Radiology as a Diagnostic Aid in Clinical Surgery

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INTRODUCTION

THIS book is intended for surgeons. Most books on radiology are written for radiologists, and as such include many diagnostic minutiae, considerable technical detail and much that is academic. There have been many excellent standard text-books produced along these lines. Recent advances in radiology are often technical in nature and may have little application to the day to day work of the practising surgeon, and therefore lie outside the sphere of this book.

The emphasis here is on clinical problems and the writer has principally selected his subjects from those on which his surgical colleagues have consulted him in daily practice in a busy teaching hospital. In particular an attempt has been made to emphasize the scope and limitations of radiology as a diagnostic aid when the surgeon is faced with any particular clinical circumstances.

Radiology is merely graphic pathology. It is a photograph in time of a state of affairs at that point in time. It has an advantage over morbid anatomy in that the subject can be considered while the patient is still alive, and an advantage over histology by biopsy in that the whole of a pathological condition can often be viewed rather than a small operative specimen. It has a further advantage over both in that the course of a condition can be observed by serial X-ray examinations, and so the progression or resolution of the disease process can be assessed. It also has limitations in that it is dependent on a difference in tissue densities, a contrast between adjacent structures, for a demonstration of those structures. This does not always exist, and though it is possible in many instances to introduce contrast in the form of contrast media, this can not always be performed, or even if it is, it does not always provide a diagnosis.

Interpretation must be based on a thorough knowledge of the normal and of normal variations; against this background, changes can be interpreted in terms of pathology, provided, again, a clear knowledge exists of the pathological processes which may occur in any anatomical site taking into consideration the age and sex of the patient. The inexperienced tend to diagnose as abnormal what are either anatomical variations or are variations due to technical factors. Interpretation is essentially the function of the trained radiologist, trained in the technical aspects of this work as well as in the fundamentals of interpretation expounded here. Yet it is essential for the surgeon to know the scope and limitations of this branch of medicine if he is to obtain all the help that can be made available, and if he is to avoid the pitfalls that too implicit a faith in the power of radiology may produce.

It is important, therefore, for the surgeon to realize that the greatest benefit will come from frequent personal contact and consultation with the radiologist, and to realize that the radiologist, by virtue of his training and experience, is best adapted to decide how to conduct a radiological examination and how to derive the maximum information from the radiological investigation of any particular clinical problem. This, however, the radiologist can only do if he is aware of the clinical problem and is not merely asked to conduct an examination as a technical feat. It should therefore be the aim of the surgeon requesting an X-ray examination to provide the necessary clinical details of the case to be investigated, rather than to give instructions of technical requirements, and then to leave the radiologist to decide how to conduct it.

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CHAPTER 1

EMERGENCY WORK

IN any general hospital in an industrial town it is common for up to one-quarter of the total number of X-ray investigations to be emergency cases mainly referred from the casualty department. That does not imply that a quarter of the work of such an X-ray department is casualty work, for, of course, many of these investigations are of a minor nature quickly carried out. Nevertheless it is an indication of the importance of the aid that X-ray facilities are required to provide in this field of medical practice. It may be argued that much of this work is of doubtful necessity or is only necessary for medico-legal purposes, and that doctors more experienced than casualty house officers would call on this service far less; yet while it is true that those experienced in such work rely more on their clinical judgement, casualty house officers must gain their clinical experience, and while doing so must have some clinical freedom. Further it must not be forgotten that in those cases where inexperienced doctors have relied on their clinical judgement, and have subsequently been proven to be wrong, the judgement of the courts has often gone hard against them if they have failed to have the patient X-rayed.

(1) Fractures

Radiological procedure for the demonstration of and control of the treatment of fractures has become an integral part of surgical practice. This is best discussed as (a) *the investigation of suspected fractures*, (b) *the demonstration of the type and extent of clinically obvious fractures*; (c) *the control of reduction or other operative procedures and* (d) *the assessment of progress.*

(*a*) The treatment of any fracture imposes on the patient a degree, greater or lesser in extent, of immobility. The treatment of a sprain or soft tissue injury, while still requiring immobilization, is generally of a shorter duration. To treat a fracture as a sprain or as a simple soft tissue injury may, especially in children or if articulating surfaces are involved, have serious results. Radiological demonstration or exclusion of bony injury has thus become a procedure of considerable social and economic significance to the individual and to society.

In children the confirmation of a greenstick fracture may be of merely academic interest, while the failure to detect one of the commonest of injuries, slipped radial epiphysis with a posterior marginal fracture of the radial metaphysis, may have long reaching effects on the individual's

ability to play games or even to write. In this latter injury, as the epiphysis is displaced backwards, the blood vessels in the growing epiphyseal cartilage are torn, causing a local haematoma and disorganizing the zone of bone growth. Yet, unless the films are of good quality and this type of fracture is specifically sought it is easy to overlook it.

Similarly, in the adult fractures of the carpal scaphoid may avoid radiological detection. In the early stages, except in gross cases, fracture of the scaphoid is really a clinical diagnosis, and suspected cases should, in the absence of radiological confirmation, be treated on clinical grounds. If the bone is in fact fractured, and yet no fracture line can be detected on the X-ray film immediately after the injury, the fracture line will be detectable 14 to 17 days after the injury when the wrist is out of plaster. This is because in the intervening period the hyperaemia resulting from the injury causes absorption of bone trabeculae from the adjacent edges of the fracture. If. at this period after the injury, no fracture line is visible, then there has been no bony injury, and the wrist injury can be treated accordingly. It is wise, therefore, not to lose the advantage of treatment during the intervening period in suspected cases, for continued movement may prolong the necessary period of treatment, or even cause irreparable damage.

(*b*) If clinically obvious fractures are to be satisfactorily treated, then it is essential that the surgeon should know the exact site of the fracture, the type, its relationship to surrounding structures, involvement of articular surfaces, whether or not it is intra-capsular, the type and extent of deformity, whether shortening or distraction exists, the presence of comminution, and the existence of any underlying bony disease. All this information can be provided by X-ray examination.

In the investigations of these problems there are certain maxims which must be observed. It should always be routine practice to take two films of the injured part, the one at right angles to the other. Not only will this practice lead to the detection of crack fracures not readily visible in one projection, but it will also demonstrate the full extent of any deformity resulting from the fracture, deformity not always suspected from the clinical examination or from a single frontal projection of the injured part (see Fig. 1). Furthermore, the whole length of an injured bone and the adjacent joints should always be included in the survey films. It is often false economy to examine only the affected part of the bone. For example, fractures of the lower third of the tibia often have associated with them a fracture of the neck of the fibula, and, in midshaft fractures of the ulna it may be calamitous to the patient to miss the other component of a Monteggia fracture, namely dislocation of the head of the radius, because of an inadequate radiographic examination.

(*c*) After reduction of any fracture of a long bone or of a fracture dislocation, whether the reduction is maintained by a splint or by

plaster, it is normal procedure to re X-ray in order to confirm that the reduction achieved is clinically acceptable. It is sometimes stated that radiological opinions on such examinations are unnecessary; this, however, is not true. In departments where mutual trust and reliance exists radiological opinions on these examinations will be clear reports of fact, occasionally drawing the attention of the surgeon to some feature that he had overlooked; they will at all times avoid comment or judgement on the result, for this lies entirely within the realm of clinical judgement as to what is regarded as a satisfactory or acceptable state of affairs taking into consideration such matters as the clinical state of the patient, age, function etc. The fact that all such examinations are seen and reported on by a radiologist will also have the effect of maintaining the technical standard of the radiography.

Some injuries are such that they require X-ray control during the operative procedure of reduction or treatment. For example reduction of fractures of the neck of the femur and their fixation by nail or screw can only be achieved under X-ray control. There are now many variations of the type of nail or screw used, and there are many variations on the method of ensuring that it enters the neck of the femur in the right direction and that the right length of nail or screw is used. However, most methods include the following basic fundamentals:—

(i) Reduction of the fracture.

(ii) X-ray of the hip in two planes, antero-posterior and lateral, to confirm the satisfactory reduction.

(iii) Insertion of a guide wire from below the greater trochanter through the femoral neck into the femoral head.

(iv) X-ray examination of this in an antero-posterior plane to confirm the direction of the guide wire and show its end so that a nail or screw of the correct length can be selected.

(v) X-ray examination in an antero-posterior plane of any further guide wires that it may subsequently be necessary to insert if the direction of the first one is incorrect.

(vi) Insertion of the nail or screw and subsequent plate fixation.

(vii) X-ray demonstration in two planes, antero-posterior and lateral, of the site of the nail or screw.

From this it is obvious that the radiological control has a great part to play. A dark-room with rapid processing facilities must be adjacent to the theatre, so that there is the minimum of delay in the films being available for viewing. Also it is more satisfactory to have two mobile X-ray sets in the theatre, one set up for the lateral projections and one for the overhead projection. Similarly some form of cassette tunnel or holder that will fit to the operating table is required for both projections.

(*d*) The assessment of repair by radiological means requires a full understanding of the processes of repair.

In the early stages of repair the condition is one of exudate, partly fluid partly clotted haematoma, between the bone ends, under the raised periosteum and in adjacent soft tissues, undergoing organization. A rapidly growing hyperaemic fibrous cellular granulation tissue growing from the bone ends surrounds and invades the haematoma. Hypertrophic cartilage growing in the marrow space and beneath the periosteum marks the early stage of callus formation. The fibroblastic granulation tissue between the bone ends, by which continuity has already been established, is then invaded and replaced by these cartilage cells. The hyperaemia then diminishes, and calcification of the cartilaginous matrix takes place. This is the stage of union by callus. During the later stages of the laying down of the hypertrophic cartilage, osteoblastic activity is considerable and bone is laid down in the cartilaginous matrix, this gradually maturing to fully formed but irregular bone, which in due course is replaced by lamellar bony trabeculae along the lines of stress. Periosteal new bone is absorbed and the bone remoulded by normal osteoclastic and osteoblastic activity and finally fat and marrow cells re-appear in the marrow space.

Radiology is merely a graphic representation of the pathological process, but as always in bone conditions, the radiological representation lags behind the clinical state. In the early stages of fracture repair, organizing blood clot and cartilage growth casts no shadow. Hyperaemia in bone, however, always produces a local osteoporosis, and so after seven to ten days the adjacent bone ends of the fragments are seen to become slightly osteoporotic and a little less well defined. Then as calcification in the cartilaginous matrix takes place this becomes visible, usually in a zone rather wider than the normal tubular form of the continuous bone. This calcifying callus is not visible until three or more weeks have elapsed. In due course as osteoblastic activity progresses, trabecular bone replaces this calcifying callus, and at the same time osteoclastic resorption reshapes the callus and tubulation is affected. Radiological union has not taken place until continuous bony trabeculae can be seen bridging the gap and this may take three to four months. The age of the patient affects very much the rate of the later stages, union taking place sooner in younger subjects. Similarly, slow union may be due to deviation of the blood supply from one fragment of the bone or due to excessive traction in maintaining reduction of the fracture. The former may be anticipated from the anatomical site of the fracture as demonstrated radiologically, while distraction of the bony fragments demonstrated on the post-reduction films may indicate the possibility of the latter. In all cases clinical evidence of union occurs much sooner than radiological union.

If immobilization of the fracture has been inadequate, repeated movement causes recurrent local haemorrhage, increase in the size of

the haematoma and increase in the local hyperaemia of the bone ends attempting to initiate the process of repair. This excessive hyperaemia will produce radiologically a more marked resorption and osteoporosis of the bone ends which is readily recognized on the radiograph after two to three weeks. Invasion of the granulation tissue so formed by hypertrophic cartilage cells leading to callus formation shows radiologically as a large mass of calcifying callus. Such a mass of callus is usually an indication that immobilization has not been entirely effective.

Repeated movement with decalcification of the bone ends may, of course, lead to delayed union, and osteoporosis thus shown is to be regarded as a danger signal and an indication that, unless immobilization is more effective, prolonged treatment may be necessary. If delayed union is allowed to continue it may lead to established non-union. In this event the gap between the bone ends becomes clearly defined and the edges of the bony fragments become quite clear and even sclerotic (see Fig. 1). These surfaces become smooth, the gap between being

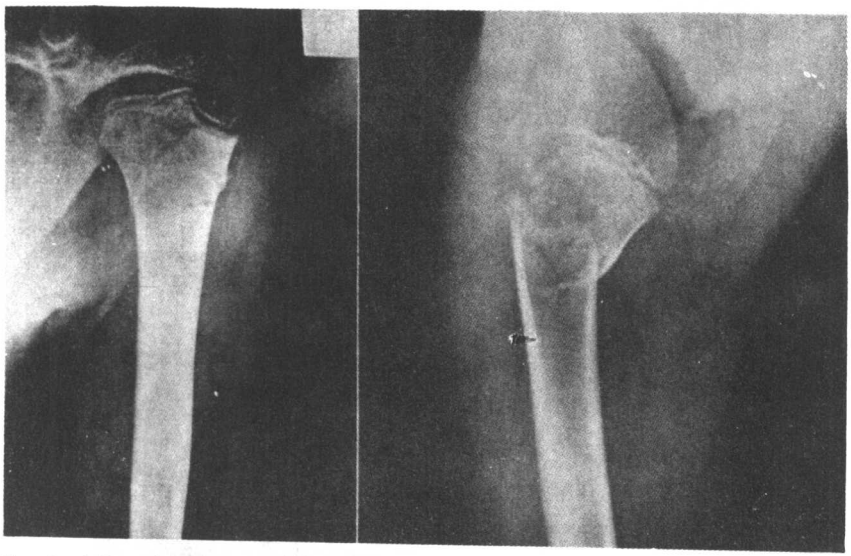

FIG. 1. A.P. and vertical views of the left shoulder snowing a fracture of the surgical neck. Alignment in the frontal projection appears satisfactory, but the other projection shows that angulation exists.

filled by fibrous tissue; serum loculation may take place in this cicatricial mass forming a false joint or pseudarthrosis.

In the normal control of repair and review of progress the bone may be X-rayed through plaster. Calcifying callus can usually be seen through the shadow of the plaster, but if there is any doubt as to progress it is wise to X-ray out of plaster or when the plaster is being changed.

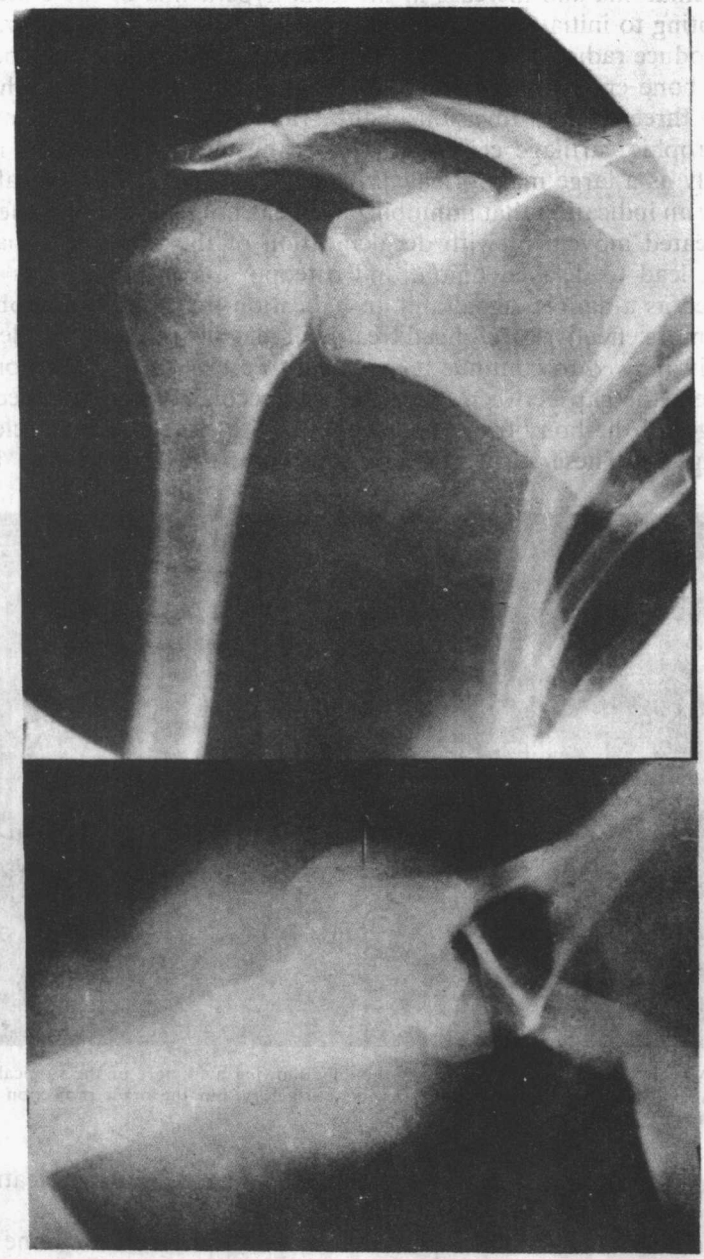

FIG. 2. A.P. and vertical-projection in a case of posterior dislocation of the shoulder joint.

(2) Conditions of Skeletal Trauma that may be Missed Despite the X-ray Examination

(*a*) *Posterior Dislocation of the Shoulder Joint.* This is an unusual injury, the physical signs of which are often masked by swelling. In particular, swelling may mask the flattening of the anterior aspect of the shoulder and prominence of the coracoid process which become apparent as the swelling subsides, by which time of course, valuable time has been lost in reducing the dislocation with resulting permanent disability.

Radiographically a single antero-posterior film of the shoulder may not reveal the dislocation, and in all cases of shoulder injury it should be routine practice to take a vertical projection of the joint. This is most conveniently taken with the X-ray tube above the shoulder and a curved cassette in the axilla, but if the patient is unable to abduct the shoulder a satisfactory demonstration can be achieved by putting the cassette above the shoulder and the X-ray tube below without moving the elbow from the patient's side. This projection will always demonstrate a posterior dislocation as well as bony relationships in any other form of shoulder injury.

On the routine antero-posterior film the features which suggest posterior dislocation (see Fig. 2) are:

(i) Internal rotation of the head of the humerus.

(ii) Loss of parallelism between the articular surfaces of the head of the humerus and the glenoid fossa.

(iii) The head of the humerus appearing "smaller" and its trabecular

FIG. 3. P.A. and lateral projection of the wrist showing fracture of the scaphoid and dislocation of the carpus posterior to the lunate.

pattern more clearly defined than usual; this is due to the head of the humerus being nearer the film than normally.

(*b*) *Trans-scapho-perilunar Fracture-dislocation of the Carpus.* The radiographic features of this injury may be difficult to interpret if the surgeon is not familiar with the appearances. As in all fracture-dislocations time is an essential factor in treatment, so it is of importance to recognize the nature of the injury at the first examination.

In this injury the scaphoid is fractured, the lunate and proximal half of the scaphoid are in normal relationship with the radius, and all other carpal bones including the distal half of the scaphoid are dislocated backwards.

In most hospitals the routine practice in X-raying wrist injuries is to take three projections, a postero-anterior, an oblique and a lateral. The bony injury, the scaphoid fracture and possibly an associated fracture of the radial styloid, will be readily seen on the postero-anterior film; but it is the lateral film which shows the posterior dislocation of the carpus (see Fig. 3).

(3) Head Injuries

Radiographically head injuries can be classified as fractures of the vault of skull, fractures of the base of skull, and fractures of the facial bones.

X-ray examinations of the head require, besides the co-operation of the patient, exact and precise positioning of the patient's head, positions some of them difficult to achieve and maintain. It is useless to send a badly shocked or concussed patient for X-ray examination of the head as films obtained under such conditions are unlikely to be of diagnostic value. Unless it is the surgeon's intention to deal immediately with a head injury and it is desired to demonstrate the extent of or exclude a depressed fracture of the vault, shocked or concussed patients should be treated accordingly before being sent for X-ray examination.

(*a*) *Fractures of the Vault of the Skull.* Of the three radiographic divisions the vault is the simplest to demonstrate, only antero-posterior and lateral projections being required. Fractures of the vault may be seen to be linear or stellate, to cross recognizable vascular channels such as the middle meningeal vessels, or to involve air sinuses such as the frontal sinus. Depression of a fracture will probably not be detected unless stereographic views or a special tangential projection of the fracture site is taken. Probably a more certain way of detection is examination with the surgeon's finger during toilet of the scalp.

(*b*) *Fractures of the Base of the Skull.* A fracture of the base is a diagnosis usually made on clinical grounds. Radiographic demonstration of the base of skull is a difficult manoeuvre requiring the full co-operation of the patient—co-operation usually far beyond the power of any patient on whom a clinical diagnosis of fracture of the base has

been made. Further, if following a clinical diagnosis of fracture of the base of skull, even the most satisfactory films fail to demonstrate a fracture line, the patient will still be treated for fracture of the base. If for academic or medico-legal purposes it is desired to have a permanent record of the fracture, the patient can safely be sent for X-ray examination the day before his discharge when he is able to co-operate fully, for such fracture lines persist for many months or even years.

(*c*) *Fractures of the Facial Bones.* These injuries comprise fractures of the nasal bones, lateral face fractures, and depressed fractures of the zygomatic arch, upper and lower middle face fractures, and fractures of the mandible. Their significance is concerned mainly with three factors—they may be concerned with alterations in vision, particularly diplopia, they may be concerned with dental occlusion and they may have cosmetic effects (see Fig. 4).

FIG. 4. Injury to the face with considerable soft tissue swelling. The film shows fracture of the infra-orbital margin and diastasis of the fronto-zygomatic suture and obliteration of the air space in the antrum due to haemorrhage.