Radiographic anatomy and imaging of the acetabulum

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Abstract

Imaging of the acetabulum in the trauma patient can be challenging but includes a number of well-established techniques. These include plain anteroposterior radiographs, 45° oblique Judet views, CT scanning and intraoperative fluoroscopy. An understanding of Letournel's lines is essential for the characterization of acetabular fractures from plain radiographs. A number of named features, for example the 'gull sign' and the 'spur sign' correlate with specific traumatic pathology. We define the role of CT scanning and describe the methods and potential utility of intraoperative fluoroscopy in acetabular trauma.

Keywords acetabulum; radiography; trauma

Acetabular fractures

Fractures of the acetabulum result when the head of the femur drives into the acetabulum. The position of the hip joint at the time of impact and the direction and magnitude of force determine the fracture pattern and degree of displacement.

The Judet and Letournel classification describes the different fracture patterns that arise. This was originally based on three radiographic views, the anteroposterior (AP) pelvis and two Judet views. The classification is split into five elementary and five associated fracture patterns as detailed in the relevant chapter. Radiographic imaging is key for the diagnosis and management of acetabular fractures.

Normal anatomy of the pelvis and acetabulum

In order to interpret images of acetabular trauma, the normal radiographic anatomy of the pelvis must be understood. This can be best appreciated on a standard AP radiograph. This view is taken with the patient lying supine, with the feet in 15° of internal rotation to visualize the femoral neck better by compensating for normal femoral neck anteversion. See Figure 1.

Initial assessment of acetabular trauma frequently includes an emergency AP-pelvis X-ray. This image is obtained during the process of initial resuscitation and facilitates immediate diagnosis. Suboptimal image quality, due to patient rotation or inadequate exposure are frequently seen as resuscitation manouevres are prioritized over optimal radiographic positioning. See Figure 2.

The pelvic girdle consists of paired innominate bones which are connected anteriorly by the pubic symphysis and posteriorly by the sacrum. Each hemi-pelvis comprises the blade-like ilium, the ischium inferiorly and the pubis anteriorly. The acetabulum or 'hip-socket' is the part of the pelvis where the ilium, ischium and pubis meet. The 'acetabular column principle' was described by Letournel in 1993 and remains a useful and accurate representation of acetabular anatomy. It is illustrated below. See Figure 3.

This considers each hemi-pelvis as an inverted 'Y' shape. Weight is transmitted via two columns; anterior and posterior. Adjacent to the columns and extending over the femoral head are the anterior and posterior walls of the acetabulum. The femoral head articulates with the acetabulum.

Letournel's lines

Letournel's lines are key radiographic identifiers of acetabular anatomy. The **iliopectineal line** is the radiographic landmark for the anterior column of the bony pelvis and curves from the inner border of the ilium down and round to the pubic symphysis. A disruption to this smooth, sweeping line signifies disruption to the anterior column of the acetabulum. The **ilioischial line** runs from the medial border of the iliac wing to the medial border of the ischium and ends at the ischial tuberosity. This represents the posterior column. The **anterior and posterior walls** of the acetabulum can be seen on the AP radiograph. The anterior wall is the shallower, more medial of the two arc-shaped lines forming the acetabulum whereas the posterior wall is wider, extending out more laterally, overlapped by the femoral head. The posterior wall is identified most easily by tracing the outer border of the ischial tuberosity upwards (distal to proximal) to the lower edge of the acetabulum, where it blends into the margin of the posterior wall. Similarly anterior wall can be identified by tracing the inferior border of the superior pubic ramus upwards, distal to proximal. As this cortical line meets the acetabulum, it merges with the anterior wall, just medial to the base of the posterior wall. The **roof or weight-bearing dome** should also be evaluated. This starts superolaterally over the femoral head and ends at the top of the fovea medially. The **'teardrop'** represents a tangential view down the medial wall of the acetabulum and cotyloid fossa, seen as two vertical parallel lines. Fracture lines extending through here signify separation of the posterior and/or anterior columns. See Figure 4.

Additional radiographic views of the pelvis

Additional radiographic views of the pelvis can be taken which give more information than the AP pelvis. **Judet views** are oblique views of the pelvis taken with the patient tilted, left

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Figure 1 Anteroposterior pelvis radiograph.

Figure 2 Anteroposterior pelvis radiograph in the trauma situation. The image is often malrotated and may be inadequate.

Figure 3 Letournel's 'acetabular column principle'. Reproduced courtesy of Zahid Askar.

or right side up, at 45°. When the hip under examination is more anterior (obturator oblique view), a profile view of the anterior column and posterior acetabular rim can be seen. See Figure 5.

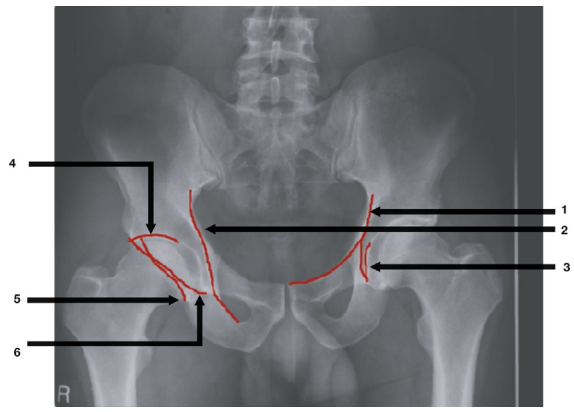

Figure 4 Anteroposterior pelvis radiograph showing Letournel's lines. 1, iliopectineal line; 2, ilioischial line; 3, radiographic teardrop; 4, acetabular dome; 5, anterior wall; 6, posterior wall.

Likewise when the hip under examination is more posterior (iliac oblique view), we see a profile view of the posterior column and anterior acetabular rim. See Figure 6.

Inlet/outlet views of the pelvis, in contrast, are obtained by cranial (inlet) or caudal (outlet) orientation of the imaging beam. They are frequently useful for the evaluation of pelvic ring fractures. They are less useful in the diagnosis of acetabular fractures. However, inlet/outlet orientation, in combination with the obliquity of Judet views, is often useful intraoperatively in guiding the passage of anterior and posterior column screws and in confirming fracture reduction.

Computed tomography (CT) scans

CT scans have revolutionized the approach to evaluating acetabular fractures preoperatively and are routinely taken on arrival in the emergency department. The traditional imaging of acetabular fractures, in the form of AP and Judet views, is no longer practised by all pelvic units, since a modern CT can be reformatted to give these views and much more besides. However, at the time of writing, intraoperative plain X-ray fluoroscopy (rather than CT or infra-red navigation) is the standard mode of imaging and therefore surgeons need to be familiar with the traditional X-ray views, even if they are not always obtained in the emergency department setting.

Due to their higher resolution CT scans are also useful for **diagnosing undisplaced fractures** which may be missed on a plain radiograph. The concomitant use of contrast means that significant vascular injuries associated with pelvic and acetabular trauma can be identified and used to help direct subsequent embolisation of bleeding vessels.

Specific advantages of CT scanning include diagnosis of **marginal impaction** of the posterior acetabulum following posterior wall/column fracture, best seen on axial slices. Articular **dome impaction** is also seen more clearly on CT, best visualized on coronal cuts. Comminution of the articular surfaces and femoral head fractures can be characterized and visualization of intra-articular fragments (e.g. after reduction of a dislocated native hip joint) is also best seen on CT. Three-dimensional (3D)

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