Interpretation of pelvis and hip radiographs

Introduction

Fractured neck of femur is an important cause of morbidity and mortality in the elderly (Lyons, 1997). For a variety of medical and social reasons falls are common in this age group and this is compounded by the presence of age-related osteoporosis. Leg shortening and external rotation of the hip are the classical findings but are not invariably present.

While the findings of a fracture on plain radiographs are usually straightforward there are a few potential pitfalls in interpretation. In certain cases specialized imaging techniques may be required to confirm the existence of a fracture. Fractures of the pubic rami are also seen frequently among the elderly, although the treatment is often conservative. Other pelvic fractures are most commonly encountered in those involved in high impact trauma and particularly road traffic accidents. Unstable injuries may require orthopaedic surgery and there is an associated risk of neurological, vascular and urogenital trauma.

Junior doctors working in the fields of emergency medicine, orthopaedics and care of the elderly require at least a basic understanding of the radiological investigation of these injuries.

Bony anatomy

The pelvis forms a bony ring consisting of two innominate bones and the sacrum, which is reinforced by ligaments. Force applied to one area will result in disruption elsewhere in the ring. The innominate bone comprises the ilium, ischium and pubis. Posteriorly the innominate bones articulate with the sacrum at the sacroiliac joints and anteriorly at the pubic symphysis. The ilium forms the iliac crests superiorly, the pubis the superior and inferior pubic rami around the obturator foramen, and the ischium the lesser and greater sciatic notches and the projection of the ischial tuberosity. The ossification centres for these bones meet at the tri-radiate cartilage where the acetabulum forms a synovial ball-and-socket joint with the spherical femoral head connected by the ligamentum teres. The neck is set at an angle of 125° to the shaft. The trochanteric crest joins the lateral greater trochanter and the medial lesser trochanter.

The blood supply to the femoral head is of great importance in determining the vascular deficits resulting from a fracture. The femoral head receives its blood from vessels that pass along the joint capsule and are reflected proximally in the retinaculum. There is only a negligible centrifugal blood supply via the ligamentum teres. Arteries also pass upwards from the femoral diaphysis to supply the neck of femur. A fracture in the inter-trochanteric plane still allows blood to reach the femoral head from the retinaculum. However, an intracapsular fracture at the subcapital or transcervical level will disrupt both the retinacular and diaphyseal blood supply and lead to avascular necrosis of the femoral head.

Imaging

The mainstay of imaging remains the plain radiograph. The anteroposterior pelvic view is part of the trauma series of images along with the lateral cervical spine and chest X-ray. The patient lies supine and the cassette is placed underneath them. A lateral view may also provide additional valuable information and is performed with flexion of the affected hip. Diagnostic quality may be limited in obese patients and using a bright-light or re-windowing on a workstation is often necessary. Other views are now rarely required in adults.

Computed tomography (CT) is performed in cases of unstable pelvic injuries in which orthopaedic surgery is contemplated or if there is suspected trauma to the pelvic viscera. Three-dimensional reconstructions may be helpful in planning reconstructive surgery. CT or fluoroscopic cysto-urethrography may be needed to exclude bladder perforation or disruption to the urethra (Deck et al, 2001).

Impacted femoral neck fractures may be difficult to appreciate on early radiographs. A coronal magnetic resonance imaging (MRI) study readily demonstrates discontinuity of bone marrow and localized oedema in these cases (*Figure 1*) (Pandey et al, 1998). MRI is also a sensitive test for evaluating the presence of avascular necrosis.

Tips on interpretation

Many injuries will be readily apparent but a systematic approach will help to avoid missing fractures. Carefully scrutinize the whole pelvic ring. If one fracture is seen then another fracture or dislocation is usually associated with it. Ensure that the sacro-iliac joints are not widened or asymmetrical, or there is not diastasis of the pubic symphysis. Review the bones forming the obturator foramina, again looking for complementary fractures. Acetabular fractures are essential to recognize and the film should be inspected for continuity of the iliopectineal and ilio-ischial lines (*Figure 2*). The sacrum should not be overlooked and any symmetry of the arcuate lines of the sacral foramina should raise the suspicion of a fracture. The appearance of the coccyx is variable and injuries are not clinically important.

Femoral neck fractures are frequently displaced and clearly seen; however, some fractures are only revealed by looking for subtle findings. Look carefully at the

Figure 1. Coronal T2-weighted magnetic resonance image of the right hip. The wavy dark band (arrow) demonstrates an impacted femoral neck fracture that was not seen on plain radiographs.

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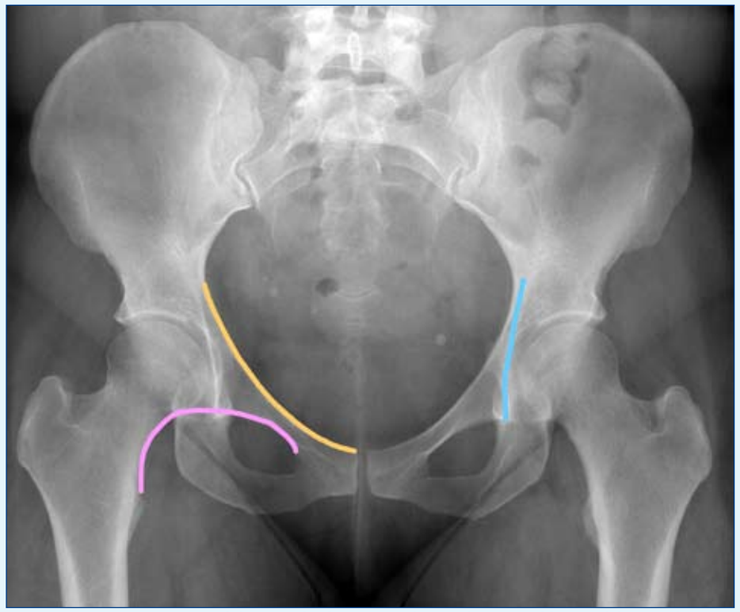


Figure 2. Anteroposterior view of the normal pelvis. Orange line = iliopectineal line; pink line = Shenton's line; blue line = ilio-ischial line.

trabecular pattern of the femoral neck to ensure it is not disrupted. Also review the bone cortex for a breach or the dense transverse line of an impacted fracture (*Figure 3*). The curve of the lower border of the superior pubic ramus and the inferior aspect of the neck of the femur should form a smooth arc (Shenton's line) which becomes discontinuous following a fracture. The medial half of the femoral head is projected over the posterior acetabular rim in the normally located hip.

Important injuries

Anterior-posterior compression pelvic fractures

These injuries are the result of force applied directly to the anterior or posterior aspects of the pelvis such as in a head-on road traffic collision. They lead to widening or disruption of the pubic symphysis and sacroiliac joints. There may be variable rupture of the sacrotuberous and sacrospinous ligaments which determine the stability of the injury. Obturator ring fractures may also be associated.

Figure 3. The impacted subcapital femoral neck fracture is revealed by a dense transverse band (arrow).

Vertical shear pelvic fracture

The mechanism of this injury is an axial load on the pelvis most commonly transmitted through the lower limb such as in a fall from a height. This manifests itself as vertical displacement of the hemipelvis compared to the contralateral side. In the anterior pelvis pubic rami fractures are observed (*Figure 4*), while posteriorly the sacrum is fractured or there is sacroiliac joint diastasis. Alternatively a fracture of the iliac wing may occur.

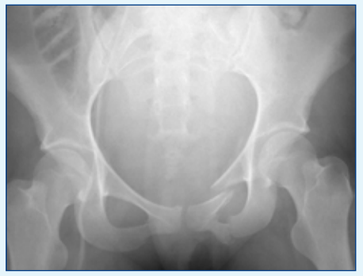
Lateral compression pelvic fractures

These are the most commonly seen type of pelvic ring fractures and occur when there is direct force to the lateral aspect of the pelvis such as in a side impact collision. Complex obturator ring fractures are invariably present. An ipsilateral sacral compression fracture or iliac wing fracture are commonly associated. The most unstable form comprises a lateral compression injury on the side of the impact and a contralateral anterior-posterior compression fracture (windswept pelvis).

Avulsion fractures

Fractures of the apophyses at the site of tendon insertions are usually seen in young atheletes, especially footballers and gymnasts. The avulsed fragment of bone has a typical location on the pelvic ring. Common fracture sites and the tendon insertions include the anterior superior iliac spine (sartorius), anterior inferior iliac spine (rectus femoris), ischial tuberosity (hamstrings) and the pubic tubercle (adductors).

Figure 4. A vertical shear fracture. The inferior and superior pubic rami fractures were accompanied by a sacral fracture (not shown).



Acetabular fractures

Functionally the pelvis comprises an anterior pelvic column (iliac wing, superior pubic ramus and anterior wall of the acetabulum) and a posterior pelvic column (posterior ilium, posterior and medial acetabular walls and the ischium). Acetabular fractures may involve the walls of the acetabulum and the pelvic columns (*Figure 5*).

The most common injury is a fracture of both columns in which the free-floating acetabulum is displaced medially (*Figure 6*). The 'spur sign' represents the part of the ilium that remains attached to the sacrum. The iliopectineal line (from the sciatic notch to the superior pubic ramus) is the landmark for the anterior column, and the ilio-ischial line (from the sciatic notch inferiorly into the teardrop) indicates continuity of the posterior column.

Figure 5. A pelvic fracture disrupting the iliopectineal line (arrow).

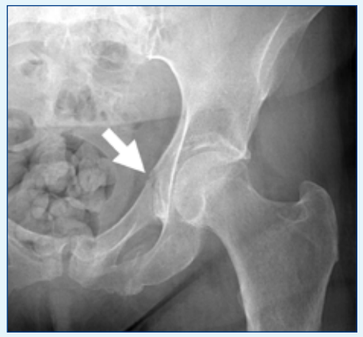
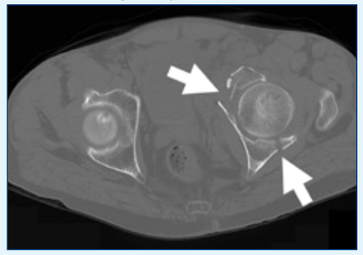


Figure 6. An axial computed tomogram of the pelvis demonstrating fractures of the pelvic columns and acetabular walls (arrows).



Hip dislocation

Posterior dislocations are the most common injury by far and are frequently caused by the knee striking the dashboard in a road traffic collision. The femoral head may be fractured against the acetabulum and the ligamentum teres avulsed. On the frontal pelvic X-ray the femoral head is displaced superiorly and laterally. In the rarer anterior dislocation the femoral head is generally projected over the obturator foramen.

Fractured neck of femur

This is the most commonly encountered injury. Careful examination of the femoral neck, continuity of the trabeculae and integrity of Shenton's line should be ensured in each film. The level of the fracture should be documented as this reflects the potential for the development of avascular necrosis (*Figure 7*), as well as whether the fracture is displaced (*Figures 3, 8* and *9*). Stress fractures occur over time and may be compressive, starting on the inferior cortex, or tension, starting on the superior cortex.

Conclusions

Pelvic fractures are complex injuries but an understanding of functional anatomy makes the radiological appearances more understandable. While these are usually seen in the context of high-impact trauma femoral neck fractures are a common presentation in the elderly following a fall. Systematic review of the film, with a bright light if necessary, is needed to avoid missing subtle injuries. **BJHM**

Figure 7. The level of the fractured neck of femur determines the likelihood of avascular necrosis developing. A = subcapital; B = transcervical; C = basicervical; D = intertrochanteric.

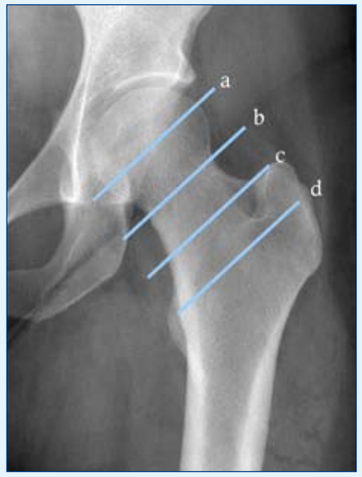


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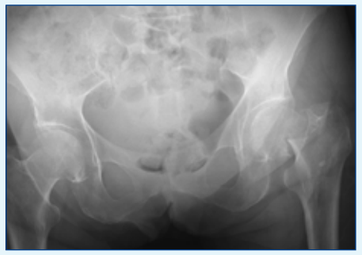
Figure 8. An intertrochanteric fracture of the neck of femur.

Figure 9. A basicervical fracture of the neck of femur.



KEY POINTS

- Pelvic ring fractures are frequently multiple.
- Sacroiliac joints and pubic symphysis may be involved.
- Some injuries are unstable and may lead to trauma of the intra-pelvic viscera.
- Femoral neck fractures are common but may be subtle.
- Document the level of femoral neck fracture and the degree of displacement.