Low and high energy pelvic injuries

Pelvic injuries cover a spectrum of pathology, from high energy injuries in the young population to low energy fragility fractures in older people. Owing to the long-term morbidity and high rates of mortality in higher energy injuries, the initial care of such fractures requires a diligent and prompt approach from the trauma team. Fragility fractures of the pelvis have contrasting injury patterns and patient groups. The frequency of such fragility fractures (and related burden of care for hospitals) is increasing as a result of the ageing population. This article discusses the assessment and management of high energy pelvic injuries and of lower energy pelvic and acetabular injuries.

Pelvic anatomy

The pelvis has numerous roles. From a musculoskeletal perspective, this inherently stable ring forms the link between the axial skeleton and the lower limbs, offering skeletal support for weight-bearing, maintaining posture and providing a point for muscular attachments to allow locomotion, perineal tone and sphincter support. It also houses and protects the pelvic organs and is linked with the body's strongest ligaments, named by their origins and insertions: the sacroiliac complex, sacro-tuberous, sacro-spinous, ilio-lumbar and lumbo-sacral ligaments (Tissingh et al, 2017).

The pelvic ring is composed of two innominate bones, which connect to the sacrum posteriorly and the pubic symphysis anteriorly (*Figure 1*). Each innominate bone comprises an ilium, ischium and pubis bone, fusing at maturity along a 'Y'-shaped ossification line with the centre of the Y in the acetabulum (*Figure 2*). Each innominate bone also divides into anterior and posterior columns, which function as struts to provide pelvic stability (*Figure 3*). The lateral profile of the innominate bone resembles the Greek λ, with the longer limb forming the anterior column and shorter limb being the posterior column (Tissingh et al, 2017). The anterior column comprises the pubis and ilium, with continuation from the iliac wing to iliac crest through the superior pubic ramus. The posterior column consists of the ischium and ilium, with extension from the posterior ilium just below the greater sciatic notch to the ischial body and inferior pubic ramus (Tissingh et al, 2017).

The abdomino-pelvic soft tissues housed within the pelvis are protected by the lesser and greater pelvis. The lesser or 'true' pelvis is a short curved tunnel enclosed by the pelvic brim and pelvic floor to contain the rectum, distal urinary tracts and internal genitalia. The greater or 'false' pelvis is a space above the pelvic brim and is bound by the bilateral ilium to protect the inferior abdominal viscera including the sigmoid colon and ileum.

The aorta bifurcates above the pelvis (L4 level) forming two common iliac arteries. The arterial tree branches once again at the

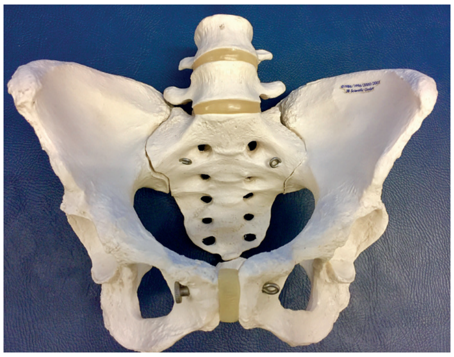

Figure 1. Anterior view of pelvis.

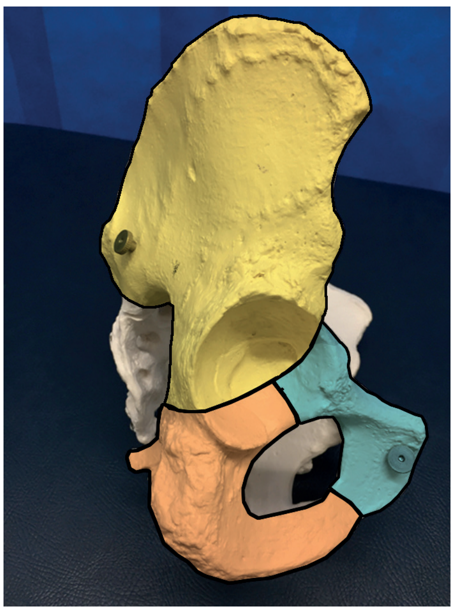

Figure 2. Illustration of ossification of pelvic bones: ilium (yellow), pubis (blue) and ischium (orange).

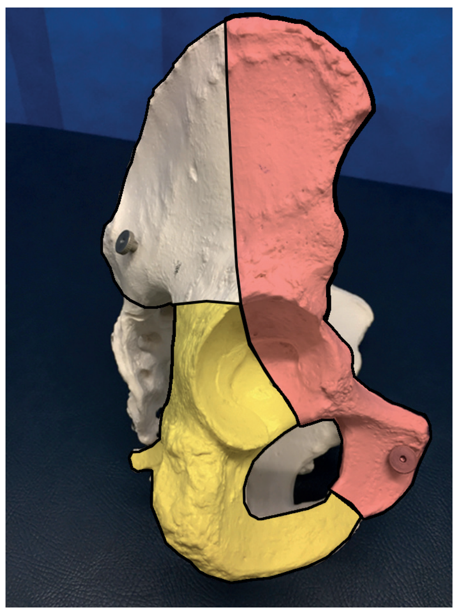

Figure 3. Illustration of anterior column (red) and posterior column (yellow) of pelvis.

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proximal aspect of the pelvis into the internal and external iliac arteries. The internal iliac artery is the main blood supply to the pelvis and the external iliac becomes the femoral artery at the level of the inguinal ligament, acting as the main supply to the lower limbs. A complex venous plexus forms over the posterior wall of the pelvis for return to the venae cava. This conglomerate of vessels intertwines with the lumbar plexus and the arterial tree.

High energy pelvic injuries

High energy pelvic fractures are commonly seen after motor vehicle accidents and falls from height (Guthrie et al, 2010).

Initial management

Pelvic injuries must be assessed with caution and in line with Advanced Trauma Life Support (ATLS) principles. The ATLS primary survey involves the assessment and simultaneous management of common life-threatening conditions (Guthrie et al, 2010; ATLS Subcommittee et al, 2013). Patients with displaced pelvic ring injuries are at risk of major bleeding as a result of disruption of the pre-sacral and paravesical venous plexi. Circulatory resuscitation and attention to ongoing haemorrhage is of paramount importance, as is the prompt application of a pelvic binder to stabilize the pelvis in the pre-hospital setting before the patient is transferred to a major trauma centre (British Orthopaedic Association, 2018).

Intravenous tranexamic acid should be given within 1 hour of injury (British Orthopaedic Association, 2018). Extensive blood loss can lead to the lethal triad of acidosis, hypothermia and coagulopathy, so sensible but timely use of packed red cells, fresh frozen plasma and platelets is recommended in the presence of haemodynamic instability (British Orthopaedic Association, 2018). Clinicians should familiarize themselves with their hospital's massive transfusion protocol. Persistent haemodynamic instability indicates ongoing bleeding and in such instance an emergency angiographic embolization of active bleeding vessels or laparotomy with open pelvic packing should be performed (British Orthopaedic Association, 2018).

Pelvic binder application

A pelvic binder should be applied at the level of the greater trochanters (*Figure 4*) during initial resuscitation, to provide mechanical stability. Ideally the device should remain in place no longer than 24 hours post injury and external fixation for temporary pelvic stabilization should be considered if early surgical stabilization is not available (British Orthopaedic Association, 2018).

Figure 4. Application of a pelvic binder.

Associated injuries

Owing to the proximity of the numerous anatomical structures within the pelvis, there is a high frequency of associated injuries with pelvic fractures, including major urological injuries (British Orthopaedic Association, 2018). Presence of blood at the external urethral meatus, a high riding prostate or a perineal bruise should raise suspicion of urethral injury (British Orthopaedic Association, 2016). Urology input and consideration of urethrography is advised. Multiple catheter attempts should be avoided as suprapubic catheterization may be required (British Orthopaedic Association, 2016).

The presence of wounds to the lower abdomen, groin, buttocks, perineum, vagina and rectum (including sphincters) are indicative of an open pelvic fracture and urgent antibiotics and assessment by a consultant general surgeon is required (British Orthopaedic Association, 2017, 2018). Urgent bladder drainage by cystostomy tube and bowel diversion with an end-colostomy may be needed (British Orthopaedic Association, 2018). Debridement should be as for any open long bone fracture and patients will also need combined plastic and orthopaedic surgical care (British Orthopaedic Association, 2017).

A thorough neurological and vascular examination of lower limbs should be undertaken and documented. Damage to the sacral nervous plexus should be excluded by assessing anal sensation and tone.

Pelvis stability tests are controversial, as compression or distraction forces placed on the pelvis can disturb newly formed blood clots. These tests have both a poor sensitivity and specificity and the ATLS guidelines do not recommend their use in the presence of shock or obvious fractures (Huber-Wagner et al, 2009; ATLS Subcommittee et al, 2013). Internally and externally rotating the pelvis is an alternative way to detect pelvic tenderness that may reduce further bleeding, but this is also controversial.

Imaging

After haemodynamic stabilization, high energy trauma requires a computed tomography scan, with intravenous contrast, of the head, chest, abdomen and pelvis. Using a computed tomography scan for early assessment of high energy trauma will identify potentially life-threatening associated injuries and increase the probability of survival in patients with polytrauma (Huber-Wagner et al, 2009; ATLS Subcommittee et al, 2013). Such imaging will characterize bony pelvic ring injuries, but pure ligamentous injuries can be missed if anatomically reduced by a pelvic binder (Fletcher et al, 2016). A post-binder X-ray is therefore advised after resuscitation for all poly-traumatised patients, even in the presence of a 'normal computed tomography' as the binder may mask pelvic ring injuries (British Orthopaedic Association, 2018).

Classifying high energy pelvic fractures and their clinical outcomes

Injury patterns are determined by the direction and size of the force acting on the pelvis at the time of injury, which occur in predictable patterns. Pelvic injuries often involve failure at two parts within the bony ligamentous ring, being either two fractures or a fracture and a dislocation. As such, clinicians should be wary of the 'isolated pubic rami fracture', particularly in the younger patient, where missed sacro-iliac disruptions can have devastating clinical impacts.

The Young–Burgess classification system (*Table 1*) categorises pelvic ring disruptions by direction of force, identifying four sub-

Table 1. The Young–Burgess classification of pelvic ring disruption

Anterior-posterior compression	I	Pubic symphysis diastasis <2.5 cm. No posterior instability
	II	Pubic symphysis diastasis >2.5 cm. Anterior sacroiliac joint diastasis. Disruption of sacrotuberous and sacrospinous ligaments
	III	Dislocation of sacroiliac joint. Associated with vascular injury
Lateral compression	I	Compression fracture of pubic rami and ipsilateral anterior sacral ala
	II	Pubic rami fracture and ipsilateral posterior ilium fracture dislocation
	III	Ipsilateral lateral compression and contralateral anterior posterior compression
Vertical shear	Posterior and superior directed force	

From Burgess et al (1990)

groups based on the severity of disruption (Burgess et al, 1990). These include the anterior-posterior compression, lateral compression, vertical shear and combined mechanisms. Determining the category is possible from an anterior-posterior pelvis radiograph. Clinicians should note that in an anterior-posterior compression injury, identifying characteristics include a widening of the pubic symphysis (diastasis) and/or the sacro-iliac joint. Lateral compression injuries tend to demonstrate impaction fractures of the sacro-iliac joint, iliac wing or acetabulum. Cephalic movement of the hemi-pelvis or iliac wing is indicative of a vertical shear disruption.

The Young–Burgess classification both guides management and predicts transfusion requirements through its sub-groups (Burgess et al, 1990). Typical transfusion requirements were a mean of 5.9 units over all groups, with lateral compression mechanisms requiring 3.6 units, vertical shear mechanisms requiring 9.2 units, anterior-posterior compression mechanisms requiring 14.8 units and combined mechanisms requiring 8.5 units (Burgess et al, 1990). Lateral compression injuries were hypothesized to exhibit less blood loss, as local vessels are shortened rather than subjected to tensile or shear force. Any bleeding would, in addition, tamponade by a pelvic ring of a fixed volume because the ligamentous structures remain unviolated (Burgess et al, 1990).

Long-term management

High energy pelvic injuries should be managed by multidisciplinary teams at specialist centres. Patients requiring surgical stabilization should be transferred to such a centre within 24 hours of injury (British Orthopaedic Association, 2018). Thromboprophylaxis should be provided early in line with local policies (British Orthopaedic Association 2018).

Low energy pelvic injuries

In contrast to high energy pelvic fractures in the young, fragility fractures of the pelvis are typically low energy lateral compression injuries in older people who have osteoporosis (Cosker et al, 2005; Rommens et al, 2015). These fragility fractures of the pelvis are the result of a fall from standing height or less and would not occur in the presence of healthy bone (National Institute for Health and Care Excellence, 2017; Rommens et al, 2017). The underlying osteoporosis is often secondary to vitamin D deficiency, long-term steroid use and long-term immobilization. With the ageing population, fragility fractures of the pelvis will become more common.

Morbidity is high with fragility fractures of the pelvis and short-term sequelae (the result of immobility and pain) include pressure ulcers, urinary tract infections, delirium and venous thromboembolism (Pagenkopf et al, 2006; Breuil et al, 2008). Long-term sequelae include reduced quality of life, a loss of independence and chronic pain (Koval et al, 1997; Hill et al, 2001). The frailty of these patients is illustrated by the mortality rates of 27% by 1 year, similar to those with neck of femur fractures (Morris et al, 2000).

Presentation

Patients typically present with pain in the groin, pubic area, posterior pelvis or the lower back. Most patients find mobilization difficult as the pain is often aggravated by weight bearing (Rommens et al, 2015, 2017). Clinical examination shows tenderness over the fractured region and pelvic instability is rarely noted. Neurovascular examination of the lower limbs is recommended in all patients (Rommens et al, 2017).

Imaging

Fragility fractures of the pelvis are often diagnosed as fractures in isolation and deemed minor injuries. However, fragility fractures of the pelvis are not universally benign. Mechanistically the pelvic ring is rigid and so tends to fail at two points. With modern magnetic resonance imaging and computed tomography, the presence of fractures to the posterior elements of the pelvis (such as the ilium, the lateral mass of the sacrum and the sacroiliac joint) can be revealed (Scheyerer et al, 2012; Rommens et al, 2017). Displaced pelvic ring fractures can be unstable and imaging should clarify their presence. Undisplaced fractures seldom require surgical intervention, but clarifying their presence allows the clinician to appreciate the injury severity and guides rehabilitation.

All patients require a pelvis anterior-posterior radiograph. If a pubic rami or sacral fracture is identified, further X-rays should also be used including inlet views to identify posterior displacement of the pelvic ring or opening of the pubic symphysis and outlet views to look for any vertical shift of the pelvis (*Figure 5*).

If an acetabular fracture is identified, two oblique views of the pelvis are required (Judet views) (Tissingh et al, 2017):

1. The iliac oblique view, to assess both the posterior column of the pelvis and the anterior wall of the acetabulum
2. The obturator oblique view, for the anterior column of the pelvis and the posterior wall of the acetabulum.

Any fracture of the posterior elements or acetabulum (identified by radiograph), posterior tenderness without diagnosis or any patient failing to progress with mobilization warrants a computed tomography scan of the pelvis (*Table 2*) (Rommens et al, 2017). Computed tomography is excellent at determining the fracture configurations for displaced fractures and is readily available in most hospitals. Magnetic resonance imaging should not be a routine part of the imaging work-up, but should be considered when the diagnosis remains uncertain (despite

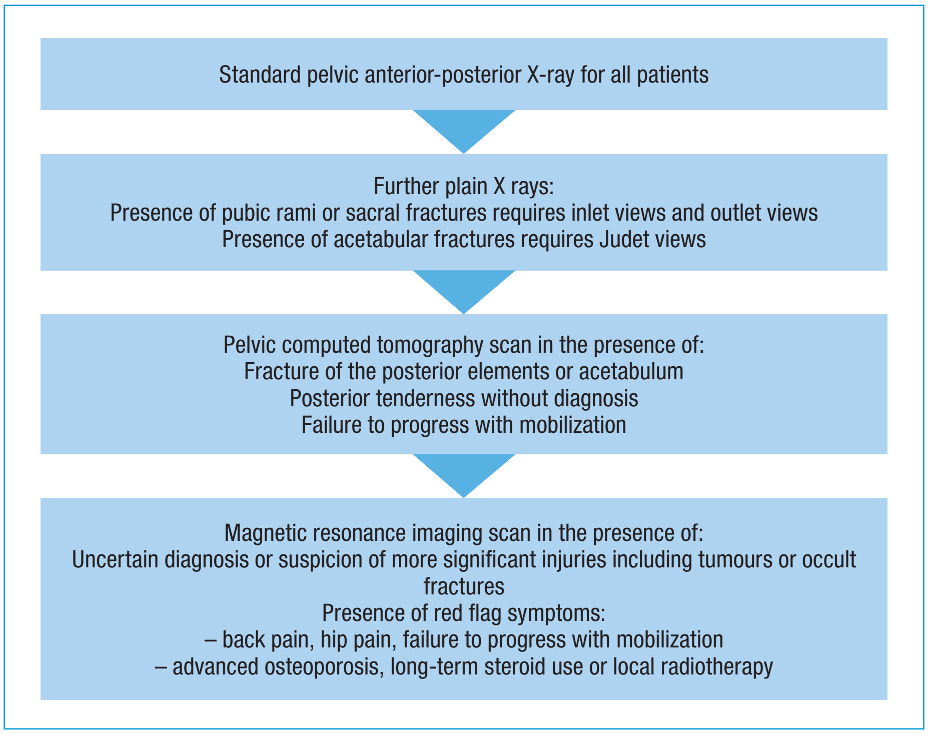

Figure 5. Diagnostic work-up for low energy pelvic injuries.

computed tomography imaging) or there is suspicion of a more significant injury. Magnetic resonance imaging is sensitive for undisplaced fractures but also for pre-existing bone bruises and tumours (*Figure 5*) (Henes et al, 2012). Red flags for more significant injuries include:

- Back pain
- Hip pain (pain on rotation pin rolling the hip joint) (expected in acetabular fractures)
- Posterior pelvic tenderness
- Failure to progress with mobilization
- Advanced osteoporosis, long-term steroid use or local radiotherapy.

Classification

Instability is uncommon in fragility fractures of the pelvis, but if missed can have severe consequences. The classification system by Rommens et al (2015) is helpful in assessing such patients and guiding management (*Table 2*). There are four categories which are based on fracture patterns on conventional radiographs and computed tomography scan (Rommens et al, 2015, 2017) (*Table 2*).

Management

Initial bed rest, pain control and careful nursing are required for all patients.

Early mobilization (within pain limits) of type I fragility fractures of the pelvis should be considered to avoid the sequelae of immobilization and encourage fracture healing (Kenwright et al, 1986). Mobilization in this instance can be permitted, as the weight-bearing axis avoids the anterior pelvis ring, passing from the femoral heads through the superior acetabulum, the ilium, sacroiliac joints and on through the sacrum and lumbar spine. Progression with mobilization should at all times be guided by the patient and not be prematurely imposed.

Type II fragility fractures of the pelvis are equally managed with early mobilization. However, failure to tolerate mobilization should lead the clinician to consider use of percutaneous stabilization (Rommens et al, 2017).

Both type III and IV fragility fractures of the pelvis require surgical intervention, although minimally displaced type III lesions can be stabilized percutaneously without the need for open reduction (thereby avoiding its associated morbidity) (Rommens et al, 2017). By contrast, significantly displaced types III fractures require open reduction and internal fixation including sacroiliac screw osteosynthesis, bridging plate osteosynthesis, trans-sacral positioning bar and angle stable plating (Rommens et al, 2017).

Type IV fractures should be treated with surgical stabilization to prevent further displacement of lumbosacral segments into the pelvic ring. Bilateral stabilization or iliolumbar fixation is recommended to restore pelvic stability (Rommens et al, 2017).

More recent surgical management includes sacroplasty, in which polymethylmethacrylate cement is injected into the fractured sacrum to reduce pain levels (Rommens et al, 2017). In the event of doubt, the local pelvic specialist orthopaedic surgeon should always be consulted.

Table 2. Classification of fragility fractures of the pelvis

Type I: isolated anterior pelvic ring fractures	Ia	Unilateral anterior ring disruption
	Ib	Bilateral anterior ring disruption
Type II: non-displaced posterior fractures only	IIa	Non-displaced and isolated posterior fracture
	IIb	Sacral crush injuries with anterior disruption
	IIc	Non-displaced sacral, sacroiliac or iliac fractures with anterior disruption
Type III: displaced but unilateral posterior fractures combined with an anterior pelvic ring fracture	IIIa	Displaced unilateral ilium fracture
	IIb	Displaced unilateral sacroiliac fracture-dislocation
	IIIc	Displaced unilateral sacral fracture
Type IV: displaced bilateral posterior fractures	IVa	Bilateral iliac fractures or sacroiliac disruptions
	IVb	Spinopelvic dissociations associated with bilateral vertical fractures through the sacral ala with a horizontal component connecting them (a U- or H-type sacral fracture)
	IVc	A combination of different posterior instabilities

From Rommens et al (2015)

Long-term management

Fragility fractures of the pelvis take at least 6–8 weeks to unite and owing to the dysfunctional bony health in this patient group, healing can take up to or over 3 months. An early discussion with the patient and family is recommended, to stress the frailty of the patient and manage long-term expectations (*Table 3*). Blood investigations should also be performed to highlight any reversible causes of osteoporosis such as thyroid dysfunction, vitamin D deficiency or hypogonadism (Tsiridis et al, 2006; British Orthopaedic Association, 2015).

Conclusions

Pelvic fractures are a clinical challenge because of the complexity of the pelvic anatomy and the variation of injury patterns. Appropriate initial management adhering to ATLS principles is key to managing high energy pelvic injuries. By contrast, fragility fractures of pelvic are low energy injuries, which typically require non-operative treatment unless unstable fracture patterns are identified. In all types of pelvic injury, prevention of complications is crucial in long-term management. By understanding clinical presentation and injury mechanisms, suitable investigation and management can be delivered to achieve better short and long-term outcomes. **BJHM**

Conflict of interest: none

Table 3. Long-term management goals for fragility fractures of the pelvis
Pain relief
Careful nursing including rolling to prevent pressure ulcers
Osteoporosis treatment
Prophylaxis of venous thromboembolism
Early removal or indwelling urinary catheters
Weight bearing as tolerated
Walking aids to offload weight bearing away from the pelvis

KEY POINTS

- All patients with high energy pelvic fractures should be initially managed using Advanced Trauma Life Support principles and require urgent imaging assessment.
- Complex pelvic injuries with haemodynamic instability should be promptly attended to by a multidisciplinary team followed by rapid transfer to a major trauma centre for specialist care.
- Fragility fractures of pelvic are low energy injuries and generally require non-operative treatment unless they show unstable fracture patterns.
- Prevention of complications is crucial in long-term management of all pelvic injuries.

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