that the process might be of considerable utility in the early diagnosis of extrauterine gestation. These hopes, however, have not only not been fulfilled, but at the present there is very little prospect of their ever being so. In the same way, it was at one time thought that the process would materially assist in the recognition of malpresentations; but until we have means in our power of producing *x* rays in far greater quantity than is at present possible, all such procedures must be confined to the laboratory.

DIAGNOSIS OF STONE IN THE KIDNEY.

Of the possibility of applying the process to the diagnosis of renal or vesical calculus it is at present too early to speak with certainty. The evidence that a skiagraph can furnish is one-sided; for if there is no sign of a shadow on the plate in the region of the kidney, this is not evidence that no stone exists, for we may have failed to get the rays to traverse the thickness of the body; on the other hand, if a decided shadow is obtained, this is proof positive that some foreign body is present. So that in some cases a positive diagnosis can be given, and in any case the information afforded cannot fail to be suggestive.

USES IN THE LIMBS.

Coming now to the extremities, we reach the region in which so far the process has proved itself of most value. *A priori* it might be seen that the limbs would prove themselves most adaptable to skiagraphic purposes, for in them

there is the greatest proportion of opaque bony tissue to transparent flesh, and in them fractures and dislocations, for the elucidation of which the process is particularly useful, are most frequent.

Taking the joints and bones of the extremities in order: As to the shoulder, I have had cases brought by surgeons of rheumatoid arthritis and displaced epiphysis, in both of which great assistance was afforded by the use of the *x* rays. But it is in the elbow-joint that the greatest use will probably be found for the skiagraph in surgery. Owing to the complexity of its structure, this joint offers more conditions of difficult diagnosis than perhaps any other in the body. Fractures, separated epiphyses, epicondylar fractures, and many other intricate combinations of lesion which occur in or around this joint, can all be revealed with the greatest clearness by the use of the *x* rays. The joint is one very easily skiagraphed even in the most muscular subject; owing to its mesial position in the extremity, any view or series of views can be obtained. Nor is it too deep to allow of the successful use of the fluorescent screen without elaborate precautions. We may therefore confidently expect that, as regards this region of the body at least, the systematic use of the *x* rays will leave no more cases to suffer from the evil effects of erroneous diagnosis.

In the forearm and wrist the applications so far are practically limited to the diagnosis of fractures and the recognition of the position of foreign bodies. Unfortunately it is not a simple matter to diagnose a dislocation of the metacarpal bones with the aid of a skiagraph, as here a side view is difficult, and an anteroposterior view does not give us all the information we desire, and it is in this direction that displacements most occur.

HIP DISEASE.

In the case of the lower extremity, the consideration of the practical applications is necessarily more or less a repetition of what has already been stated with regard to the upper; there are one or two points, however, which require notice. The hip-joint, like the shoulder-joint, with which it is of course homologous, presents several conditions in which early and decided diagnosis is invaluable. But, like the shoulder, it is in many cases a very difficult point of which to obtain a satisfactory skiagraph. This is due to the large extent with which it is surrounded with dense muscular tissue. In very well developed and athletic men I have, after several attempts, not been able to obtain successful negatives.

In the vast majority of cases, however, it presents no difficulties, and fortunately it is just those cases in which the use of the *x* rays are of the greatest use that are the easiest to skiagraph. In early tuberculous disease a decided diagnosis is invaluable, and as this is most frequent in children, no serious difficulty ever presents itself. Dr. Macintyre has obtained some very beautiful pictures of this condition. In cases of congenital dislocation, too, the process can give us information as to the extent of the acetabular rim, which can not be obtained in any other way.

The above are the applications which, so far, the discovery of Professor Roentgen have found in the domain of practical medicine. How much further the discovery is likely to be of use it is not possible to foresee, but if the promise of development which late physical researches hold out are fulfilled, we may expect very great advances at no very distant future. With the rays as they are at present available, however, no great advance is to be expected, for their practical utility depends directly on their physical capabilities; and, as these are known more or less accurately, it is quite possible to predict in what condition applications will be found. But it is not too much to imagine that other rays of a similar nature may be discovered, rays that cannot pass through carcinoma, and can through all other tissues, just as the *x* rays cannot pass through bone, but can through the remaining constituents of the body. Should such or similar forms of energy be discovered, it is a curious speculation to realise what the routine of physical examination will become; but for the present we must be content to pursue our investigations quietly without undue speculation, and to be thankful that we live in the age when the tangent of physical research is nearing its point of contact with the circle of the art of medicine.