PELVIC TRAUMA

Patients w/ traumatic pelvic ring injuries represent an incredible challenge;

- risk for exsanguinating pelvic haemorrhage
- severe injuries to other organ systems (due to magnitude of force)
- coordination of definitive care (surgical vs angiographic)

The majority of high-energy pelvic ring injuries are caused by MVAs, motorcycle crashes & pedestrians (vs vehicles) - accounting for ~80-84% of pelvic fractures.

- Falls from height account for a further 5-12%.
- Mortality ranges from 9-22%, however increases rapidly when the patient is in a shocked state on hospital presentation.
- Lateral impact remains the most prevalent mechanism of injury.

Principles of Disease.

Bony & ligamentous anatomy.

- Pelvis ring = sacrum, pubis, ischium, ilium.
- Bony protection of solid viscera
- Attachments for muscle groups
- Transmits weight from trunk to lower limbs (mainly through *posterior arch*).
- *Ligaments include:*
  - Symphysis pubis
  - Sacrospinous
  - Sacrotuberous
  - Iliolumbar
  - Anterior & posterior sacroiliac ligaments

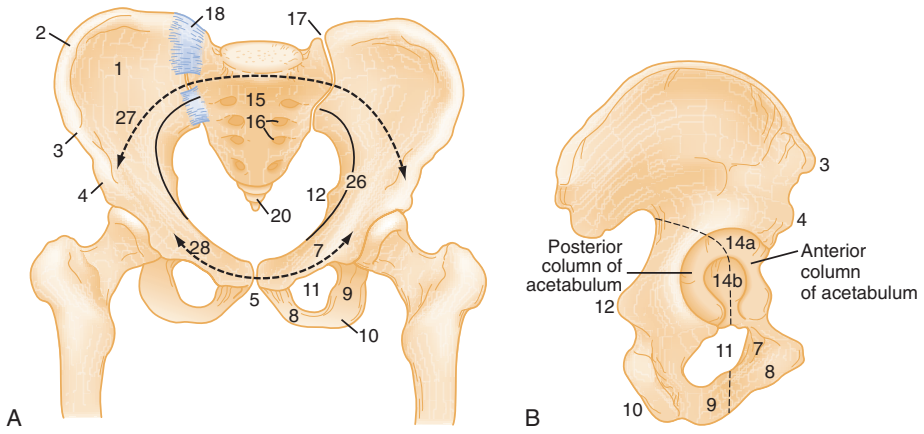
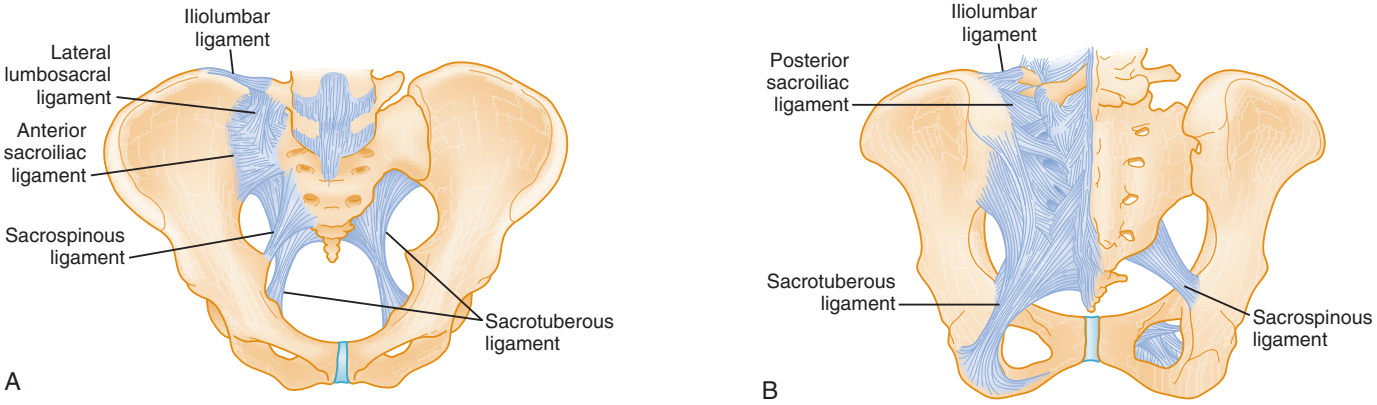


Figure 52-1. Bony pelvic anatomy. **A,** Anterior view of pelvis. **B,** Lateral view of right innominate bone. (*1*) Iliac fossa, (*2*) iliac crest, (*3*) anterior superior iliac spine, (*4*) anterior inferior iliac spine, (*5*) symphysis pubis, (*7*) superior ramus of pubis, (*8*) inferior ramus of pubis, (*9*) ramus of ischium, (*10*) ischial tuberosity, (*11*) obturator foramen, (*12*) ischial spine, (*14*) acetabulum ([*14a*] articular surface, [*14b*] fossa), (*15*) sacrum, (*16*) anterior sacral foramina, (*17*) sacroiliac joint, (*18*) anterior sacroiliac ligament, (*20*) coccyx, (*26*) arcuate line, (*27*) posterior or femorosacral arch, through which main weight-bearing forces are transmitted, (*28*) anterior arch.



Vascular anatomy.

- Most of the blood supply to the pelvis comes from the *internal iliac arteries*.
- Largest branch is the *superior gluteal artery* (most commonly injured with posterior arch fractures).
- *Obturator & internal pudendal branches* often injured with #s of pubic rami.
- Venous system has many collaterals. Arranged in a plexus.
    - No valves, therefore bidirectional flow.

Neurological anatomy.

- Cauda equina courses through the sacral spinal canal.
- Lumbar & sacral plexus.
- Injury to posterior bony pelvis/sacrum can result in lower limb neurological deficits & autonomic dysfunction (of bladder, bowel & genitalia).

Pathophysiology & Patterns of Pelvic Fracture.

There are numerous classification schemes for pelvic fractures.

The *Tile's* classification system focusses on biomechanical stability, whilst the *Young-Burgess* classification emphasises the mechanisms of injury.

BOX 52-1 Tile's Classification of Pelvic Fractures

Type A—Stable, posterior arch intact
Includes avulsion fractures, isolated iliac wing fracture, pubic rami fractures, minimally displaced ring fracture, transverse fractures of the sacrum or coccyx.

Type B—Partially stable, incomplete disruption of the posterior arch
Includes anteroposterior injuries (open book) and lateral compression injuries. May be unilateral or bilateral. These injuries are rotationally unstable but vertically stable.

Type C—Unstable, complete disruption of the posterior arch
Includes iliac, sacroiliac, and vertical sacral injuries that result from vertical shearing forces. May be unilateral or bilateral. These injuries are both rotationally and vertically unstable.

BOX 52-2 Young-Burgess Classification of Pelvic Fractures

Anteroposterior Compression

I. Symphysis diastasis < 2.5 cm
II. Symphysis diastasis > 2.5 cm, sacrospinous and anterior sacroiliac ligament disruption, results in rotational instability
III. Symphysis diastasis > 2.5 cm, with complete disruption of the anterior and posterior SI ligament, results in complete rotational and vertical instability

Lateral Compression

I. Sacral crush injury on ipsilateral side
II. Sacral crush injury with disruption of posterior SI ligaments, iliac wing fracture may be present (crescent fracture), rotationally unstable
III. Severe internal rotation of ipsilateral hemipelvis with external rotation of contralateral side ("windswept" pelvis), rotationally unstable

Vertical Shear

Vertical displacement of symphysis and sacroiliac joints resulting in complete rotational and vertical instability

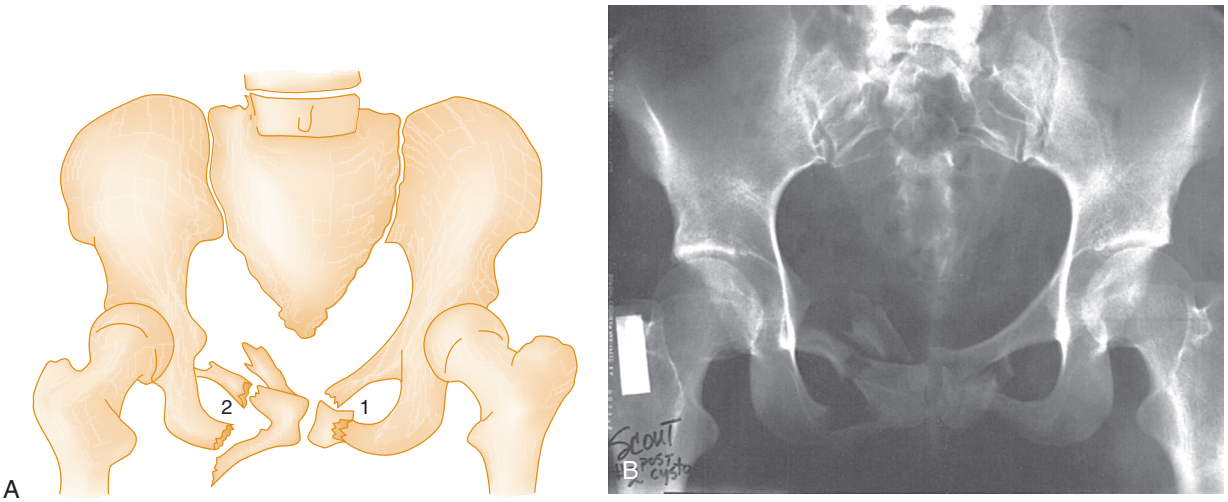
Combined Mechanisms

Any combination of the above mechanisms

Stable Injuries (Tile Type A).

- #s of individual bones w/out involvement of the pelvic ring = ~1/3 of all pelvic #s.
- Generally heal well w/ rest & analgesia.
- *Undisplaced or minimally displaced #s of Pelvic Ring:*
    - Recall that identification of a single fracture should prompt a search for a 2nd disruption.
- Isolated # through the *superior or inferior pubic ramus* = the most common pelvic fracture (*stable fracture*).
    - usu. elderly people post fall.
    - fracture of *both on the same side* = conservative management.
        - but should trigger a search for a posterior pelvic injury.

- A *straddle-fracture* = four-pillar injury.
    - both pubic rami on both sides are fractured.
    - “butterfly segment”
    - commonly associated w/ lateral compression or vertical shear forces.
    - CT is required to assess for posterior arch injury & plan for surgery.
    - Genitourinary tract is frequently injured w/ this type of fracture.



- *Isolated fracture of the iliac wing* can occur due to direct trauma on the iliac crest.
    - Generally a lateral compression force.
    - Fracture may extend into the acetabulum.

- *Transverse fractures of the sacrum.*
    - These do *not* compromise the pelvic ring.
    - At or below S4 = very unlikely to cause neurologic injury.
    - Above S4 = common to have neurologic injury.
    - A dedicated *pelvic outlet view* on X-ray helps image the injury.

- *Avulsion fractures.*
    - Usually occur during athletic activities and result from a sudden, forceful muscular contraction or excessive muscle stretch.
    - More commonly in older children and teenagers.
    - *Ischial tuberosity* - hamstring contraction
    - *Iliac crest epiphysis* - w/ abdominal wall contraction
    - *ASIS* - forcible contraction of the *sartorius muscle*
    - *AIIS* - forceful contraction of the *rectus femoris* (as in kicking a ball)
    - Surgical intervention is rarely required.

- *Stress Fractures.*
    - Occur with vigorous athletic, military training & the last trimester of pregnancy.

- *Pathologic and Insufficiency Fractures*.
    - Related to neoplasm, Paget's or dietary osteomalacia.

Partially Stable and Unstable Injuries (Tile Types B and C)

- A result of high-energy impacts (generally described as AP, lateral compression or vertical shear)
- Combinations result in complex injuries....

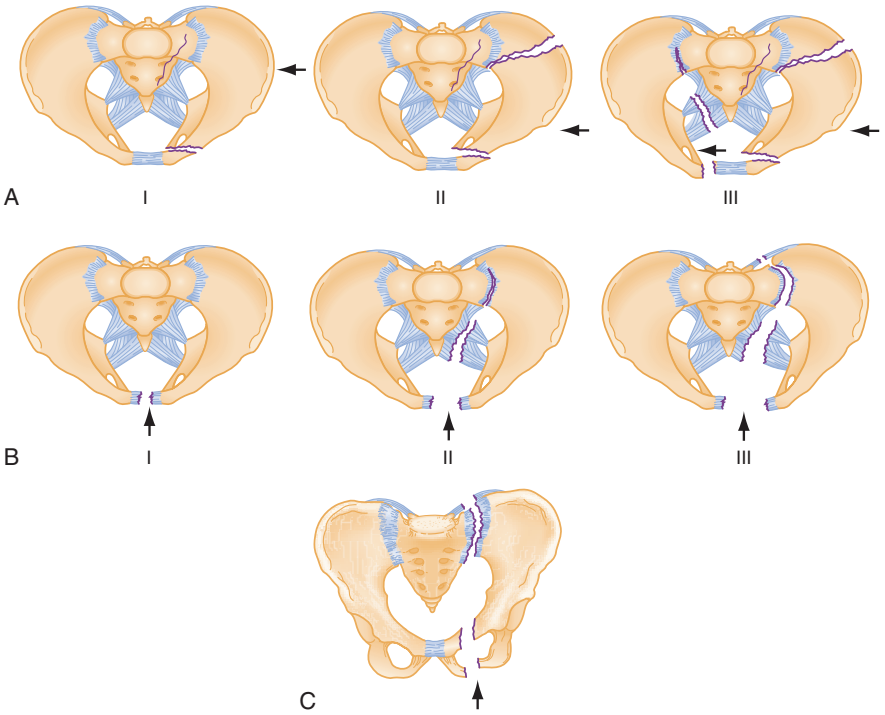
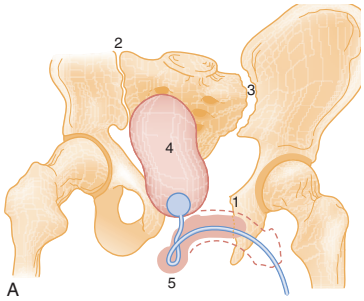
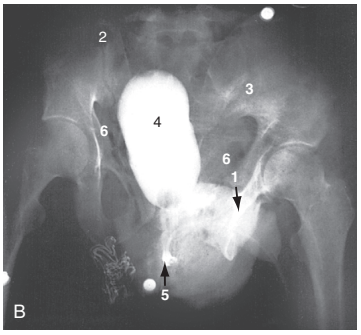


Figure 52-6. Young-Burgess classification. **A,** Lateral compression. Type I: A posteriorly directed force causing a sacral crushing injury and horizontal pubic ramus fractures ipsilaterally. Type II: A more anteriorly directed force causing horizontal pubic ramus fractures with an anterior sacral crushing injury and either disruption of the posterior sacroiliac joints or fractures through the iliac wing. Type III: An anteriorly directed force that is continued, causing external rotation of the contralateral side; the sacroiliac joint is opened posteriorly, and the sacrotuberous and spinous ligaments are disrupted. **B,** Anteroposterior (AP) compression. Type I: Symphysis disrupted but with intact posterior ligamentous structures. Type II: Continuation of a type I fracture with disruption of the sacrospinous and potentially the sacrotuberous ligaments and an anterior sacroiliac joint opening. Type III: Continuation force disrupts the sacroiliac ligaments. **C,** Vertical shear. Vertical fractures in the rami and disruption of all posterior ligaments. This injury is equivalent to an AP type III or a completely unstable and rotationally unstable fracture. Arrow indicates the direction of force. (Redrawn from Young JWR, Burgess AR: Radiologic Management of Pelvic Ring Fractures. Baltimore, Munich, Urban & Schwarzenberg, 1987. Browner: Skeletal Trauma: Basic Science, Management, and Reconstruction, 3rd ed. Copyright © 2003 Saunders, an Imprint of Elsevier.)

Anteroposterior Compression.

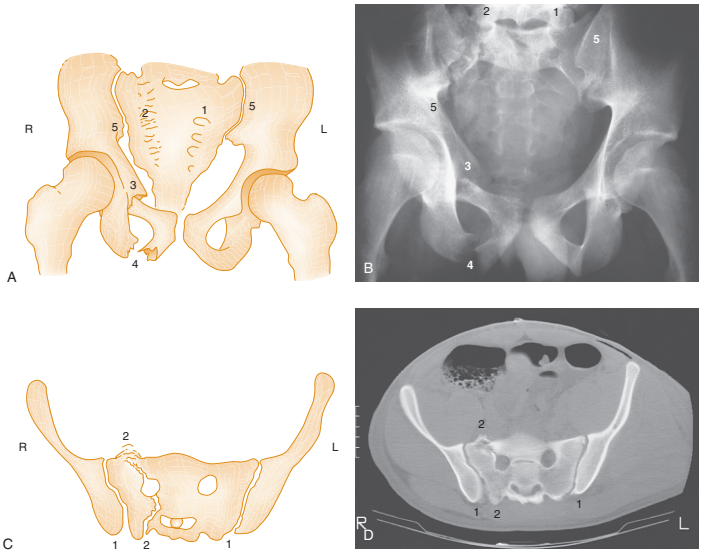
- Severe AP compression forces result in disruption at or near the symphysis pubis. The "*open book" fracture !!*
  - Symphysis widening of < 2.5 cm is considered a stable injury
- With continued force, the hemipelvis externally rotates, tearing the sacrospinous, sacrotuberous & anterior SI ligaments.
- Diastasis of the pubic symphysis > 2.5 cm, the posterior injury is usually seen as widening of the SI joint (occasionally as a sacral or iliac fracture)
  - With progression of force, there is separation of the hemipelvis
  - SI joint is seen as widely separated on X-ray.
- There is often an overlap of pelvic injury presenting with a 'suggestive open book' on X-ray - therefore be careful in your assessment for vertical instability.
- Careful assessment is required for concomitant neurological or vascular injury.
  - Hemorrhagic shock can occur





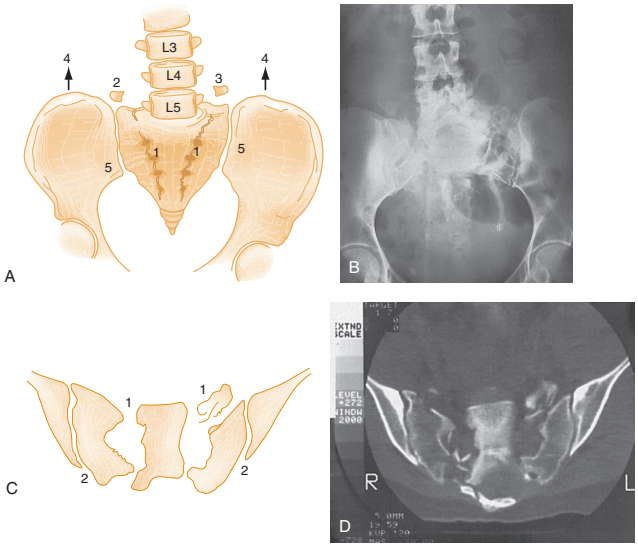
Lateral Compression.

- Lateral compression of the pelvic ring results in varying degrees of *internal rotation of the affected hemipelvis.*
- Causes buckling of the sacrum and horizontal pubic rami fractures.
    - Rami fractures may occur on the ipsilateral or contralateral side, the latter being referred to as the “bucket-handle” fracture
- The symphysis may disrupt w/ increasing force.
- Evidence of sacral injury may be subtle on plain xray.
- “*Windswept pelvis”* - contralateral hemipelvis externally rotates
- Vertical stability is usu. maintained.
- Pelvic volume is reduced in lateral compression --> therefore less blood loss.



Vertical Shear.

- Represents *the most unstable injury to the pelvic ring.*
- Assoc. w/ violent axial loading of the hemipelvis.
- Fractures occur in vertical planes.
    - *Anteriorly* - symphysis, rami.
    - *Posteriorly* - gross displacement & instability through sacrum, SI joints & ilium.
- Clues to this injury include:
    - Avulsion of ischial spine, lower lateral lip of sacrum, & transverse process of L5.
- Accounts for major haemorrhage & neurological injuries.



Vertical Sacral Fractures.

- These fractures involve the pelvic ring & are caused my high-energy impacts.
- Classified into three groups:
    1. laterally into the sacral foramina
    2. through the foramina
    3. medially to the foramina (involving the central spinal canal).
- Carefully examine cortical lines on plane imaging.
- High risk of neurological injury (up to 58% when medial to the foramina)

Open Pelvic Fractures.

- Exists when there is a direct communication b/ween fracture site and skin, rectum or vaginal wound.
- Potential lethal injuries (early from haemorrhage, later from sepsis).
- Also thoroughly inspect perineal and gluteal wounds in the setting of pelvic fractures....

Penetrating Pelvic Trauma.

- A challenge due to the pelvis's complicated anatomy.
- Vascular injuries can include both arteries (incl. aorta / iliacs) & veins (int., ext. & common iliacs).
- Genitourinary & hollow viscera injuries are common.

Clinical Features.

History.

- Understanding the *mechanism of injury* is crucial.
- Determine the direction of force that is applied to the pelvis.
    - Head-on MVAs = AP force.
    - Side-on impact = lateral compression.
    - Falls from height = vertical shear.
- Age is a contributing factor to mortality.

Physical Examination.

- Inspection:
    - Rotation of iliac crests suggests serious injury.
    - Leg length discrepancy suggests hip injury or migration of an unstable hemipelvis.
    - Look for lacerations/punctures (?association w/ open fractures).
        - Including genitalia / anus.
    - Bruising/haematomas.
        - Periumbilical area = *Cullen's sign.*
        - Flanks = *Grey Turner's sign.*
- Palpation:
    - Point tenderness is a worrying sign.
    - **Keep manipulation of the pelvis to a minimum. DO NOT SPRING.**
- Dedicated lower-limb neurovascular injury is crucial.

Associated Pelvic Injuries.

Urologic.

- Overall incidence of bladder/urethral disruption w/ any pelvic # = ~6%.
    - Urethral injuries in women are very rare.
- Bladder injuries most commonly assoc. w/ anterior arch fractures.
    - Symphysis disruption >1cm & fracture around obturator ring = significant independent risk factors.
- Gross haematuria mandates evaluation of lower urinary tract.
    - Involves:
        - Retrograde urethrogram, IV pyelogram, CT and cystography.
    - Frank blood at urethral meatus = urethrogram only.

Neurologic.

- Assoc. w/ vertical shear fractures and transverse fractures above S4 level.
    - Vertical shear fractures:
        - Involving foramina = 28% neuro injury.
        - Medial to foramina = *56%* neuro injury.
- Cauda equina syndrome, plexopathies & radiculopathies can all occur.
- Hyperaesthesia & later anaesthesia of '*saddle-distribution*' is concerning!
    - Always do lower limb reflexes & bladder scans (?post-void residual)

Gynaecologic.

- Blood at introitus may indicate urethral injury, open pelvic fracture or local laceration.
- Low threshold for gynaecological input.

Associated Non-Pelvic Injuries.

- Fatal pelvic injuries rarely occur in isolation.
    - Other organ systems are generally involved.
- Be meticulous with your examination and further investigations.

Diagnostic Strategies.

Radiology.

- Routine x-rays of the pelvis are not necessary in asymptomatic patients who are alert, awake and have a normal physical examination.
- They are advised by ATLS for patients w/ severe mechanisms of injury, altered level of consciousness or distracting injuries.

- ***Plain X-ray:***
    - Symphysis is no more than 5mm wide.
        - Overlapping is *abnormal.*
    - Normal SI joint is 2-4mm wide.
    - Look for symmetry of *iliac wings* and *obturator foramina.*

BOX 52-3 Radiographic Clues to Posterior Arch Fractures

Avulsion of L5 transverse process*
Avulsion of ischial spine*
Avulsion of lower lateral lip of the sacrum (sacrotuberous ligament)*
Displacement at the site of a pubic ramus fracture
Asymmetry or lack of definition of bone cortex at superior aspect of the sacral foramina

- Concerns have arisen regarding the accuracy of a single AP pelvis x-ray.
    - Sacral #s & SI joint disruptions are poorly visualised.
    - Can be better imaged with dedicated *inlet & outlet* x-rays.

- ***Computed Tomography:***
    - Has become imaging of choice for evaluating the injured pelvis.
    - Excellent assessment of the posterior arch & pelvic stability.
    - Provides more detail on the acetabulum.
    - Much higher Sn & Sp than plain x-ray.
    - Extension of CT to incorporate abdomen & pelvis also assesses for concomitant injury (and helps plan for surgical repair).

Evaluation of Haemorrhage.

- Haemorrhage is the most devastating direct complication of pelvic #s.
- Bleeding results from lacerations of rich vascular networks supplying the pelvis.
    - Often pools in the retroperitoneal space.
- Bleeding is commonly venous.
    - May be contained & tamponaded by an intact peritoneum.
- Combination of both pelvic & intraabdominal bleeding is devastating.
- Early identification of the source of bleeding in an unstable patient is crucial.

- ***Diagnostic Peritoneal Lavage.***
    - Largely replaced by CT & USS.
    - False positives can occur, as pelvic blood can dissect up the anterior abdominal wall.
    - Negative DPL = likely pelvic source, therefore angiography is required.
    - Positive DPL = laparotomy.

- ***Ultrasound.***
    - FAST scan is used freely.
    - Does *NOT* identify retroperitoneal blood.
    - Often used as a triage point to decide on laparotomy vs angiography.

- ***CT.***
    - Unquestionably the diagnostic test of choice for differentiating between pelvic & intra-abdominal injuries.
    - Assessed for extravasation of IV contrast material.
    - Patients must be 'reasonably stable enough' to safely transport to CT.

Management.

Resuscitation.

- Mortality of blunt trauma patients w/ pelvic ring fractures & haemorrhagic shock approaches 50% !!!
- *Give blood products early* in accordance with your local ***massive transfusion protocol.***
    - Aim for RBC:FFP:PLT ratio of 1:1:1.
    - Don't forget Cryoprecipitate.
    - Adjuncts include *tranexamic acid* & optimisation of *ionised* Ca^{2+}.
- End-point of resuscitation = evidence of end-organ perfusion.

Control of Haemorrhage.

- Two therapeutic modalities can be employed for haemorrhage control.
    1. Mechanical stabilisation of the pelvis
    2. Angiographic embolisation.

Stabilising the Pelvis.

- Simple bed-sheet & towel clamps.
    - Tightly wrapping the pelvis.
    - Aim to position the towel *over the greater trochanters....*
- Commercial splints are also available.
- Lots of evidence to demonstrate that early splinting/stabilisation leads to lower transfusion requirements (compared to those who wait for formal external fixation)
- AP open-book injuries derive the most benefit from pelvic binding.
    - Not desirable in lateral-compression injuries (as the pelvis is commonly already internally rotated).
- External fixation (by orthopaedic surgeons).
    - Acute application does not decrease morbidity or mortality.
    - Improves outcome by limiting haemorrhage and restoring mechanical stability.
    - Application should not delay angiographic control of haemorrhage.
- Pelvic "C-Clamp" can be placed to stabilise the posterior pelvic arch.
    - Again, more beneficial for AP injuries.
    - Does *NOT* obviate the need for angiography.

Angiography & Embolisation.

- Whilst most pelvic bleeding is venous, venography is not useful in managing these patients.
    - Arteriography is however *excellent.*
- Femoral artery is punctured (on the least injured side).
    - Examination starts from the aortic bifurcation.
    - Selective branches of the internal iliac artery are examined.
- Embolisation w/ thrombogenic coils or foam are employed.
- HIGHLY EFFECTIVE.
- ***Indications:***
    - Inadequate response to initial resuscitation (persistent hypotension)
    - Presence of contrast extravasation on CT. "a blush".

The Haemodynamically Unstable Patient w/ Pelvic & Intra-abdominal Haemorrhage.

- Mortality > 40%
- A challenge to prioritise CT vs angiography.
    - Needs coordination between trauma/general surgery, orthopaedics & interventional radiology.
- Generally accepted that laparotomy comes first in the setting for a positive FAST scan or grossly positive DPL.
    - Promptly followed by angiography.
    - Alternatively; a C-Clamp may be placed by Orthopaedics at the time of laparotomy or the pelvis may be packed (to aid in tamponade of venous bleeding).
    - The pelvis should be stabilised prior to packing.

Acetabular Fractures.

- Many pelvic fractures can involve the acetabulum.
- Suggested by pain and inability to weight bear.
- Classified into *three types...*

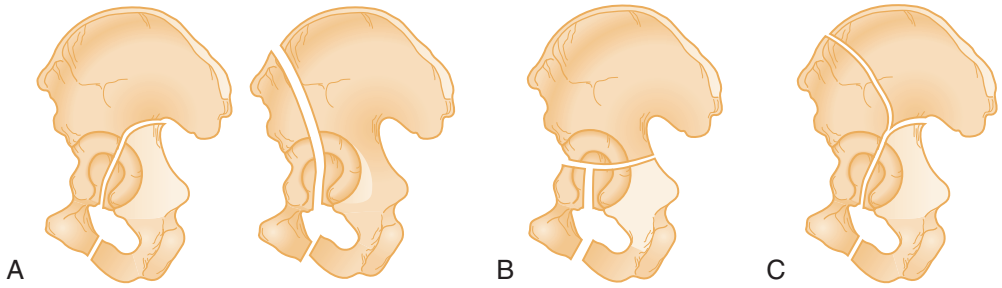


Figure 52-12. Universal classification of acetabular fractures. **A,** Type A: Fractures of one column or one wall, for example, posterior column (**left**) and anterior (**right**) column. **B,** Transverse or T-type fractures involving both columns but by definition always leaving a fragment of articular cartilage attached to the proximal ilium and, thus, to the axial skeleton. **C,** Type C: Two-column fracture of the acetabulum. By definition, no portion of the articular surface remains attached to the axial skeleton because fracture of both columns of the ilium is proximal to the joint. (From Tile M: Fractures of the Pelvis and Acetabulum, 3rd ed. Philadelphia, Lippincott Williams & Wilkins, 2003.)

- Type A:
  - Divided into anterior & posterior column injuries
  - Posterior wall injuries most common.
    - Caused by forceful impact on a flexed knee (dashboard injury).
    - Can have associated dislocation of the hip joint.
    - Examine for *sciatic nerve injury.*
  - Anterior column is injured when superior ramus # extends into the lower anterior column.
- Type B:
  - Involves both anterior & posterior column, but a portion of acetabulum remains in contact w/ ileum.
  - "T-fracture".
- Type C:
  - Typically obvious on x-ray.
  - Disruption of ileum.

all acetabular fractures require Orthopaedic consultation...

Coccyx Fractures.

- Occur frequently after a fall in the sitting position.
- Localised tenderness on examination (gluteal crease or PR).
- X-ray is not always necessary
- Treatment consists of bed-rest, analgesia, stool softeners & sitz baths.
- Caution patients that pain and recovery can be prolonged.