Pelvic fractures

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Pelvic fractures account for 1–3% of all fractures, and around 60% of them occur in men. High energy fractures of the pelvic ring often result from motor vehicle collisions, crush injuries or falls from a height. Pelvic ring fractures may be associated with severe or life-threatening soft tissue injuries. Mortality may be as high as 10–20%, and open pelvic fractures have a mortality of up to 50%.

PELVIC ANATOMY

A thorough understanding of pelvic anatomy and the mechanism of injury helps predict fracture patterns, which in turn determine treatment. The pelvis is a strong osseoligamentous ring construct which transmits load from the axial spine to the lower limbs and gives origin to muscles of the hip, knee, spine, abdomen and perineum. The ilium, ischium and pubis fuse at the acetabulum to form the innominate bone which is joined with its counterpart anteriorly at the symphysis pubis. The ring is completed posteriorly by the sacrum which joins with the innominate bones at the sacroiliac (SI) joints.

Key ligamentous supports of the pelvic ring include the anterior and very strong posterior SI ligaments, the ileotransverse ligament joining the transverse process of L5 to the posterior iliac crest, the sacrospinous, sacrotuberous ligaments and the ligaments of the symphysis pubis. These ligaments tend to rupture progressively with transfer of increasing levels of energy. This leads to increasing instability of the pelvic ring and an associated increased risk of soft tissue injury.

Pennal and Sutherland (1961) classified pelvic fractures, based on the mechanism of injury, into anteroposterior (AP) compression, lateral compression and vertical shear fractures. Further classification by Cryer et al (1988) indicates fracture patterns likely to be associated with major haemorrhage.

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EARLY MANAGEMENT

The early treatment of pelvic fractures involves managing associated, potentially life-threatening soft tissue injuries following the Advanced Trauma Life Support guidelines. Multiple large bore cannulae for venous access allow circulatory resuscitation. A pelvic belt and/or skeletal traction may be required for temporary pelvic ring stabilization in unstable fracture patterns and complements circulatory resuscitation. Inappropriate management of soft tissue complications may prejudice definitive surgical treatment of pelvic fractures and compromise outcome.

Repeated examination of an unstable pelvis should be avoided as it disrupts established haematoma and reduces the tamponade effect. Ideally, an experienced trauma surgeon should examine the pelvis as part of the initial management and establish a treatment plan.

Patients' haemodynamic status can be divided into four groups:

1. Stable with no skeletal fixation
2. Initially unstable but responds to pelvic stabilization and fluid resuscitation
3. Non-responders to pelvic stabilization and fluid resuscitation
4. Initial responders who subsequently decompensate.

Haemodynamically stable patients can be assessed fully for other injuries and definitive management established.

Haemorrhage associated with pelvic ring fractures is caused by disruption of the pelvic veins, osseous bleeding and, less frequently, arterial bleeding, any of which can cause rapid blood loss, cardiovascular shock and death. Early recognition and treatment of haemorrhage can be life saving. The energy absorbed at the time of injury correlates closely with the risk of haemorrhage.

Stabilization of an unstable pelvic ring limits the pelvic volume, reducing the volume of haematoma that can form. The quickest means of achieving initial skeletal stability is use of a pelvic belt, allowing control of the anterior and posterior pelvic ring. This may be supplemented by skeletal traction for vertically unstable fractures. Application of a skeletal traction pin to the proximal tibia is recommended unless specifically contraindicated.

Pelvic belts should only be used for temporary fracture control. Where application of a pelvic belt achieves haemodynamic control, a pelvic external fixator is often required (Riemer et al, 1993). This should be applied by an experienced orthopaedic trauma surgeon as injudicious application may result in poor stability and suboptimal haemorrhage control. The following features should be identified on the plain AP pelvic X-ray where present:

1. Symphyseal diastasis and its extent
2. Malrotation of the hemi-pelvis: internal rotation or external rotation
3. Opening of the SI joints
4. Translocation of the SI joints
5. Vertical shear of the hemi-pelvis
6. Avulsion of the transverse process of L5
7. Fractures of the anterior pelvic ring
8. Fractures of the posterior iliac crest involving the SI joint (crescent fractures)
9. Associated acetabular fractures.

If an external fixator is used the pelvis must be reduced by traction and internal rotation of the legs. A pelvic belt is then applied at the level of the greater trochanters. Under sterile conditions, the iliac crest is held between the thumb and fingers and a percutaneous technique used, avoiding vertical incisions. The outer cortex is drilled and a Schantz pin or equivalent introduced between the inner and outer tables of the ileum. The anterior iliac crest overhangs laterally, so the entry point is the inner third of the crest and follows the medial table of the ilium.

The pins should triangulate and converge in the thick buttress of bone superior to the acetabulum and anterosuperior to the greater sciatic notch. 'Low route' pin application has some biomechanical advantages but should be avoided in an emergency. An external 'A' frame fixator which allows independent pin placement with converging pins is recommended.

HAEMORRHAGE

Major haemorrhage associated with a pelvic fracture usually results from the fracture. Large volumes of blood may also be lost in the thoracic or abdominal cavities or from associated limb injuries and must be sought during both primary and secondary surveys.

Patients who do not respond to initial resuscitation require rapid assessment, via chest X-ray, diagnostic peritoneal lavage or rapid computed tomography (CT)/ultrasound scan, to find other sites of bleeding. This must not delay urgent surgical intervention where needed.

Haemorrhage is usually limited to the retroperitoneal space by the volume of the pelvic ring and abdominal wall tone. Laparotomy in the presence of extensive retroperitoneal haemorrhage releases the tamponade effect and often stimulates further bleeding. A rapidly expanding retroperitoneal haematoma is difficult to control. Laparotomy should be considered in patients not responding to resuscitation despite pelvic stabilization but should not be undertaken without stabilizing the pelvic ring. Pelvic packing can be effective but should be methodical, and overpressurization should be avoided. Catastrophic haemorrhage may require cross-clamping of the aorta and selective control of internal iliac vessels. The assistance of an experienced vascular surgeon is highly recommended.

An anterior frame applied to the iliac crests allows reasonable control of the anterior diastasis in open book fractures and helps manage haemorrhage. Posterior pelvic 'C' clamps may be required for haemodynamic control of fractures involving the posterior pelvic ring (including vertical shear fractures). The Ganz clamp can be hazardous to apply and should only be used by those familiar with the dangers. Anterior/inferior Schantz screws provide strong fixation and have biomechanical advantages but are more difficult to apply and risk acetabular penetration. External fixator frame application is not recommended for trauma room treatment.

Some patients are initially haemodynamically stabile and then decompensate. This is often seen with an arterial injury where initial blood loss is controlled by arterial spasm and subsequent vasodilatation causes delayed haemorrhage. These patients may be investigated by a contrast enhanced CT scan (Stephen et al, 1999).

Angiographic embolization may be therapeutic in cases of delayed haemorrhage which responded to initial resuscitation and have a positive contrast extraversation sign. Other sources of haemorrhage must be excluded and the technique has no place in the initial management of pelvic haemorrhage. Arterial bleeding is a relatively uncommon source of haemorrhage and contrast CT followed by angiography unnecessarily delays management of life-threatening haemorrhage in most cases. Arterial bleeding is more likely in lateral compression fractures of the pelvic ring, including crescent fractures.

IMAGING

Standard trauma X-rays should include an AP view of the pelvis. If a pelvic fracture is seen inlet and outlet views help classification. Transforaminal fractures of the sacrum and fractures of the transverse process of L5 are better visualized on the outlet view. Posterior displacement of the hemi-pelvis may be visible on the inlet view and either unapparent or subtle on the AP projection.

Vertical shear fractures may require longitudinal traction before a pelvic belt is applied to reduce the fracture. Diastasis of the symphysis pubis or wide displacement of pubic ramus fractures associated with open book pelvic ring fractures are well controlled by a pelvic belt initially. Conversion to an anterior external fixator device or use of open reduction and internal fixation (ORIF) with a symphyseal plate technique may be planned as definitive management.

External fixators are not stable enough for vertically unstable fractures. Lateral compression fractures may be severely displaced at the time of injury, causing bone fragment penetration of soft tissues before recoiling to a less displaced position. Severe soft tissue injuries may have a relatively benign radiographic appearance. These injuries may be associated with closed degloving of fasciocutaneous tissues (Morel–Lavelle lesion). Surgical incisions through these lesions should be avoided. Small open skin wounds may be associated with extensive closed degloving and derangement of the intra-pelvic organs but have less benign radiographic appearances.

Bladder or urethral injury has an overall incidence of 16.5% (Colapinto, 1980). Bladder rupture may result from direct pressure when the organ is full and is generally intraperitoneal. Perforation may also be caused by bone fragments in lateral compression injuries or be part of a symphyseal diastasis in open book injuries. These tend to be extraperitoneal ruptures although urethral rupture is more common with symphyseal diastasis. Extraperitoneal ruptures may be treated non-operatively, covered by a urethral and/or suprapubic catheter, appropriate drainage and sitting the patient up as soon as the pelvic ring has been stabilized.

If the fracture requires ORIF, the rupture should be repaired and the retropubic space of Rezius drained by a non-suction technique. The bladder should then be drained by urethral catheterization and covered with a suprapubic catheter (tunneled whenever internal fixation is required). Internal fixation increases the risk of infection but this usually settles when metalwork is removed once the fracture has united or the symphyseal diastasis is stable. Intraperitoneal rupture requires surgical repair. Microscopic haematuria occurs in 50% of patients with a pelvic fracture and needs no further investigation.

Displaced pubic ramus fractures or wide disruption of the symphysis pubis may be associated with urethral injury in the membranous male urethra rather than the female urethra. Blood at the meatus with scrotal haematoma suggests a complete or partial tear. Patients should be examined for a high riding prostate as this may indicate complete rupture. This may be difficult to appreciate in a widely disrupted pelvis with extensive perineal haematoma – retrograde cystourethrography is more accurate. Urethral injury is complete in 58% and incomplete in 42% of cases.

Urethral rupture should be covered by suprapubic catheterization under ultrasound in most cases. If the prostate is not high riding, passage of a silastic urethral catheter can be attempted. Injudicious passage of a urethral catheter risks completing a partial tear and causing further trauma; if in doubt, a suprapubic catheter should be used. Antibiotics should be used to minimize the risk of infecting the pelvic haematoma. A displaced prostatic urethra is often realigned by reduction of the fracture. There should be no tension on the urethra and catheter traction is contraindicated.

If ORIF of anterior pelvic structures is indicated, a silastic urethral catheter can be 'rail-roaded' into the bladder to allow urethral alignment. Pooled results of small series (Follis et al, 1992; Herschorn et al, 1992) suggest a slightly reduced stricture rate in cases of urethral alignment. Definitive management of urethral ruptures is controversial but should generally be repaired via a delayed procedure. There is a relatively high rate of urethral stricture, impotence and incontinence but this can be reduced by appropriate expert urological care.

NEUROLOGICAL INJURY

Neurological injury occurs in 30–40% of patients and ranges from severe motor and sensory impairment of bowel, bladder and lower limb function to mild paraesthesia. Of sacral fractures 50% are associated with a neurological injury. Reduction and fixation of pelvic fractures does not seem to reduce this rate of neurological injury.

The sciatic, superior gluteal, inferior gluteal and pudendal nerves exit the greater sciatic notch. The superior gluteal and the sciatic nerves are at greatest risk of injury, particularly in vertical shear fractures and when fractures enter the sciatic notch. Sacral fractures often extend vertically through the sacral foramina and may damage exiting nerve roots. The lumbosacral trunk is vulnerable to damage from SI joint disruptions and internal fixation techniques. Anterior SI plating probably carries the highest risk. Percutaneous SI screw fixation is a minimally invasive, biomechanically powerful technique for SI joint dislocations and other fracture dislocations of the posterior pelvic ring but needs skilled application to avoid injuring the sacral nerve roots.

Mortality of open pelvic fractures can be up to 50% (Raffa and Christiensen, 1976). Many patients die at the scene of the accident or fail to respond to resuscitation, and pelvic sepsis is the commonest cause of death in those surviving initial resuscitation. These patients need emergency surgery to gain optimal stability of the pelvis. As with other open injuries, thorough debridement and washout of open wounds is required, together with a mandatory double-barrel diverting colostomy and copious distal limb washout to protect the pelvis from contamination. Bladder and urethral injuries should be managed as above. Antitetanus and antibiotic prophylaxis are needed and repeated debridements may be necessary, particularly where pelvic packing is required. Vacuum-assisted closure suction dressings are invaluable in managing extensive open pelvic wounds and open degloving injuries.

Following emergency resuscitation and stabilization, a definitive plan of fracture management should be formulated. Stable lateral compression fractures may allow patients to mobilize non-weight bearing on the injured side until fracture union occurs. Unstable fractures and dislocations are more likely to go on to malunion or nonunion. Pain, pelvic obliquity and exacerbation of associated soft tissue injuries are more likely in these cases.

The primary goal of surgery is management of haemodynamic instability and soft tissue injuries. Secondary goals are avoidance of pelvic obliquity, persistent instability and painful nonunion. Some patients complain of chronic SI pain despite appropriate surgery but this tends to be less severe following stable internal fixation. Unstable fractures are better managed by operative stabilization to facilitate effective initial nursing, which may allow early subsequent mobilization. Deep vein thrombosis is common following major pelvic fractures and may complicate treatment. Deep vein thrombosis prophylaxis is recommended and should be continued for 3 months. Caval filtering may be indicated for established proximal thrombosis.

The other principal risks of surgery are infection, neurovascular injury and heterotopic ossification, although the latter is more common with operative approaches to posterior wall or column fractures of the acetabulum. The risk of heterotopic ossification may be reduced by meticulous surgical technique, debridement of devitalized muscle, careful use of indomethacin and radiotherapy in selected cases. When indicated treatment should be carried out by surgeons trained in pelvic reconstruction, ideally in a tertiary referral unit. As many cases will not be managed primarily in a tertiary centre, early telephone advice should be sought. Telemedicine for remote review of radiological data is likely to be increasingly important in the assessment of these cases.

A multidisciplinary team approach is required for the emergency treatment and rehabilitation of these patients who often present complex management problems. All these sequelae have a profound influence on the potential for socioeconomic reintegration. **HM**

Colapinto V (1980) Trauma to the pelvis: urethral injury. *Clin Orthop* **151:** 46–55

Cryer HM, Miller FB, Evers M (1988) Pelvic fracture classification: correlation with haemorrhage. *J Trauma* **28:** 973–80

Follis HW, Koch MO, McDougal WS (1992) Immediate management of postmembranous urethral disruptions. *J Urol* **147**(5): 1259–62

Herschorn S, Thijssen A, Radomski SB (1992) The value of immediate or early catheterisation of the traumatised posterior urethra. *J Urol* **148**(5): 1428–31

Pennal GF, Sutherland GO (1961) Fractures of the pelvis (motion picture). American Academy of Orthopaedic Surgeons Film Library, Park Ridge, IL

Raffa J, Christiensen NM (1976) Compound fractures of the pelvis. *Am J Surg* **132:** 282–6

Riemer BL, Butterfield SL, Diamond DL et al (1993) Acute mortality associated with injuries to the pelvic ring: the role of early mobilisation and external fixation. *J Trauma* **35:** 671–5

Stephen DJ, Kreder HJ, Day AC et al (1999) Early detection of arterial bleeding in acute pelvic trauma. *J Trauma* **47**(4): 638–42