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Appendicular skeleton: ABCs Image Interpretation Search strategy

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Abstract

Timely interpretation of plain radiographic images is essential for effective management of patients, particularly within a trauma setting. It is not uncommon that the opinion of radiographers is sought to assist the attending physician in reaching a correct diagnosis. Some radiographers might be reluctant to offer their opinion as they might feel ill-equipped to interpret plain film images. This review article aims to provide radiographers with an easy to follow ABCs systematic approach when interpreting plain film radiographs of the appendicular skeleton in the trauma setting.

Keywords

Image interpretation search strategy, radiographers' opinion, trauma, pattern recognition.

Introduction

Timely interpretation of plain radiographic images is essential for effective management of patients, particularly within a trauma setting. Interpretation of diagnostic images is quite often left to relatively inexperienced staff that had little or no training in image interpretation. Guly[1] found that most diagnostic errors missed were by junior doctors and that the majority of those errors were not difficult to diagnose. It is therefore not uncommon that the opinion of radiographers is sought to assist the attending physician in reaching a correct diagnosis. A study by Coleman and Piper[2] showed that radiographers outperformed casualty officers and nurse practitioners in the radiographic interpretation of the appendicular skeleton. Kelly et al[3] concluded that the performance of junior doctors were positively impacted when a radiographer's opinion was introduced.

Cowling[4] identified a variety of issues leading to diversity in radiographer educational standards internationally. It is therefore prudent to assume that image interpretation might not be included as a learning outcome in all radiography training programs internationally. Professional bodies such as the Australian Institute of Radiography[5] and the Health Professions Council for South Africa [6] state that radiographers could provide an opinion to the medical practitioner responsible for the patient. Some radiographers might be reluctant to offer their opinion on pattern recognition as they might feel ill-equipped to interpret plain film images.

The ABCs system of radiological assessment was first introduced in 1995 by Nicholson and Driscoll and subsequently edited by Chan[7]. This system provides a simple and systematic approach to enhance interpretation skills. It has been adapted for different body systems and is not limited to plain film imaging only. This review article will only focus on plain film image interpretation of the appendicular (peripheral) skeleton.

The ABC systematic assessment[7] stands for:

A: Adequacy; alignment
B: Bones
C: Cartilage and joints
S: Soft tissue and foreign bodies
S: Satisfaction of search
(adaptation from original ABC Systematic assessment)

Key points to consider when interpreting plain film radiographs

- **Mechanism of injury**
  The mechanism of injury which can be derived from the clinical history or by enquiring from the patient is essential as it can provide clues to a suspected pathology and assists in consistent and accurate identification of radiographic trauma.
- **Anatomy**
  You need to know the normal radiographic anatomy including variations of normality[8] on all projections to be able to distinguish the normal from the abnormal.
- **Two views**
  A minimum of two views[7] must be taken as a fracture might only be visible on one of the views.
- **Descriptive terminology**
  Communicating a radiographic opinion requires effective and accurate descriptive terminology. It is essential to build on appropriate medical terminology when articulating pathology. This includes descriptive fracture terminology e.g. discriminating between intra-articular vs. extra-articular fractures, comminuted vs. impacted fractures, dislocation vs. subluxation and accurately describing the location of a fracture e.g. proximal vs. distal fractures.

ABCs systematic approach

- **Adequacy**
  Check that the correct projections have been undertaken to match the clinical history; e.g. should a thumb x-ray be done instead of a hand or ankle x-ray instead of a foot. Ensure that the required radiographic anatomy is visible on the views taken; e.g. the lateral ankle must include the base of the fifth metatarsal[9]. Furthermore, check whether additional views are required. Consider the images below in Figures 1a and 1b demonstrating the importance of always imaging both joints above


Figure 1a


Figure 1b

and below the injury in the lower leg[7]. This also applies to the forearm.

- **Alignment**
  Check the relationship of bones around joints and the alignment to each other to be able to exclude dislocations and subluxations.

Upper limbs

- **Shoulder alignment**
  Asses for an even glenohumeral joint space which should be no greater than 6mm[7]. The inferior margin of the acromion and the lateral clavicle should be level (see Figure 2a – white line) or when assessing acromioclavicular joint (ACJ) alignment. Figure 2b demonstrates an ACJ dislocation. Shoulder dislocations are described by the position of the humeral head with respect of the glenoid[7]. An anterior dislocation is shown on the antero-posterior (AP) view when the humeral head is displaced infero-medially (see Figure 2c). Posterior dislocations are best seen on the Y-, or axial view which shows the humeral head displaced posteriorly to the glenoid fossa (see Figure 2d).
- **Elbow alignment**
  Two lines need to be assessed for the elbow to determine whether there is a dislocation or subluxation. The radiocapitellar line (RCL) is a line drawn along the proximal longitudinal axis of the radial head and neck and should bisect the capitellum[10] on both the AP and lateral projections (see Figures 3a and 3b). The anterior humeral line (AHL) is a line drawn on a true lateral projection along the anterior cortex of the humerus and should have approximately one third of the capittellum lying anterior to the AHL[10] (see Figure 3b). Compare these images to Figure 3c demonstrating dislocation of the radial head and Figure 3d demonstrating a displaced supracondylar fracture.
- **Wrist alignment**
  Posteroanterior (PA) view: The intercarpal joint spaces should be uniform and not greater than 2mm wide as widening of joint spaces may be indicative of joint disassociation and ligamentous injury. Check Gilula's three carpal arcs (see Figure 4a) where Arc 1 (white arc) outlines the proximal surface of the scaphoid, lunate and triquetrum, Arc 2 (grey arc) outlines the distal surface of the previously mentioned three carpal bones and Arc 3 (dark grey arc) outline the proximal surface of the capitate and hamate bones[7]. Any disruption to these arcs is suggestive of pathology.
  Lateral view: It is essential to assess the lateral wrist for carpal disruption. A straight line drawn should bisect the base of the third metacarpal, the capitate, the lunate and the distal radius (see Figure 4a). Any disruption to this alignment is indicative of a perilunate (see Figure 4b) or a lunate dislocation (see Figure 4c)[7].
- **Hand alignment**
  Alignment should be checked

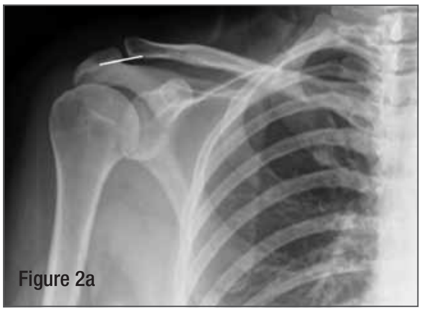
Figure 2a


Figure 2b


Figure 2c


Figure 2d

Figure 3a

Figure 3b

Figure 3c

Figure 3d


Figure 4a

Figure 4b

Figure 4c


Figure 5

on at least two views for hand and finger injuries. On the PA view subluxations or dislocations can be indicated by overlapping of joint margins (see Figure 5). Ideally the lateral view should preferably be perpendicular to each other (Figure 5).

Lower limbs

- **Hip alignment**
  The femoral head can dislocate anteriorly, posteriorly or centrally. Dislocations are normally seen on the anteroposterior view.
  AP view: Shenton's line[7] is a smooth unbroken curve along


Figure 6a


Figure 6b


Figure 6c


Figure 7a


Figure 7b


Figure 7c

the upper margin of the obturator foramen which continues infero-laterally below the margin of the femoral neck in the medial aspect of the femoral shaft, as seen on an AP radiograph of the pelvis (see Figure 6a). Interruption of the curve occurs with subluxation or dislocation of the hip.
Lateral view: Posterior hip dislocation is the most common hip dislocation (80%)[10]; and quite often have associated fractures (see Figure 6b). Anterior hip dislocations are also associated with a femoral head fracture. The femoral head can dislocate in a supero-laterally or infero-medially direction[11] (see Figure 6c). The proximal femur will be positioned medially on the AP radiograph.

- **Knee alignment**
  AP view: Check that the femoral condyles align with the tibial condyles (see Figure 7a). A significant step is indicative of a tibial plateau fracture (see Figure 7b).
  Lateral view: On the lateral view the ratio of the patella ligament length to the patella length should be in the range of 0.8-1.2[7] (see Figure 7c).
- **Ankle alignment**
  On the AP view the distance between the tibiotalar and fibiotalar joints should be less than 4mm in the adult patient. On the lateral view the long axis of the distal tibia and fibula should overlap[7]. See Figure 8 demonstrating a lateral talar shift.
- **Foot alignment**
  The tarsometarsal joint should be evaluated carefully. On the dorsiplantar view of the foot the medial margin of the base of the 2nd metatarsal should align with the medial margin of the middle cuneiform[7] (see Figure 9a). On the oblique view the medial margin of the 3rd metatarsal should align with the medial margin of the lateral cuneiform[7] (see Figure 9a). Alignment disruption is indicative of a Lisfranc dislocation[11] (see Figure 9b) which is a serious foot injury.

  » **Bones.** Each bone needs to be checked separately. Trace the cortical margins of all bones. Check for abnormal steps in the cortex and for any disruption in the trabecular pattern. Remember that fractures can present with a lucent appearance (see Figure 10a) indicating gaps between fractures or with a sclerotic appearance (see Figure 10b) indicating overlapping fragments. In bones that form a ring-like structure there will usually be a second fracture or an associated dislocation. Figure 10c demonstrates a


Figure 8


Figure 9a


Figure 9b


Figure 10a


Figure 10b


Figure 10c

Galeazzi fracture of the radius with an associated dislocation of the distal radio-ulnar joint.

» **Cartilage and joints.** Alignment of all joints should be checked for signs of dislocations or subluxations as previously discussed. Check each joint space in an orderly fashion, looking specifically at the congruity and separation of the margins of the joint space. The bones should not overlap and the joint spaces should be uniform in width. Check for small avulsion fractures as missing these could have serious consequences e.g. talar dome avulsion fractures also termed osteochondral fractures (see Figure 11a). Scrutinise carefully whether any fractures cross the articular surface as this becomes a more complex fracture. Figure 11b demonstrates an intra-articular comminuted fracture at the base of the 1st metacarpal joint; also known as a Rolando fracture. Check for additional fractures or dislocations as can be seen in Figure 11c which demonstrates a typical Monteggia fracture with dislocation of the radial head (line) and a fracture of the proximal ulna (arrow).

» **Soft tissue.** Scrutinise cortical margins carefully in areas where soft tissue swelling is evident. Soft-tissue signs can be indicative of an occult fracture. In the elbow elevated fat pads are seen as triangular radiolucencies. In particular an elevated posterior fat pad raises a high suspicion of an intra-articular fracture (see Figure 12a). In the wrist a displaced pronator quadratus fat pad may indicate a subtle distal radius fracture[7] (see Figure 12b). A lateral view of the knee performed with a horizontal beam will demonstrate a positive soft tissue sign known as lipohaemarthrosis if an intra-articular fracture is present. Lipohaemarthrosis[12] is seen as a fat-fluid level (see Figure 12c) superior to the patella. Lipohaemarthrosis can also be visible in the glenohumeral joint if shoulder views


Figure 11a


Figure 11b

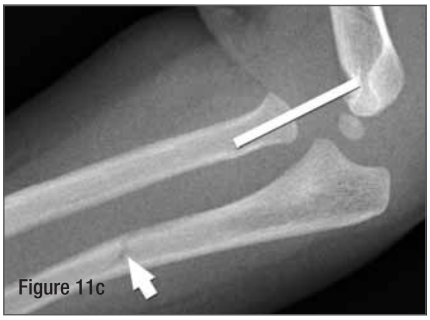
Figure 11c

Figure 12a

Figure 12b

Figure 12c

Figure 12d

are undertaken in an erect position. Figure 12d demonstrates an effusion in the knee as the suprapatellar bursa is greater than 5mm with no evidence of a fat-fluid level. Scrutinise soft tissue for the presence of a foreign body.

» **Satisfaction of search.** Scrutinise the whole image for additional pathology. Figure 13 demonstrates a comminuted fracture of the scapula. Close scrutiny of the posterior ribs identifies multiple rib fractures which should prompt the exclusion of a pneumothorax.

Conclusion

Radiographers are an integral part of the health care team and can provide a significant contribution to patient management particularly in settings where there is an absence of on-site radiologists. Radiographer's opinion on radiographic images is sought regularly. However, radiographers should make every effort to equip themselves with the necessary knowledge and skills to provide an accurate description of pathologies as seen on plain film radiographs. This article aimed to provide radiographers with an easy to follow systematic approach when interpreting plain film radiographs of the appendicular skeleton in the trauma setting.

Figure 13

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