THE RADIOLOGY OF LIVING ANATOMY*

BY

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Sir George Newman's speech at the opening of the Annual Congress of the British Institute of Radiology in 1932 contained the following statement:

"When I was trained as a medical student, a great many years ago, I had to learn my anatomy on the dead body. But we may now, by means of x rays, learn in the ideal way (which we thought of in those far-off days as impossible to reach) of the anatomy of the living body; ideal, because all the tissues of the human frame are different in the dead body from what they are in the living. The x ray has, therefore, real weight in the study of human anatomy, of anatomy, not as it lies in dust and ashes, but as a living entity, the crown and summit of nature, the greatest thing as far as we know that has been created, on this planet at all events, if not in the whole universe."

Radiological study of the living body has contributed considerably to our knowledge of anatomy, but such knowledge must be regarded as supplementary to that which can be obtained in the dissecting room only. It is dependent on the relative density of the tissues or organs and their contents to x rays, and is in fact a study of shadows. While in the case of radiographs of the bones or of the lungs detail of the delicate structure can be portrayed, in most cases we have to base our knowledge on the internal or external contour of the organ. By the aid of substances of a lesser or greater density than the surrounding tissues we are able to show the outline of the interior of every tubular viscus. Finally, by the aid of the fluorescent screen, the movements of the viscera and skeleton can be followed.

Since radiology is now recognized as an essential method of examination, the extent and usefulness of which increases with improved technique each week, it becomes imperative for the medical student to appreciate the radiographic appearance of the normal anatomy. Unless the student or clinician has made himself familiar with the radiographic appearances, no matter how intimate his knowledge of dissecting room or surgical anatomy may be, he will be liable seriously to misinterpret the shadows produced by x rays. It is not suggested that the student should have an extensive course in radiology added to the already crammed curriculum. That it would have to be an extensive course if the whole subject were taught becomes obvious when we see how radiology has spread its tentacles into every branch of clinical medicine. So vast is the data already collected, and so rapidly are further advances being made, that it is certain radiologists of the future will have to specialize in the study of one system only if progress is to continue.

Radiology of the living anatomy may be learnt from: (1) radiographs taken in standard positions of patients of known age and sex; (2) serial radiographs taken at intervals of fractions of a second, minutes, days, weeks, or months to show development; (3) fluoroscopic examination; (4) cine-radiography. The student must first confine himself to a study of radiographs of normal structures at different age periods from infancy to old age, taken in standard positions. The variations to be seen in these, of the skeletal system alone, will indicate the extent of the knowledge required for correct interpretation. In no part are the variations of form more apparent than in the skull, in which we never see the

same radiographic appearance in two individuals, a factor which would be infallible for criminal records.

Obviously it will be impossible to give a very extensive account of the variations met with, and I shall confine myself to a demonstration of a few of the radiographic appearances of normal structures which have led to serious misinterpretation.

Radiography of the Skull

Radiographs of the skull must be taken with the central ray in the sagittal plane; the slightest obliquity of the skull respective to the central ray may result in the production of a radiograph in which the dense structure of the base obscures the normal accessory sinuses on one side, and this may lead to the error of diagnosing that the sinus is occluded. The dense shadow of the petrous portion of the temporal bone may be projected through the plane of the antrum, and its straight upper surface may be misinterpreted as a fluid level. The most serious results have followed the misinterpretation of shadows of pathological processes of the maxilla and mandible as the normal maxillary antrum or foramina. Examples have been published of septic foci which have been so missed in spite of repeated x -ray examinations, and in some instances the health of the patients has been seriously affected.

An unusual instance of misinterpretation of the normal was submitted to me three years ago. A child with a swelling at the angle of the mandible was x -rayed, and the radiograph was misinterpreted as showing a sarcoma. A surgeon was consulted, and resection of the involved bone was decided upon. Immediately before the operation the surgeon asked me if I could give him an indication of the boundary of the tumour, so that he could gauge what length of bone he must remove from the crest of the ilium to form a graft. It was demonstrated to him that the radiograph showed normal structures only; the shadow of the hyoid bone, which was projected against the mandible, had been taken for that of a sarcoma. It was discovered a few days later that the swelling was due to mumps.

When I was recently confronted by a dental surgeon's misinterpretation of the shadow of the pharynx as an abscess cavity with a sinus (the shadow due to the epiglottis) tracking forwards, I realized how necessary it was for the individual using x rays to learn the radiological anatomy of the normal before attempting to interpret pathology.

The Thorax

When radiographs of the thorax in inspiration and expiration are carefully compared it becomes apparent at once that radiographs must always be made in the same phase of respiration if they are to be compared one with the other. Radiographs of the thorax also indicate another important feature—namely, that those structures which are in close contact with the radiographic film appear denser than the surrounding tissues (owing to the fact that this area is, in this way, screened from secondary radiation), and often show a fairly well defined periphery. The significance of this fact is illustrated in the following case.

A patient was radiographed at a tuberculosis clinic, and a diagnosis of bilateral spontaneous pneumothorax was made. Later, when my opinion was sought, I suggested that further radiographs should be taken: one with reduced pressure against the breasts, and another with the film barely touching the patient. These proved that the abnormal shadows were due to the contact cutting out secondary radiations and consequently reducing the density of the protected part.

Contact of the male genital organs with the film results in the appearance of well-defined opacities on the radiograph, and these shadows have been misinterpreted as stones. Irregular calcification in the thyroid,

* Abstract of paper read to the Rugby and District Medical Society, and illustrated throughout by lantern slides.

cricoid, and costal cartilages also results in the appearance of opacities on the radiograph, which have been misinterpreted as evidence of tuberculosis, or, in the case of the lower costal cartilages, of stones in the gall-bladder or kidney. It is not unusual to hear that the normal appearance of the acromio-clavicular joint has been misinterpreted as showing a fracture. The importance of adopting standard positions in which the whole of the structure can be projected on the radiograph is illustrated by radiographs of the wrist or hip-joint, in which severe fractures may be masked by the overlapping of shadows of other structures.

Alimentary Canal

Little can be learnt of the anatomy of the alimentary canal by the plain radiograph. The lumen of the structures must be filled with some media, the density of which is less or more than that of the surrounding structures. It is the common practice to use a dense medium, such as barium. It is essential, however, before an opaque medium is introduced into any part of the body that a preliminary radiographic examination should be made, so as to be quite sure that no abnormal shadows exist which might be completely obscured by the opaque material. The essential part of the examination of the alimentary canal involves fluoroscopy, of which a brief account is given later. The gall-bladder can be visualized by absorption or injection into the portal circulation of such substances as sodium tetraiodophenolphthalein, which, being excreted by the liver in the bile, make the latter denser than the surrounding structures, it can therefore be shown on the radiograph. In this examination we are dependent in some cases on so-called negative shadows—that is, gall-stones less in density than the dye-containing bile. Such negative shadows may be simulated by the shadows of bubbles of gas in the duodenum being projected into the gall-bladder shadow.

Serial Radiographs

A single radiographic examination may, in health or disease, demonstrate clearly the outline of the structures under observation, but more information of the structures can be obtained by taking a series of radiographs with an interval of time (depending upon the nature of the examination) between each. If we are studying the movements of the heart, stomach, or small intestine, the interval between each radiograph must be very short, but if we are concerned with the development of the skeleton an interval of a month would suffice. The influence of sex, food, medications, ill-health, and endocrine disorders in the growth of the skeleton can be determined in this way. In the study of pathology this method of examination is invaluable, and provides evidence which cannot otherwise be obtained. Too often further radiography is neglected if the first examination has not revealed any abnormality.

Fluoroscopic Examination

When the student has made himself familiar with the radiographic appearance of the normal anatomy he will be in a position to appreciate the more quickly the shadows projected on the fluorescent screen. The time allowed for screen examination is necessarily limited, owing to the danger of exposure of the operator and patient to the x rays. The interest shown by students in the screen examination of their colleagues is sufficient testimony of the value of this method for bringing further stimulation to the study of anatomy.

Many of the features learnt from a study of radiographs will be readily noted by the student during the screening, but it is the observation of movement of the viscera and their contents which excites the greatest interest. Such

examinations teach the student the position of the viscera in the erect, supine, or prone position. The movements of opaque meals through the alimentary canal produce a living picture, which is of the greatest contrast to that exhibited in the dissecting room, and cannot fail to impress him.

Cine-radiography

The very limited time permissible during screening, and the limited area which the observer can watch, make this method of demonstration by no means ideal for teaching purposes. What we need is a carefully edited cine-radiographic film study of the viscera, an ideal which we are rapidly approaching. The desirability of this method of demonstration was recognized by Dr. John MacIntyre of Glasgow as early as 1896—that is, a few months after Röntgen had discovered x rays. He exhibited a cine-radiograph film 40 feet in length, showing the movements of the bones of a frog's leg, to a meeting of the Glasgow Philosophical Society in that year. In the *Archives of Skiagraphy* of April, 1897, he described his experiments with direct and indirect cine-radiography. This pioneer work has been followed up by other workers in different countries.

In this country Dr. Russell Reynolds contributed a paper in 1925 describing his experiments with indirect cine-radiography. (Since writing this Dr. Russell Reynolds has informed me that he has continued his experiments and now has a reliable technique which is relatively inexpensive.) More recently Robert Janker at Bonn advanced the method to such an extent that we reasonably expect soon to use cine-radiography in teaching the radiology of living anatomy. Briefly the two methods are as follows.

Direct Cine-radiography.—The patient is placed in front of an x -ray tube and against a leaded screen containing a window opposite the area to be radiographed. Behind the screen a large roll film of the necessary size is fixed on rollers, and the timing of exposure so devised that at least sixteen exposures per second can be made on the rapidly changing film surface. From the film obtained reduced films, capable of fitting into a cine-projector, would have to be made. The large contact films permit one to study the changes in form perhaps rather better than the small films obtained in the indirect method, but the cost is very considerable, and while the method may be used for the production of standard teaching films it can never come into general use in radiographic examination. Simpler devices have been made which enable us to take a dozen or more exposures within a short time, and these are useful in the examination of the stomach and duodenum. A modification of this direct method for recording the movements of the heart was described by Robert Knox in 1925.

The Indirect Method.—This method depends on a cine-photographic record of the images produced on the fluorescent screen. The screen image must be sharply defined, and there must be no afterglow. By this method Janker has been able to make cine-radiographic films which are little inferior to those obtained by the direct method but at a trifle of the cost. The intervals between each exposure will determine the rapidity (when shown in the cine-projector) of the movements of the structures examined. We may compare the cine-photography of growing flowers—in which there may be an interval of several hours or days between each exposure, but when projected the growth, which has taken several weeks and which was imperceptible to the eye, is completed in a few minutes—with the cine-photography of the horse-race during which many exposures per second are made, but when projected at the normal film rate appear as a slow-motion picture in which even the muscular contractions can be followed.

Both these methods may be applied to cine-radiography of the human body, and should solve many of the problems of visceral movement. The movements of the heart in diastole and systole during expiration and inspiration could be so analysed. The peristalsis of the alimentary canal could be determined with greater accuracy and films obtained which would be preferable to fluoroscopic screen demonstration for the teaching of students. By this means the movements of joints can be studied better than in any other way. Two years ago Professor Lockhart, Fowler, and I conspired together to show the movements of the spine. Our efforts are to be seen in Film No. 238 of the Kodak Medical Film Library. We determined, in this manner, that extension of the spine is greater than flexion, and that the greatest range of movement takes place in the lumbar area, the least in the dorsal. This was demonstrated in a girl who was able to bend backwards and place her head between her thighs. The extraordinary mobility of the lumbo-sacral joint was also demonstrated. In a woman, aged 34, I showed that, while with flexion of the spine the anterior surface of the sacrum formed an angle of 170 degrees, with the line of the anterior surface of the lumbar vertebrae with extension the angle had been diminished to 100 degrees.

Clinical Memoranda

TREATMENT OF PANCREATIC CYSTS

I recently published¹ an account of a case in which, in a male patient, I successfully anastomosed a persisting sinus, following external drainage of a pancreatic cyst, with the anterior surface of the stomach. This operation was rendered necessary on account of the excoriation of the skin of the anterior abdominal wall by the active pancreatic fluid discharging from the sinus. The result was so satisfactory that when I encountered my next case I decided to make an anastomosis between the cyst and the stomach at the first operation, and so save the patient several weeks or even months of discomfort resulting from that constant discharge of irritating fluid over the abdominal wall which invariably follows external drainage. The result exceeded my expectations. The abdominal incision healed by first intention, and the patient left hospital in three weeks. She has been seen several times since, and on October 30th, 1933, she was examined clinically and by radiography, but no sign of the cyst could be made out.

A woman, aged 50, was admitted into the Cardiff Royal Infirmary with a history of intermittent attacks of indigestion for four to five years. On July 11th, 1933, she had sudden severe pain in the upper abdomen lasting from two to three days. Examination revealed a large tense swelling in the upper abdomen, with the stomach and transverse colon running across its anterior surface.

The abdomen was opened through a right paramedian incision, and the cyst exposed by a two-inch incision in the gastrocolic omentum. An incision half an inch long was made in the cyst, and a catheter quickly introduced and secured by a purse-string suture previously inserted. The cyst was emptied and repeatedly washed with saline, through the catheter. The fluid first drained from the cyst contained altered blood from a recent haemorrhage, and this may have accounted for the severe attack of pain on July 11th. The catheter was then removed and the anastomosis made between the cyst and the anterior surface of the stomach near the greater curvature. A clamp was used on the stomach, but not on the cyst. The actual operation was performed in the same way as a gastro-enterostomy. To avoid the possibility of obliterating the opening during the suturing two devices were employed: (1) the sutures were

interrupted in three or four places; and (2) a piece of rubber tubing one inch long and a quarter of an inch in diameter was inserted into the two openings, after putting in the posterior halves of the sutures. When the sutures were completed the tube was pushed into the stomach. The abdomen was closed without drainage.

As the posterior surface of the stomach is adherent either to a true or to a pseudo-cyst of the pancreas, it might be suggested that it would be easier to make an opening in the stomach anteriorly, and then to make a stab opening through the adherent walls of the stomach and cyst. The same procedure might be carried out in the opposite direction after opening the cyst. There are, however, at least two theoretical objections to these modifications of the operation actually performed: (1) the stomach contents might enter the cyst and possibly give rise to complications; and (2) they resemble a perforation of the gastric ulcer into the lesser sac too closely to be undertaken without serious consideration, in view of the apparent safety of an anterior anastomosis.

I am indebted to Dr. Owen Rhys, radiologist to the Royal Infirmary, for the taking of the radiographs.

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INJURY TO THE CERVICAL REGION

The following case of injury to the cervical region presents some unusual features.

A man aged 24 was brought into hospital at 11.45 p.m. on August 30th, 1933, having been run into by a motor cyclist about half an hour earlier while helping to mend a puncture, his own machine lying close by. He landed with the three machines on top of him. There was no loss of consciousness, and the only apparent injury was a compound fracture of the right tibia and fibula, and some bruising of the left arm. The actual wound was half an inch long, and was bleeding freely; this was dressed, and the patient was put to bed with his leg on a back splint. The following day his general condition was good, but his temperature was 101.6°F. He said he felt well. He had no headache, his pupils were equal and reacted briskly to light, the tendon reflexes of his arms were present and equal, and those of his left leg were normal. The condition of his leg was quite satisfactory, and a stitch was put in the wound.

On September 1st, having slept well, he ate a good breakfast and appeared quite fit, except that his temperature was 100.4°. At about 10.30 a.m. he became strange in his manner. He answered questions as though not quite sure of what was being said, and he was found sitting in bed hanging his sound leg over the side. His expression appeared vacant. He said he had no pain or headache. His face was very flushed; his pupils were equal and reacted briskly to light, but were moderately dilated. By 12 noon he was only semi-conscious, and was incontinent of urine; by 2 p.m., thirty-nine hours after the accident, he was quite unconscious, lying on his back with his arms flexed across his chest. At 7 p.m. a crop of petechial haemorrhages was first noticed, symmetrically distributed on both shoulders, from first below the clavicle in front to the spine of the scapula behind, just encroaching on the upper arm; there was also a superficial haematoma spreading up the back of the neck to the occiput. The patient was sweating profusely on his face and neck; his temperature was 100.8°, his respirations stertorous and increased to 30, and his pulse 120, with volume and tension good. He was incontinent of urine, his bladder not being distended. He could not be roused, but he would take drinks. He was still lying with his arms flexed across his chest.

On September 2nd he did not seem to be so deeply comatose. His breathing had been Cheyne-Stokes in character at times during the night, but was now regular again, though stertorous. There were a few more petechial haemorrhages, still limited to the same area; there was no stiffness of the neck. The following day his condition was much the same. A lumbar puncture was performed, the fluid being quite clear and under normal pressure. On September 5th his general condition was much weaker. He would only drink at times, and was obviously dying. A

¹ *British Medical Journal*, April 15th, 1933.