Pelvic Fractures

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Agenda

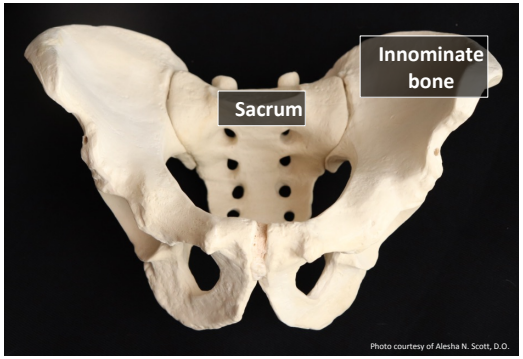
- Pelvic Anatomy
- Mechanisms of Pelvic Fractures
- Epidemiology
- Early Management/Associated Injuries
- Surgical Management
- Bringing it all together: Cases
- Questions

Pelvic Ring Anatomy

- Osteology
- Ligamentous
- Muscular
- Neurovascular

Pelvic Osteology

3 bones
- Innominate bones x2
- Sacrum



Pelvic Osteology

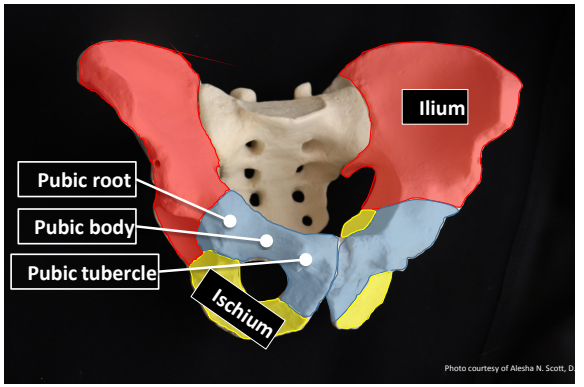
Sacrum

Innominate

Pelvic Osteology

Innominate Bone

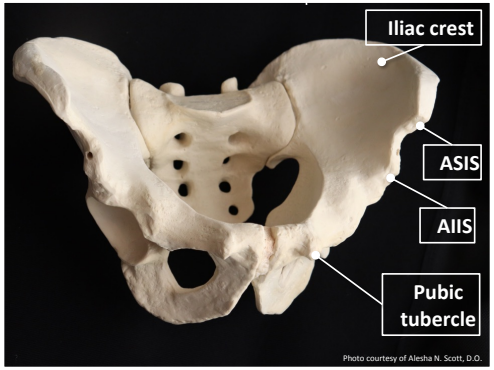
- Ilium
- Pubis
  - Pubic root
  - Pubic body
  - Pubic tubercle
- Ischium



Pelvic Osteology

Palpable Anterior Landmarks

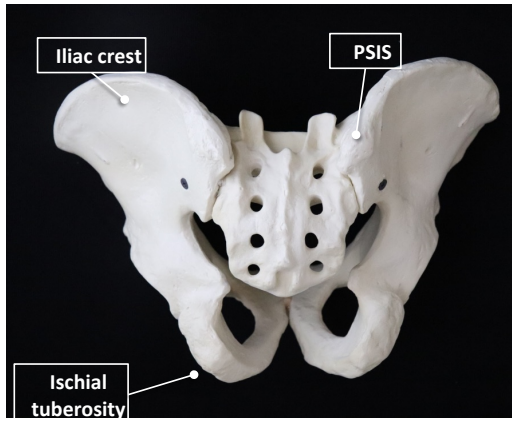
- Iliac crest
- Anterior superior iliac spine (ASIS)
- Anterior inferior iliac spine (AIIS)
- Pubic tubercle



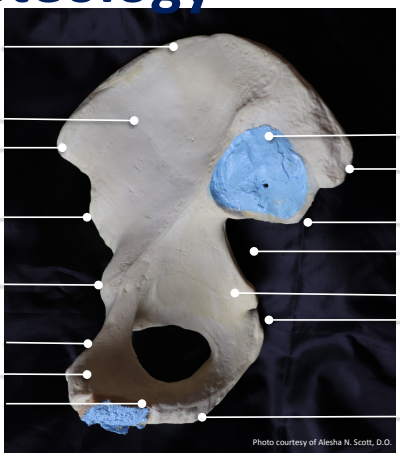
Pelvic Osteology

Palpable Posterior Landmarks

- Iliac crest
- Posterior superior iliac spine (PSIS)
- Ischial tuberosity

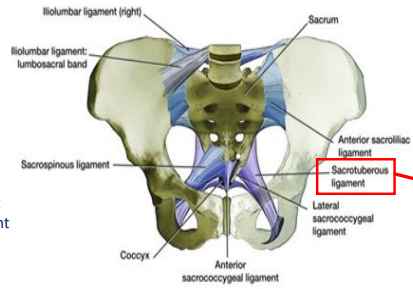


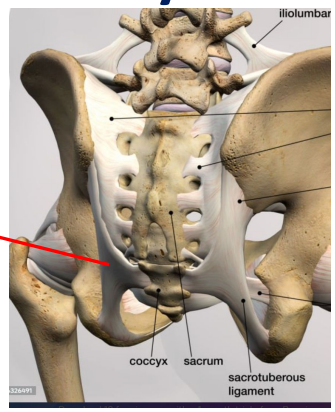
Pelvic Osteology



Ligamentous pelvic anatomy

- Anterior
  - Symphysis pubis
- Posterior
  - Anterior sacroiliac ligaments
  - Iliolumbar ligament
- Posterior aspect: strongest
  - SI Ligaments
- Pelvic floor
  - Sacrospinous ligament
  - Sacrotuberous ligament

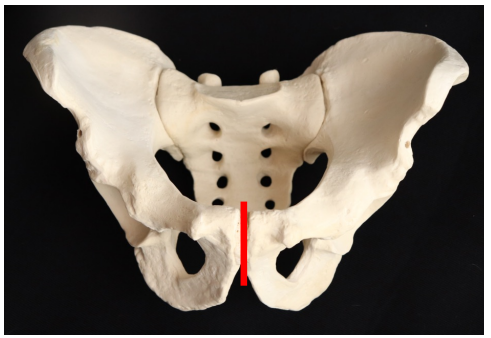




Ligamentous Pelvic Anatomy

Ligaments	Functions
• Anterior SI ligaments	→ Resist external rotation
• Posterior SI ligament	→ Resist cranial-caudal translation
• Dorsal sacroiliac ligament	→ Resist A-P translation
• Iliolumbar ligament	→ Resist rotation
• Sacrospinous ligament	→ Resist external rotation
• Sacrotuberous ligament	→ Resist cranial-caudal translation and flexion

How do you break a pretzel?

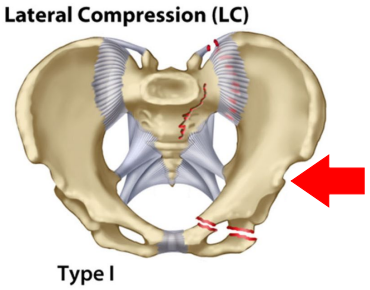


Pelvis can be injured through the ligaments/joints or from fracturing the bone

Mechanism of Pelvic Ring Injury

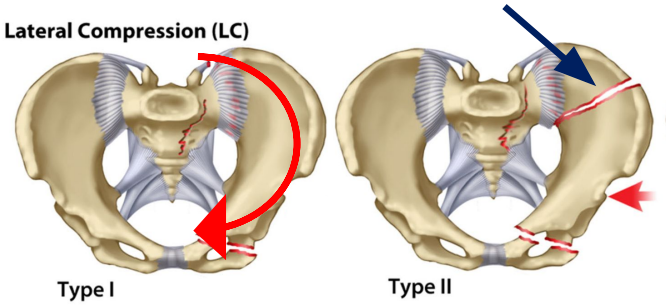
- 3 main biomechanical mechanisms
  - Lateral Compression (internal rotation of hemipelvis)
  - Anterior Posterior Compression (external rotation of hemipelvis)
  - Vertical Shear (hemipelvis moves cranial)

Mechanism of Pelvic Ring Injury



*Burgess AR, Eastridge BJ, Young JW, Ellison TS, Ellison PS Jr, Poka A, Bathon GH, Brumback RJ (1990). "Pelvic ring disruptions: effective classification system and treatment protocols". *J Trauma*. **30** (7): 848–56.

Mechanism of Pelvic Ring Injury



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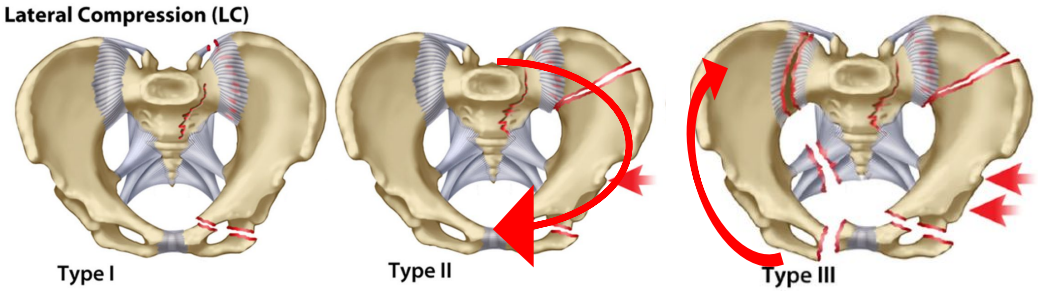
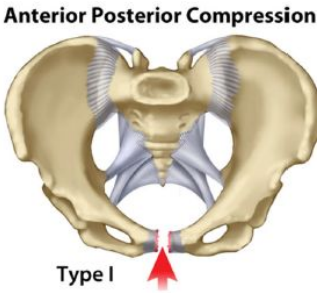


"Windswept Pelvis"

*Burgess AR, Eastridge BJ, Young JW, Ellison TS, Ellison PS Jr, Poka A, Bathon GH, Brumback RJ (1990). "Pelvic ring disruptions: effective classification system and treatment protocols". *J Trauma*. **30** (7): 848–56.

Mechanism of Pelvic Ring Injury



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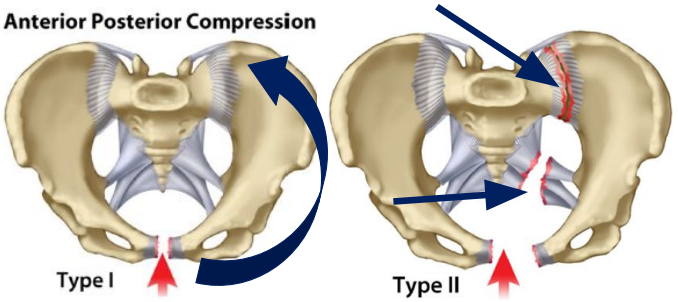

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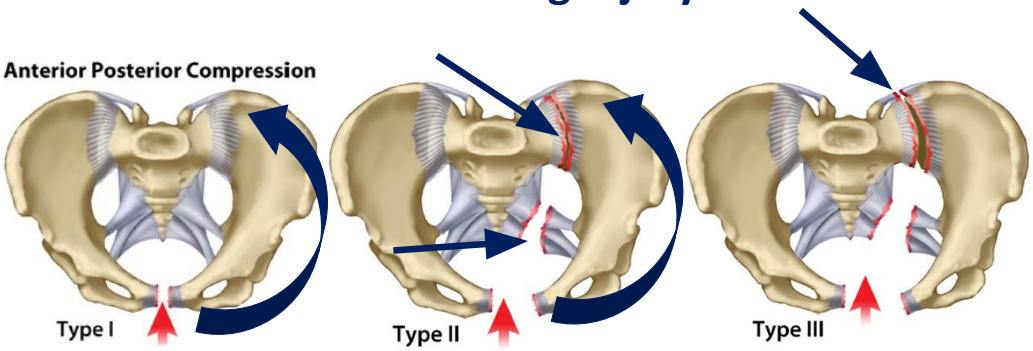
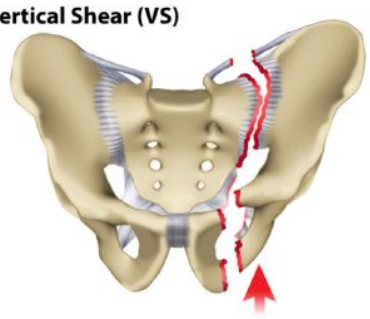
Mechanism of Pelvic Ring Injury



"Open Book"

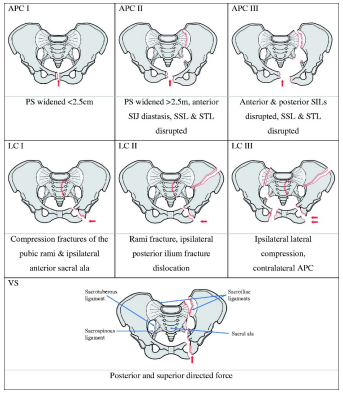
*Burgess AR, Eastridge BJ, Young JW, Ellison TS, Ellison PS Jr, Poka A, Bathon GH, Brumback RJ (1990). "Pelvic ring disruptions: effective classification system and treatment protocols". *J Trauma*. **30** (7): 848–56.

Mechanism of Pelvic Ring Injury



*Burgess AR, Eastridge BJ, Young JW, Ellison TS, Ellison PS Jr, Poka A, Bathon GH, Brumback RJ (1990). "Pelvic ring disruptions: effective classification system and treatment protocols". *J Trauma*. **30** (7): 848–56.

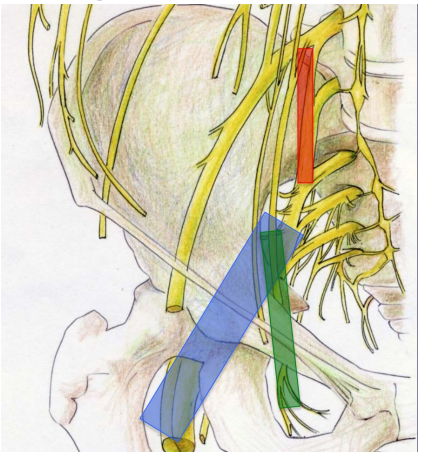
Young and Burgess Classification



Type of Injury	Figure	Morphologic Characteristics	Stability
Lateral compression	…	Transverse overlapping obturator ring fractures	Head injury; direct vascular, neural, and bladder injuries
1	8a	Sacral impaction (buckle), intact ligaments	Stable
2	8b	Iliac crescent fracture	Rotationally unstable, vertically stable
3	8c	Lateral compression type 1 or 2 on one side and AP compression injury on the opposite side	Globally unstable
AP compression		Diastasis of pubic symphysis without anterior fracture	Substantial hemorrhage
1	8d	Less than 2.5 cm pubic diastasis	Stable
2	8e	More than 2.5 cm pubic diastasis, widening of anterior SI joint	Rotationally unstable, vertically stable
3	8f	Often more than 5 cm pubic diastasis, widening of both anterior and posterior SI joints	Globally unstable
Vertical shear	8g	Vertical displacement of hemipelvis, fractures of pubis and SI joint	Visceral injuries, unstable
Combined	…	Complex fracture with combined elements of AP compression, lateral compression, or vertical shear	Variable

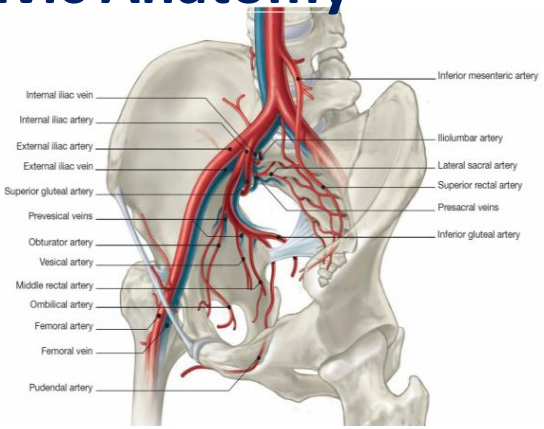
Neural Pelvic Anatomy

- L4/L5 nerve roots
  - Courses over anterior sacrum
- Sciatic Nerve
  - Exits through greater sciatic notch
- Obturator nerve
  - Exits out lateral aspect of obturator foramen
- Femoral Nerve



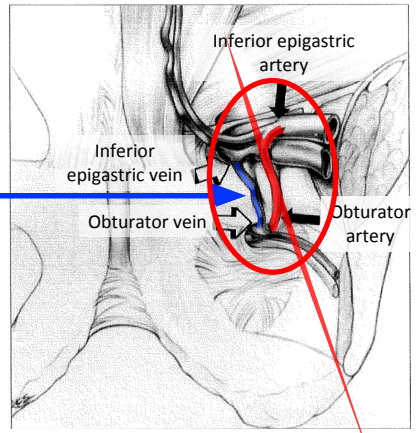
Vascular Pelvic Anatomy

<u>Bleeding</u>
- Venous
- Arterial
  - Internal Iliac System
  - External Iliac System



Vascular Pelvic Anatomy

Retropubic anatomy
- Small caliber anastomosis between obturator and external iliac/inferior epigastric systems are common (~70%)
  - Average of 6.2cm lateral to the symphysis
- In small percentage, obturator artery can be of large caliber and originate from inferior epigastric or external iliac
  - **"Corona mortis"**

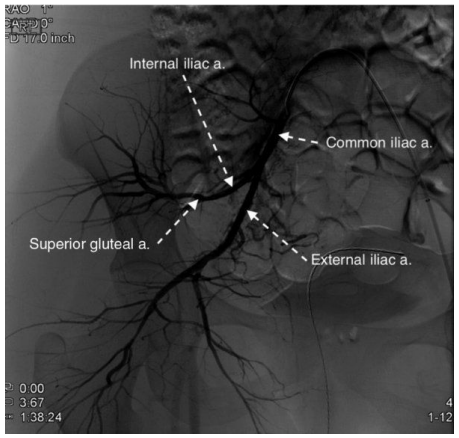


Teague DC, Graney DO, Routt ML Jr. Retropubic vascular hazards of the ilioinguinal exposure: a cadaveric and clinical study. J Orthop Trauma. 1996;10(3):156-9. Figure 1.

Vascular Pelvic Anatomy

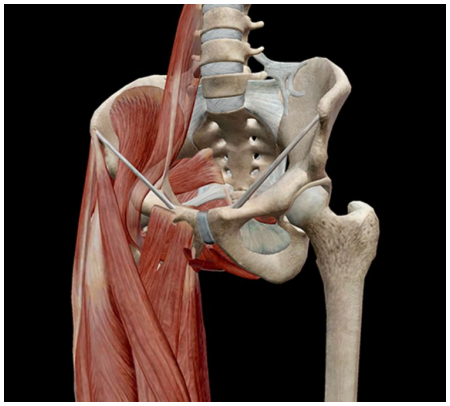
Common iliac system

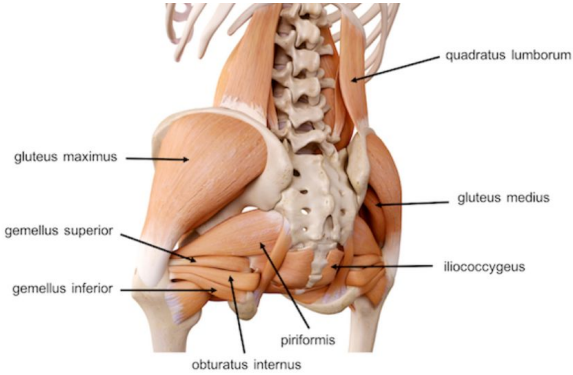
- External iliac artery
- Internal iliac artery
- Sacral venous plexus
  - Majority of the hemorrhage following pelvic ring injuries

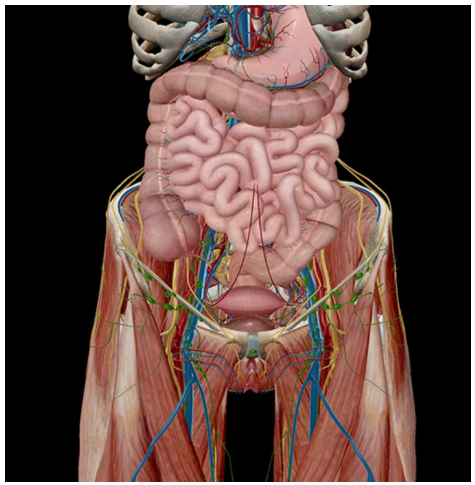


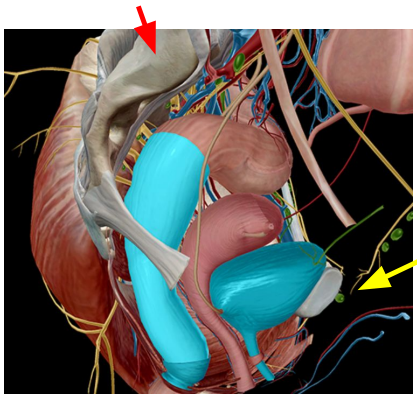
Animesh Agarwal. Pelvic Ring Injuries. In: Tornetta P, Ricci WM, eds. Rockwood and Green's Fractures in Adults, 9e. Philadelphia, PA. Wolters Kluwer Health, Inc; 2019. Figure 49-28.

Muscular Pelvic Anatomy









Epidemiology

Epidemiology

- Historically younger patients
- High energy
- Often polytrauma
  - Bones, anorectal, urogenital, soft tissue, head injuries
- MC High energy
  - MVA, MCC, Falls from large height

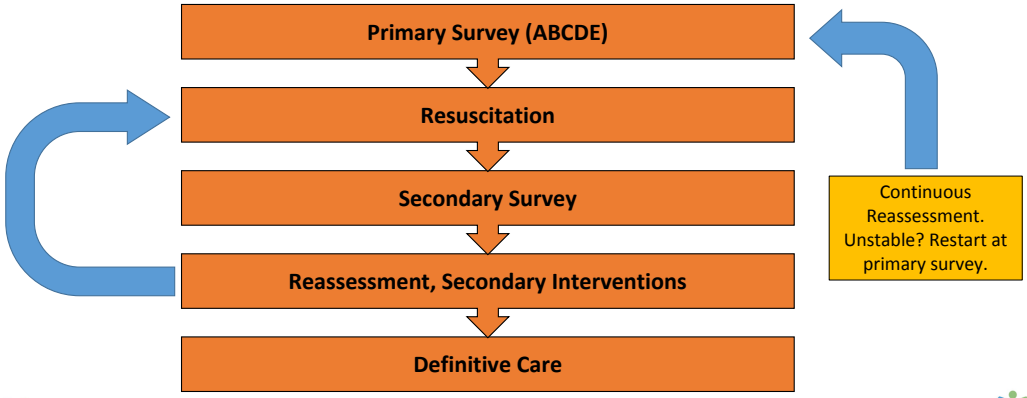
- Elderly (low energy populations)
  - Increasing, osteoporosis
  - 1990-2008
  - The proportion pts 56-75 undergoing surgery increased: 5.8% to 15%
  - Age >75: 13.6% to 39%
  - Avg Length of stay:
    - 1990: 11.2 days
    - 2008: 6.5 days

Epidemiology

- 10-20% Mortality (higher energy)
- In hospital mortality (US): 8.3% (declining)
  - **MC Cause = hemorrhage (APC)**
  - Closed Head Injury = LC
  - **Increased Mortality:**
    - Systolic <90
    - Age >60
    - Inc ISS/RTS
    - Need >4 units
  - **Assoc Conditions:**
    - Chest Injuries (63%)
    - Long Bone Fx (50%)
    - Sexual Dysfunction (50%)
    - Head/Abd Injuries (40%)
    - Spine Fx (25%)

Early Management/Associated Injuries

Principles of ATLS



Primary Survey – ABC, DE

- **A**irway with cervical spine protection
- **B**reathing – oxygenation and ventilation
- **C**irculation – including hemorrhage control
- **D**isability – neurologic status
- **E**xposure/Environment – expose patient, avoid hypothermia

Physical Exam

- Assess pelvic stability manually (once)
- Contusions, ecchymoses, degloving injuries
- Open wounds around pelvis, groin, perineum
- Leg length inequality
- Blood at urethral meatus, rectum or vagina
- Scrotal edema
- Lower extremity neurologic deficits

Hemorrhage and Pelvic Fractures

- Control of pelvic bleeding is integral in the management of a trauma patient with pelvic fractures
- Arterial and venous structures at risk within the pelvis
  - Venous plexus most frequent source of hemorrhage
  - Mortality associated with arterial injury
- Some degree of hemorrhage expected from fractured bone

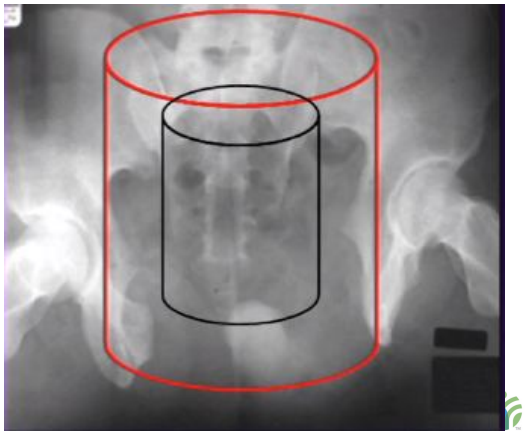
Shock (SBP<90) on presentation
Early transfusion requirements

= **Increased Mortality**

Hemorrhage and Pelvic Fractures

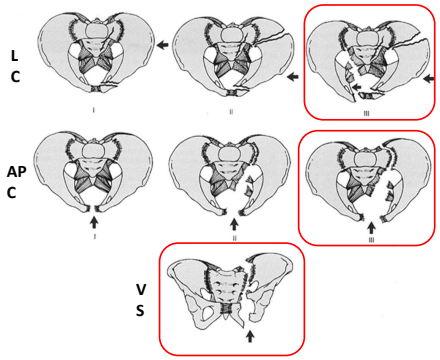
- An unstable pelvic injury may allow hemorrhage to collect in the true pelvis as there is no longer a constraint which allows tamponade.
- Cylinder:πr^2 h

Sources of blood loss
- Pre-sacral venous plexus
- Exposed cancellous bone
- Arterial extravasation



Hemorrhage and Pelvic Fractures

- Fracture pattern is associated with risk of hemorrhage + transfusion requirements
  - Original Young and Burgess description:
    - LC – 3.6 units
    - APC – 14.8 units
    - VS – 9.2 units
    - Combine – 8.5 units
- Highest risk with LC III, APC II, APC III and VS
- Severe hemorrhage can occur in any pattern

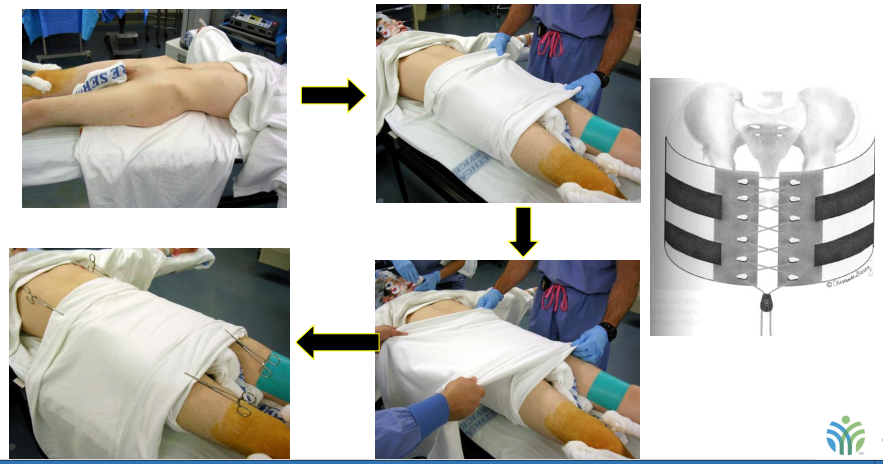


Hemorrhage Control

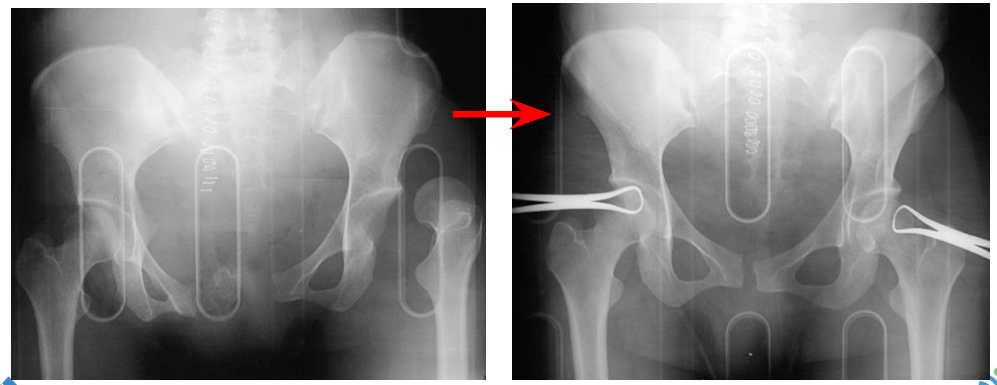
- Pelvic Containment
  - Binder, Sheet, External Fixation, C-clamp, Internal Fixation
- Angiography with embolization
- Laparotomy with pelvic packing

Pelvic Sheet/Binder

- Supine
- 2 "Wrappers"
- Placement
- Apply
- "Clamper"
- 30 Seconds



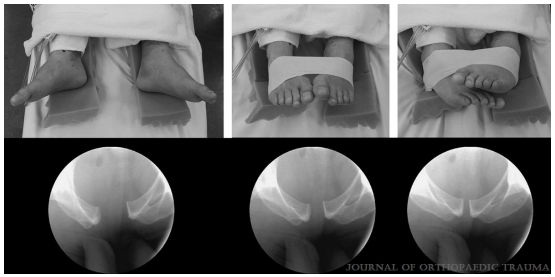
Pelvic Sheet/Binder



Pelvic Sheet/Binder

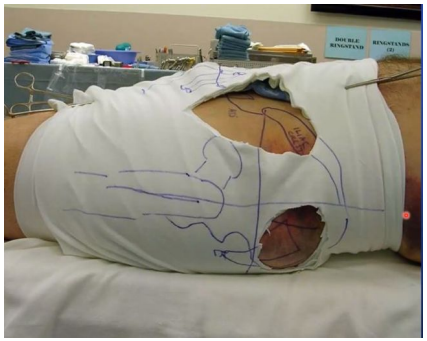
Taping lower extremities

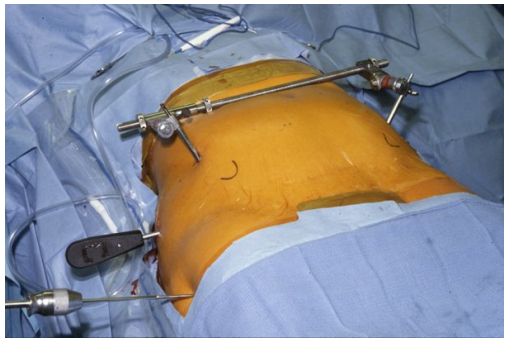
Another method for stabilizing the pelvis and decreasing pelvic volume



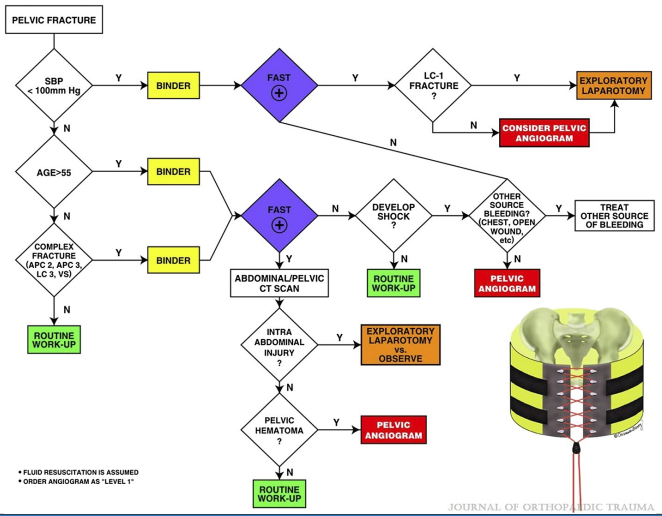
Gardner MJ, et al. Internal rotation and taping of the lower extremities for closed pelvic reduction. J Orthop Trauma, 23(5):361-364, May-June 2009.

Pelvic Sheet/Binder





Example of a Successful Pelvic Hemorrhage Protocol

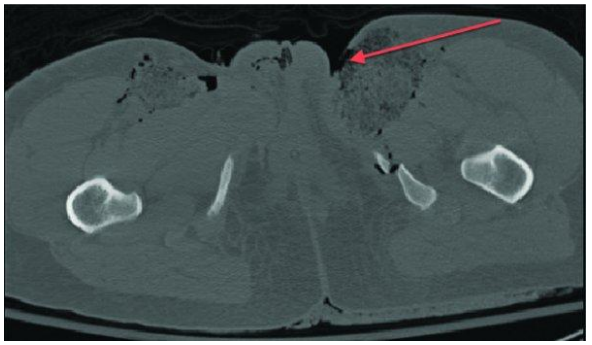


Black SR, et al. Improved survival after pelvic fracture: 13-year experience at a single trauma center using a multidisciplinary institutional protocol. J Orthop Trauma, 30(1):22-28, January 2016.

Open Pelvic Fractures

- Increased mortality
  - Up to 50% with open injuries with fecal contamination
- High index of suspicion with blood at rectum, vagina and perineal wounds
- Control hemorrhage -> washout and pack wounds
  - Will need aggressive debridement once stable
- Open fracture antibiotics
- Early repair of vaginal lacerations
- Proctoscopy to visualize rectal injury
- Consider diverting colostomy with perineal wounds or communication with colon/rectum

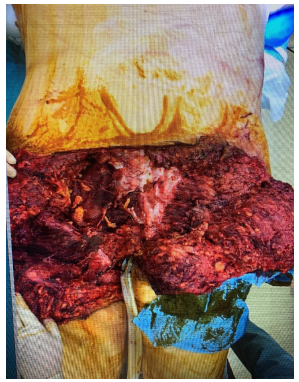
Open Pelvic Fractures



CT scan showing paralabial wound communicating with ramus fracture

Agarwal A, 49:Pelvic ring injuries, Rockwood and Green's Fractures in Adults, 9e, Tornetta et al (eds), Wolters Kluwer 2020.

Open Pelvic Fractures



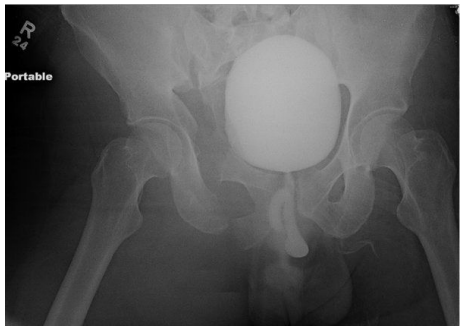
Patient prone. Degloving injury over posterior pelvis with exposed sacral fractures

Open wound in groin with APC injury

Urologic Injury

- Incidence: 6-15%
- Males have higher incidence of urethral injuries compared to females
- Bladder injuries: 60% extraperitoneal, 30% intraperitoneal, 10% both
  - Increased mortality with bladder rupture
- Microscopic or gross hematuria?
  - Cystogram
- Blood at urethral meatus?
  - Retrograde urethrogram

Urologic Injury



A. Proximal urethral disruption seen by contrast extravasation over the perineum

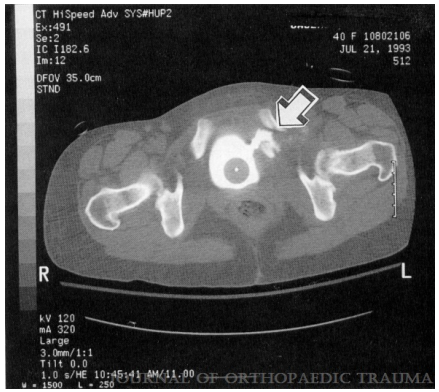
B. Cystogram showing bladder rupture with contrast extravasation

Urologic Injury

- Bladder rupture
  - Intraperitoneal = Ex-Lap and repair
  - Extraperitoneal = suprapubic catheter or direct repair. Must coordinate with urology for optimal catheter placement and/or repair in conjunction with definitive fixation
- Urethral injuries
  - Initial treatment with foley followed by delayed repair

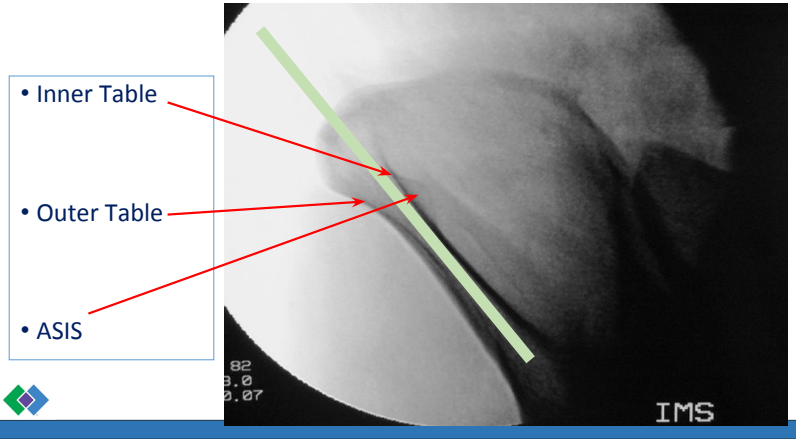
Urologic Injury

- CT cystogram with arrow indicating bladder entrapment within ramus fracture and contrast extravasation.



Surgical Management

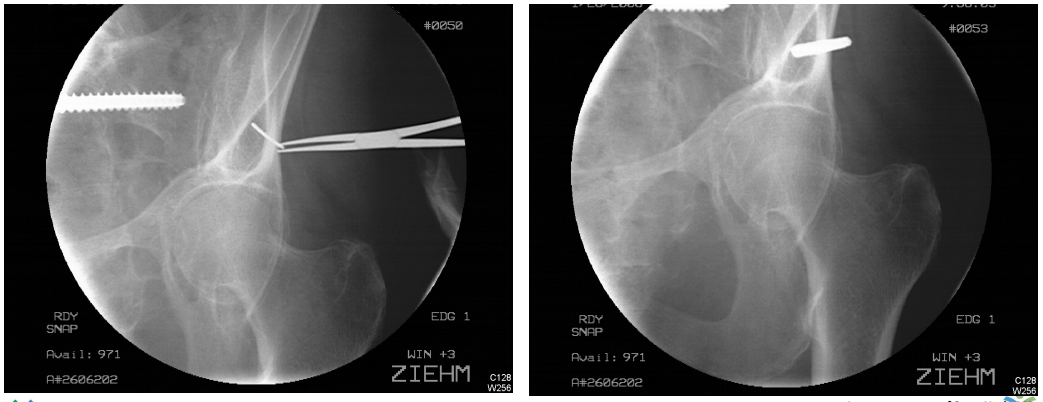
External Fixator Placement: ASIS Technique



Outlet Oblique View

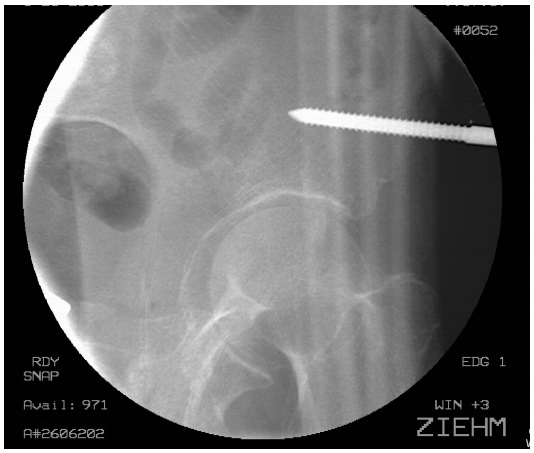
Courtesy of Sean Nork, MD

External Fixator Placement: AIIS Technique



Images courtesy of Sean Nork, MD

Outlet Obturator Oblique



Iliac Oblique

Obturator Inlet Oblique

ORIF Anterior Pelvic Ring Injuries

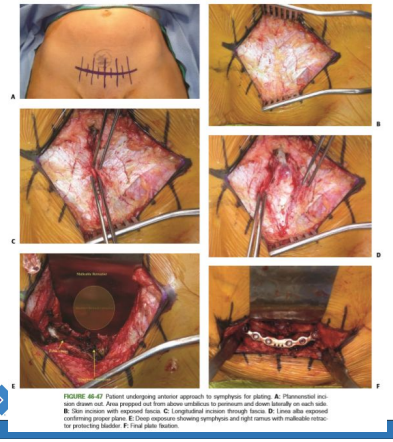


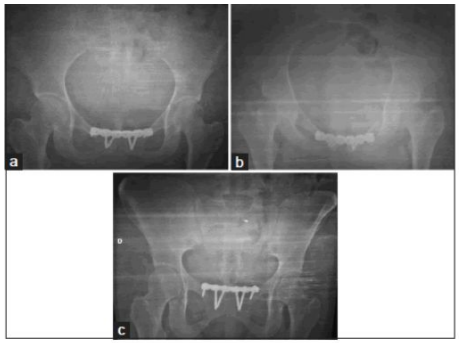
FIGURE 46-47 Patient undergoing anterior approach to symphysis for plating. **A**: Pfannenstiel incision drawn out. Area prepped out from above umbilicus to perineum and down laterally on each side. **B**: Skin incision with exposed fascia. **C**: Longitudinal incision through fascia. **D**: Linea alba exposed confirming proper plane. **E**: Deep exposure showing symphysis and right ramus with malleable retractor protecting bladder. **F**: Final plate fixation.

FIGURE 56-54, cont'd **E** and **F**, Points of clamp are placed at same level on pubic body so that with closure, any sagittal plane rotation of symphysis is reduced. **G** and **H**, Views from inside and outside pelvis show positioning of Jungbluth clamp with gliding hole and anchoring plate. SEE TECHNIQUE 56-4.

Images courtesy of Sean Nork, MD

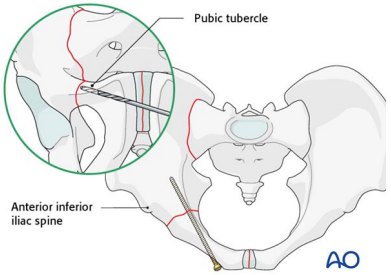
ORIF Anterior Pelvic Ring Injuries

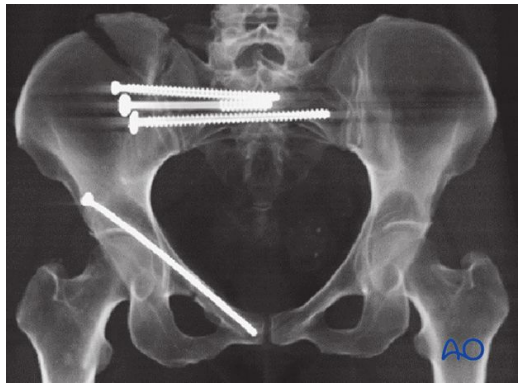
FIGURE 46-54 Photographs of symphyseal specific designed plates. **A:** Top with oblong holes centrally and locking holes peripherally; bottom plate with all locking holes. **B–D:** Representation of plate applications superiorly with CMF clamp holding reduction (B, old style four-hole plate; C, oblong symphyseal plate; D, locking symphyseal plate).



igure 3: Anteroposterior (a), inlet (b), and outlet (c) views of the pelvis how pubic symphysis reduction with internal fixation using smal agment reconstruction plate and screws. The plate was placed ove

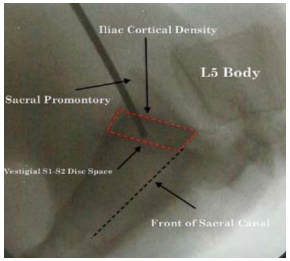
Percutaneous Fixation of Anterior Pelvis

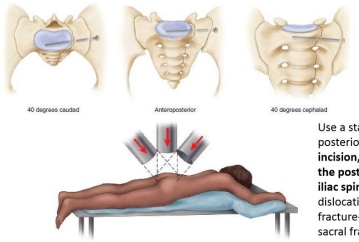




Percutaneous Sacral Fixation

- Patient supine
- Closed reduction achieved via pelvic compression
- Entry point determined
  - Should aim anterior in S1 & inferior to the iliac cortical density

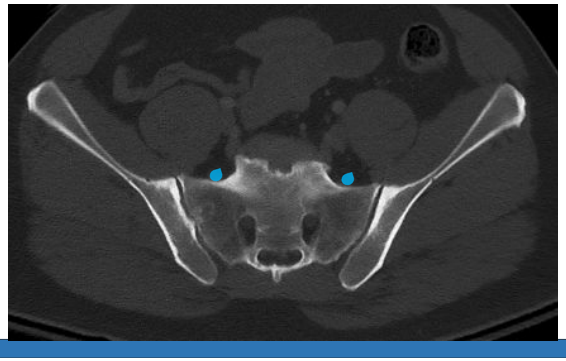


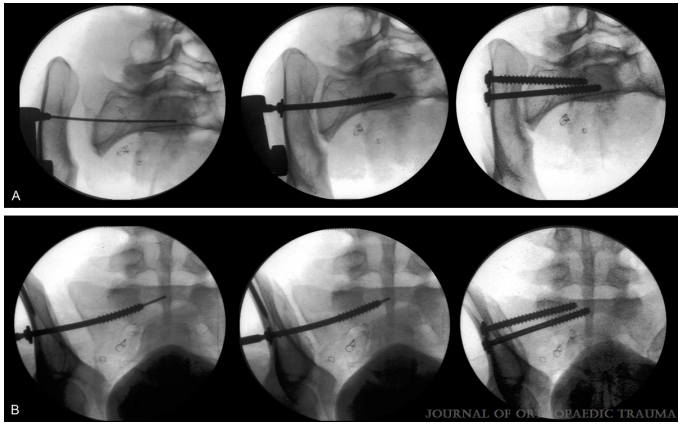


Use a standard posterior **vertical incision, 2 cm lateral to the posterior superior iliac spine** for sacroiliac dislocations, fracture-dislocations, or sacral fractures.

Neural Pelvic Anatomy

- L5 nerve root at risk with percutaneous iliosacral screw placement
  - 2cm medial to the SI joint



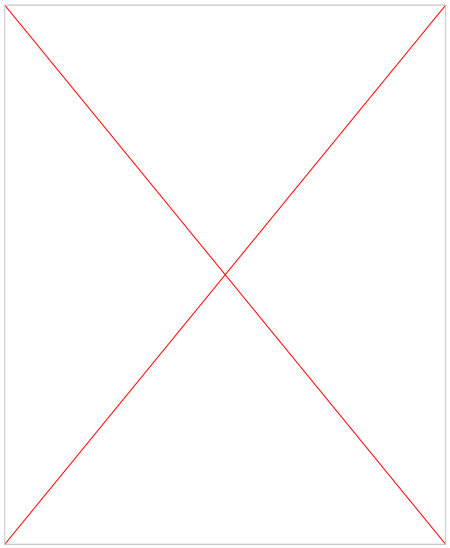


The patient underwent antishock iliosacral screw procedure to reduce wide sacroiliac diastasis, as seen on pelvic inlet view (row A) and pelvic outlet view (row B). Starting points and orientations of two screws were planned to allow balanced reduction of sacroiliac joint and safe screw placement.

Gardner MJ, et al. The antishock iliosacral screw. J Orthop Trauma, 24(10):e86-e89, October 2010.

Bringing it together: Cases

Questions?



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