Radiography, anatomy and imaging in pelvic fractures

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Abstract

Pelvic fractures are one of the leading causes of morbidity and mortality in the multiply injured patient. It is important to establish the pattern of fracture as early as possible. To do this efficiently, the correct imaging should be used. Using a combination of simple and modified plain radiography alongside computed tomography scans it is possible to clearly delineate the fracture pattern and likely direction of energy transfer through the pelvis. Pelvic ring injuries signify a significant insult and are associated with urogynaecological, colorectal and vascular trauma alongside the musculoskeletal trauma. This article provides a basis upon which orthopaedic surgeons may utilize and scrutinize pelvic imaging prior to, during and post surgical fixation.

Keywords CT scan; LC2 screw; pelvic fracture; pelvic ring disruption; plain radiography; sacral dysmorphia; trauma

Introduction

Pelvic fractures typically occur in the patient with multiple injuries through a high energy mechanism.[1] After initial and stabilizing management strategies it is essential to image the patient. Imaging plays an essential role in the diagnosis and management of pelvic fractures. It allows surgeons to establish a variety of key variables regarding the personality of the fracture. Together with the clinical situation and haemodynamic status, imaging guides the need to surgically intervene. Therefore an accurate visual description of the fracture is imperative to decide whether to operate and to guide the intra-operative method to stabilize the fracture. This chapter describes the imaging of pelvic fractures in more detail.

Prior to examining any imaging, it is important to take note of the patient's mechanism of injury. This may provide clues about what pelvic fracture pattern may be present. This may then be described by the Young and Burgess Classification system.[2] This split up into three broad criteria: lateral compression, anterior—posterior compression and vertical shear. The classification of pelvic fractures will be covered in another article. However the mechanism of injury will give one a clue with regards to how to tailor the assessment of any imaging for each patient.

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Anatomy

The hemi-pelvis is made up of three bones, the ilium, ischium and pubis. They are fixed anteriorly by the pubic symphysis and posteriorly to the sacrum via sacro-spinous, sacrotuberous, sacroiliac and iliolumbar ligaments. The posterior pelvic ligaments are the strongest ligaments in the body, thus disruption of these require significant energy transfer. The posterior osseoligamentous structures therefore provide a keystone for stability, from which the entire pelvic ring is supported. The pubic symphysis only provides 15% of intrinsic pelvic stability and is therefore the weakpoint of the pelvic ring.[3,4] Pelvic fractures have significant morbidity and mortality due the proximity of neurovascular, reproductive, urological and colorectal structures. It is essential to consider what structures may be injured when assessing the imaging for displaced pelvic fractures. Pubic rami fractures and symphysis disruptions may lead to urethral, bladder or gynaecological trauma. Sacral fractures through the foramina may result in nerve root injuries. Disruption of the sacro-iliac joints can cause significant haemorrhage from the presacral venous plexus. Any displaced pelvic fracture could potentially lead to colorectal trauma.

Plain radiography

As the management of the traumatically injured patient rapidly evolves, many patients are quickly assessed and then undergo a CT scan from their head to inferior pubic rami. However, there is still a role for traditional plain radiography. In centres without access to a CT scanner or in the haemodynamically unstable patient, plain radiographs may be performed in the resuscitation room to provide a basic radiographic assessment of the fracture. Plain radiography also plays an essential role in the intra-operative management of unstable pelvic fractures.

Anterioposterior radiographs

When assessing pelvic radiography, the pelvis as a whole must be considered as three separate rings; the pelvic ring itself and two obturator foramina. If one ring has a disruption, there must be another corresponding disruption elsewhere within that specific ring. A standard anterioposterior (AP) view is usually the only view provided. Nevertheless there is usually enough evidence from this image to determine if a pelvic ring injury is present. It is important to assess both the bony anatomy and to look for clues for ligamentous injury. The first thing to look at is the three rings in the pelvis. Disruptions in the obturator foramens indicate pubic rami fractures. These in turn may hint towards a bigger pelvic ring injury. Displaced fractures of the iliac wing are usually easy to recognize in plain radiographs. More subtle findings, crucial to recognize, are potential ligamentous injuries. These may be in isolation to bony injuries. Anterior ligamentous injuries are demonstrated by widening of the pubic symphysis; posterior ligamentous injuries are represented by widening of the sacro-iliac joints. AP pelvis radiographs also provide a clue as to the mechanism of injury and the Young and Burgess classification.

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Anterior posterior compression (APC) injuries can be identified by widening of the pubic symphysis. The pubic symphysis is usually 4–5 mm wide. Anything more than 1 cm is considered abnormal.[5] There are usually no pubic rami fractures as the energy is transferred across the pelvis from front to back, through the pubic symphysis. As the level of energy transfer to pelvis increases, the symphysis distance widens further, with more than 2.5 cm of diastasis considered to be an unstable APC fracture pattern.[5] When the diastasis is more than 2 cm it is very likely associated posterior ligamentous structural injuries will have occurred resulting in widening of the sacro-iliac joints. Hence the APC is typically a ligamentous injury pattern (Figure 1).

The energy from Lateral compression (LC) trauma to the pelvis transfers to the anterior and posterior pelvic structures. It therefore causes disruption of the ipsilateral pubic rami and ipsilateral sacro-iliac joint (Figure 2). Higher degrees of LC trauma (LC2) cause a small crescent fracture of the ilium near its articulation with the anterior sacroiliac joint. This fragment is usually easy to identify on plain radiograph by assessing the pelvic ring in conjunction with the superior rim of the ilium, particularly at the sacro-iliac joint. Fractures of the pubic rami are typically horizontal in nature, distinguishing LC trauma from other mechanisms of pelvic injury. The posterior pelvic ligaments remain intact and because the sacrotuberous and sacrospinous ligaments remain uninjured, vertical translation of the hemipelvis is avoided. The final structure to be injured as energy transfer from LC trauma to the pelvis increases is the contralateral pelvis. The ipsilateral hemipelvis to the trauma rotates into the contra-lateral hemipelvis causing an APC type fracture pattern on this side. There may be a vertically orientated pubic rami fracture on the contra-lateral hemipelvis.

Vertical shear (VS) trauma to the pelvis causes vertically orientated pubic rami fractures (Figure 3). As energy is transferred posteriorly, the posterior ligaments are ruptured causing superior displacement of the ilium on the sacrum. With high energy VS fractures, the vertical displacement of the hemipelvis is usually accompanied by fractures to the transverse process of L5.[6]

Inlet and outlet radiographs

Pelvic ring injuries are best assessed using inlet and outlet views (Figure 4). These views show displacement to any structures in the pelvic ring. The Inlet view provides a birds-eye view of the pelvic ring and an axial view of the sacrum. It is the best radiograph to assess ring disruption for APC and LC injuries. It is performed by aiming the X-ray beam 30–60 degrees towards the head of the patient.[7] Outlet views are performed by tilting the X-ray beam approximately 30–60 degrees to the feet.[7] This view is best to assess vertically displaced pelvic ring fractures. It also provides a true AP of the sacrum and therefore can be a screening tool for assessment of sacral fractures. The use of these views on initial assessment of pelvic injuries is becoming less common because of the expansion in use of rapid spiral CT scans in trauma protocols. Nevertheless, these are essential views when following up conservatively or surgically managed pelvic ring injuries. They are also of great importance intraoperatively which will be covered later in the article.

With the advent of a trauma network In the UK, the majority of patients with pelvic injuries are arriving to hospital with a binder in situ. This life-saving device, applied by paramedics, brings about its own set of difficulties. From a clinical aspect, it is essential to remove the binder in good time as the risk of pressure necrosis is very high after 24 h. From the point of view of imaging, a correctly applied binder can easily hide pelvic injuries by reducing displacement of fractures and ligamentous injuries.[8] Therefore it is essential to assess for pelvic pain and signs of pelvic injury such as scrotal haematoma and tenderness over the pubic symphysis on the secondary survey. If there are any concerns of a pelvic injury, it is imperative to acquire a plain radiograph of the pelvis out of the binder (Figure 5).

With any type of anterior pelvic injury there is a risk of urethral or bladder injuries. The best assessment of urethral or bladder trauma is via retrograde urethrogram and cystogram. Patients with any difficulty in passing a silicon catheter, or a successfully passed catheter which drains nothing or purely blood, should have a retrograde urethrogram.[9] This is usually done in the resuscitation room with an X-ray plate positioned under the pelvis. 20 ml of dilute IV contrast should be passed through a paediatric catheter gently inflated at the urethral meatus. An AP pelvic radiograph is then taken to assess if there is any contrast leak from the urethra (Figure 6).

If when siting the original catheter, it passes easily into the bladder but there is blood stained urine, a retrograde cystogram should be conducted.[10] This is done with 300 ml of dilute IV contrast instilled into the bladder via the catheter. The catheter

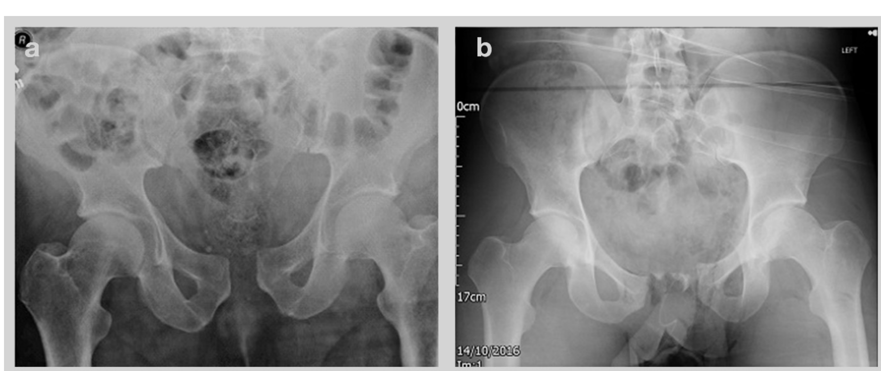

Figure 1 Plain radiographs depicting (**a**) APC2 and (**b**) APC3 pelvic fractures. It is important to recognize not only the anterior diastasis but also the posterior ring disruption.

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