Acute Management of Pelvic Ring Injuries

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***Images belong to James Black MD unless otherwise indicated**

Objectives

Understand the treatment algorithm for the hemodynamically unstable patient with a pelvic ring injury

- Review pertinent anatomy and injury patterns
- Systematic evaluation of the trauma patient
- Goals of initial resuscitation and necessary interventions
- Acute stabilization methods

Background

- Overall mortality 10-15%

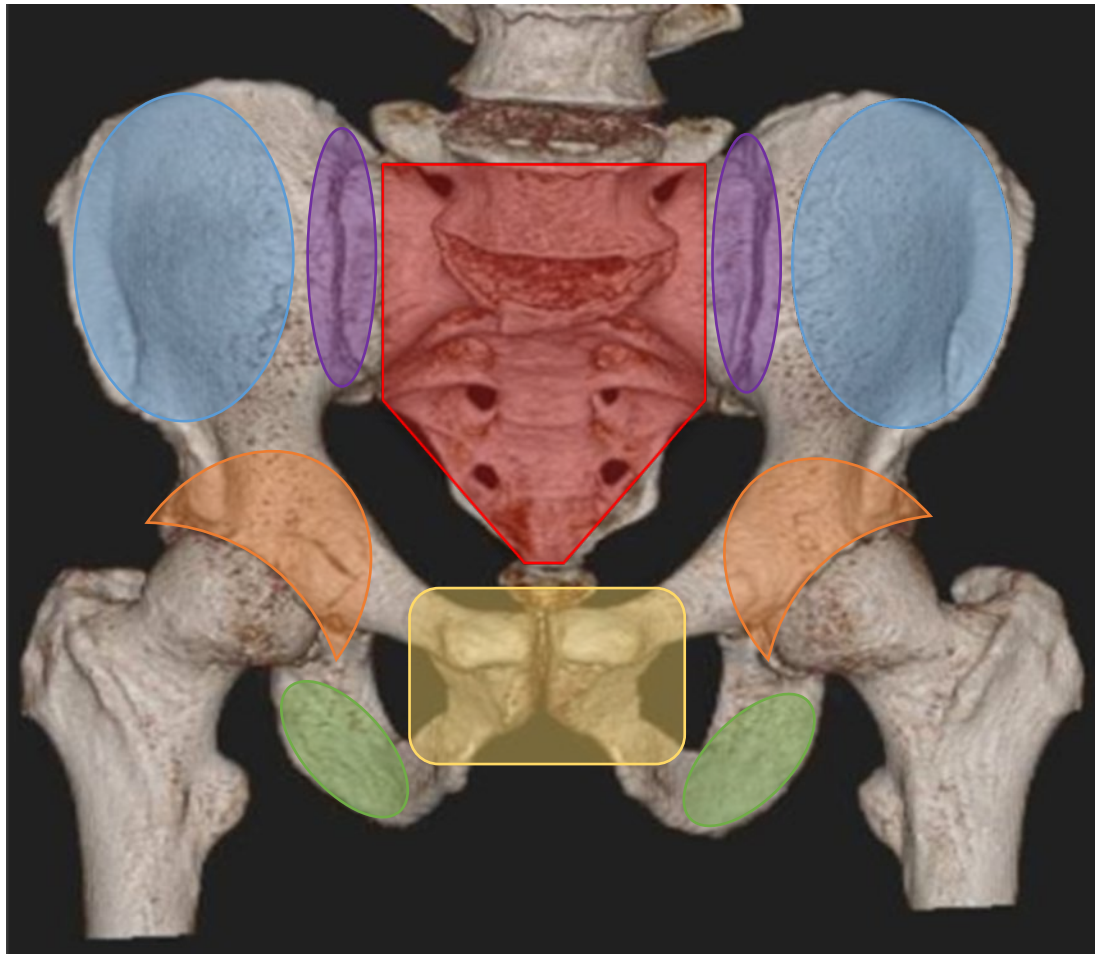
- Increasing mortality (up to 50%) with:
  - Hemodynamically unstable on arrival on ER
  - Concomitant head, chest and major abdominal injuries
  - Open pelvic fractures
  - Age >65

Pelvic Anatomy Review

- Basic pelvic osteology
- Pelvic ligaments
- Pelvic vasculature

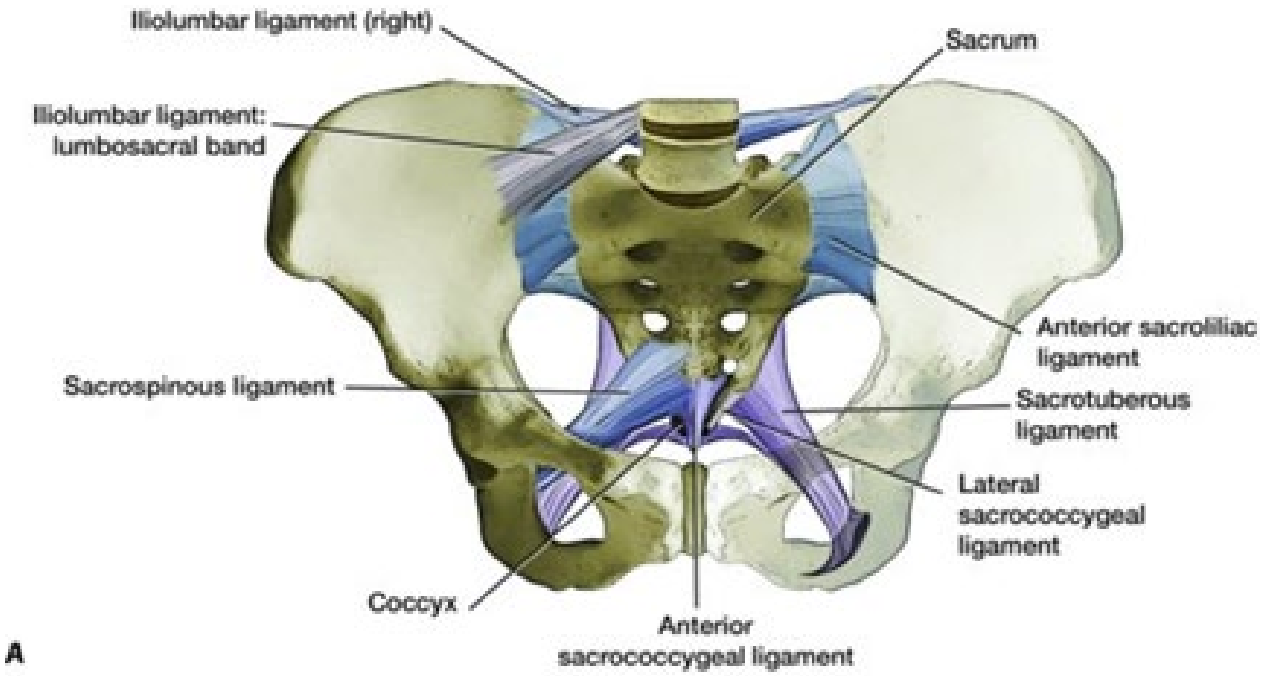
Courtesy of Joshua Gary, MD

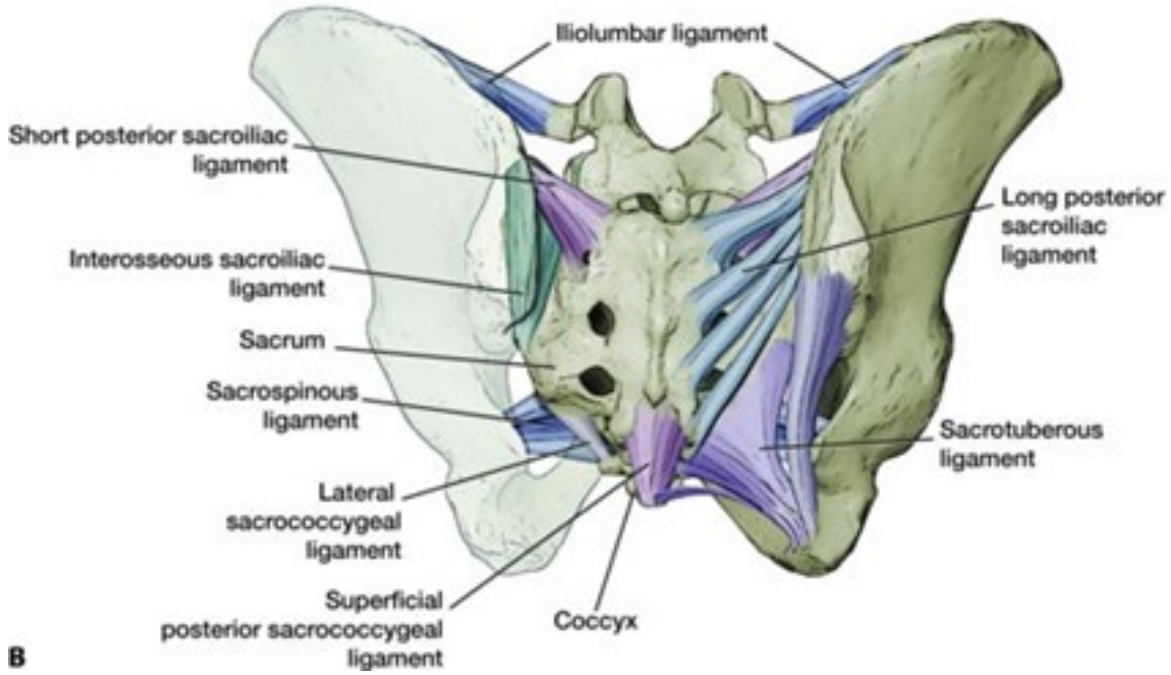
Pelvic Anatomy Review - Osteology



- Ilium
- Sacrum
- SI Joint
- Acetabulum
- Pubis
- Ischium

Pelvic Anatomy Review - Ligaments



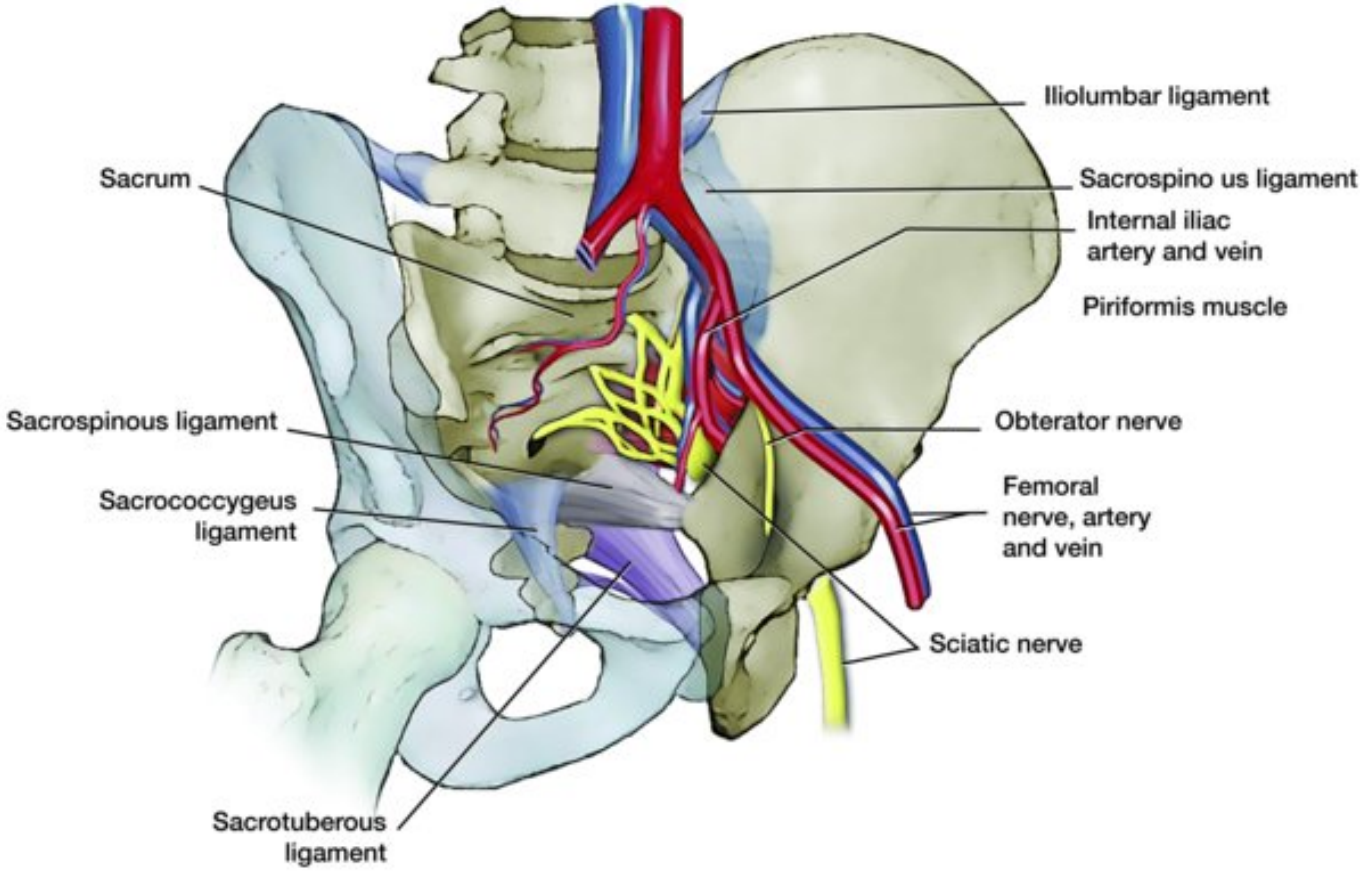


Anterior view – ligaments intact on right side, with the sacrospinous and ILL (lumbosacral band) removed on the left side for better visualization of underlying structures (sacrotuberous, lateral coccygeal, and full visualization of anterior sacroiliac ligaments).

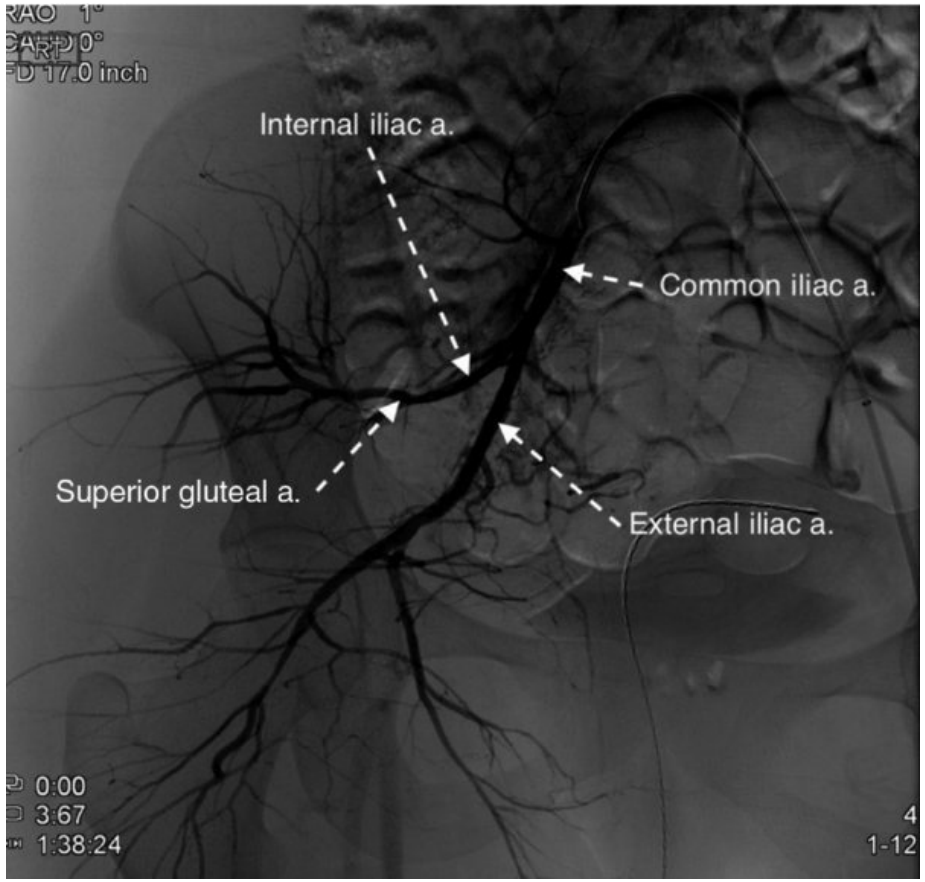
Posterior view – ligaments intact on right side, with the long posterior sacroiliac and sacrotuberous ligaments removed on left side for better visualization of underlying structures (sacrospinous, interosseous sacroiliac, and short posterior sacroiliac ligaments).

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

Pelvic Anatomy Review - Vasculature



A. The left hemipelvis is visualized with a transparent sacrum and L5 body. The internal iliac branches are seen anterior to the SI joint. The proximity of the bladder and urethra to the symphysis is appreciated. The nerve roots exiting the foramen are demonstrated with the L5 nerve root anterior on the sacral ala.



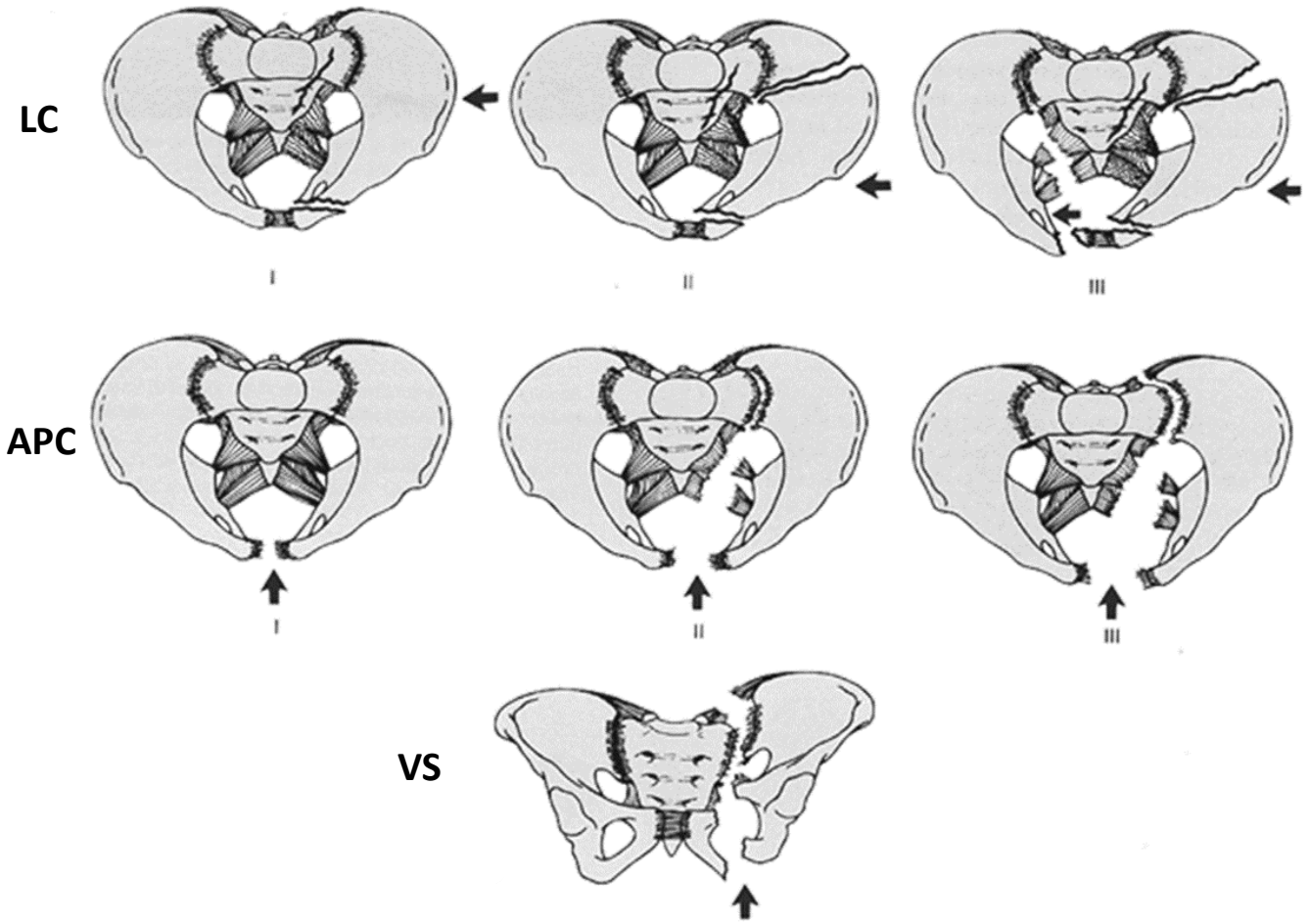
B. Arteriogram of pelvic arteries with common iliac and branches identified. Note the superior gluteal artery exiting the greater sciatic notch.

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

Young and Burgess Classification

Young and Burgess Classification of Pelvic Ring Injuries

- LC: Anterior injury = rami fractures
  - LC I: Sacral fracture on side of impact
  - LC II: Crescent fracture on side of impact
  - LC III: Type 1 or 2 injury on side of impact with contralateral open-book injury
- APC: Anterior injury = symphysis diastasis/rami fractures
  - APC I: Minor opening of symphysis and SI joint anteriorly
  - APC II: Opening of anterior SI, intact posterior SI ligaments (PSILs)
  - APC III: Complete disruption of SI joint
- VS type: Vertical displacement of hemipelvis with symphysis diastasis or rami fractures anteriorly, iliac wing, sacral facture, or SI dislocation posteriorly
- CM type: Any combination of the above injuries



Courtesy of Sean Nork, MD

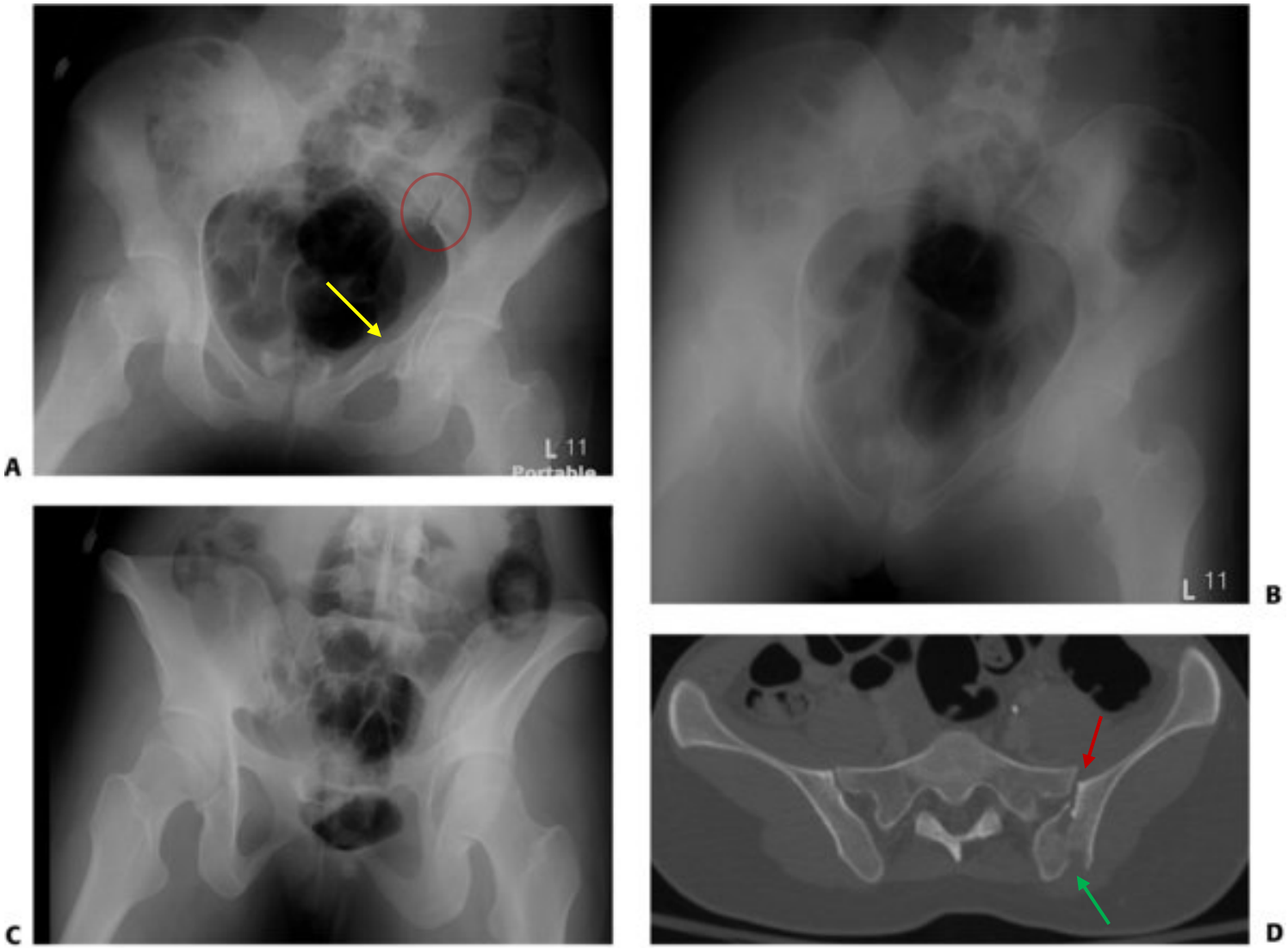
Agarwal A, 49:Pelvic ring injuries in Rockwood and Green's Fractures in Adults, 9e, Tornetta et al (eds), Wolters Kluwer 2020.

LC I

A: AP radiograph showing posterior lesion (*red oval*) and anterior lesions (rami fractures; *arrows*).
B: CT scan axial cut showing impaction fracture of sacrum (*arrow*).
C–E: 3D reconstructions of AP, inlet, and outlet views showing injury.

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

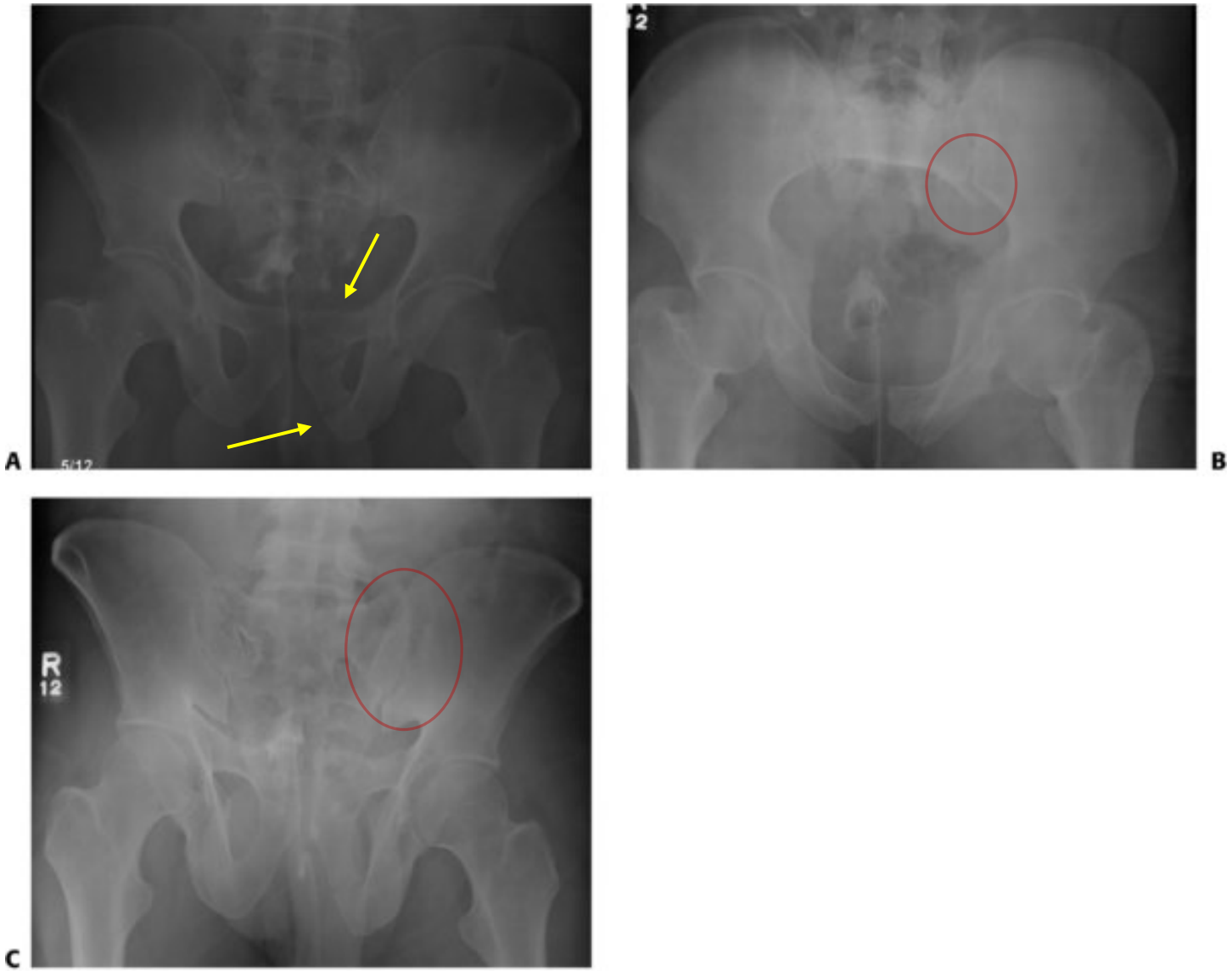
LC II: fracture-dislocation (crescent) through left SI Joint



A: AP radiograph showing anterior injury (ramus fracture, *yellow arrow*) and posterior injury (SI joint widening, *red oval*).
B: Inlet view radiograph.
C: Outlet view radiograph.
D: Axial CT scan showing posterior ilium crescent fracture (*green arrow*) and SI joint dislocation (*red arrow*).

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

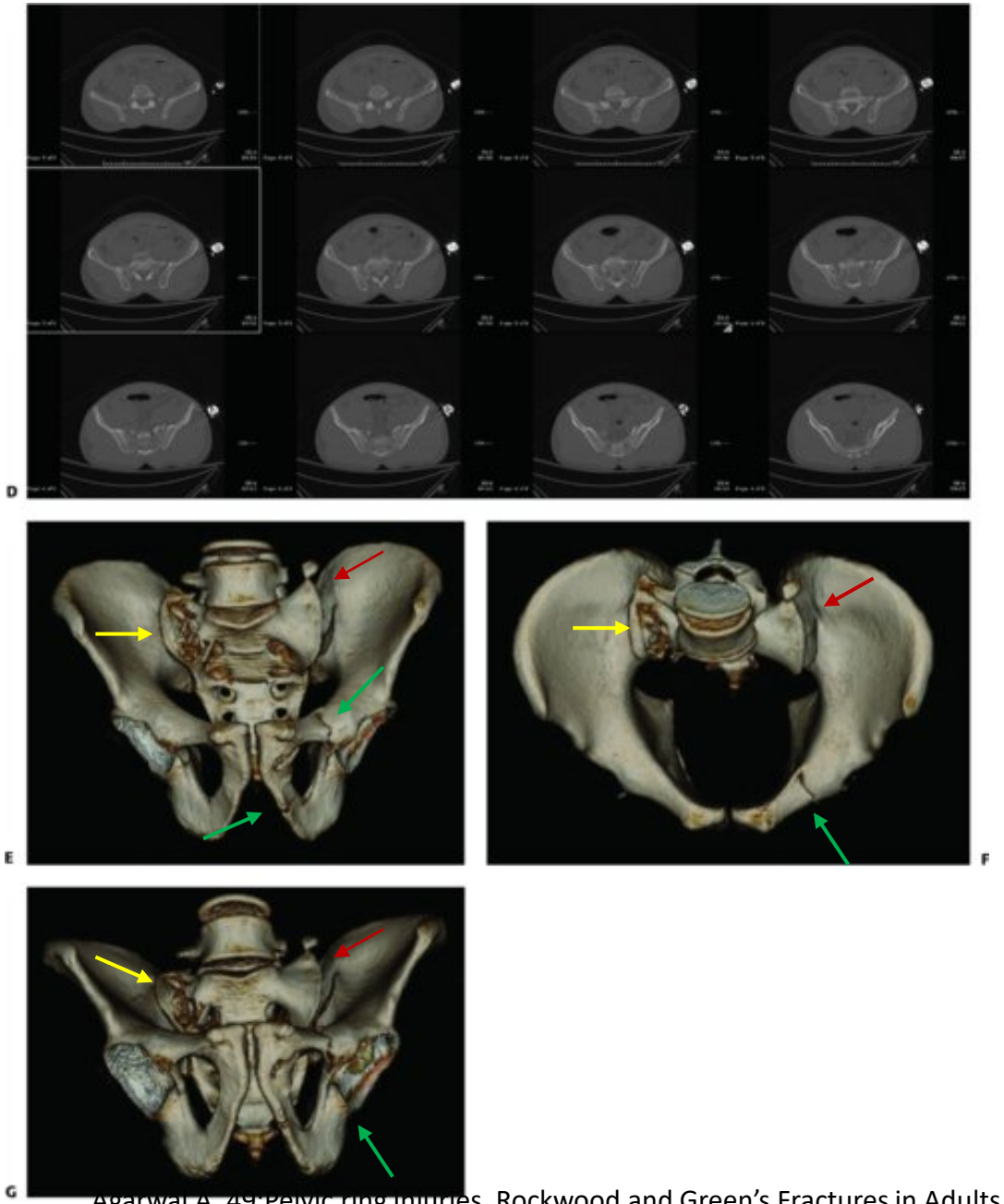
LC III: right-sided LC injury and left-sided APC injury



A: AP view radiograph showing left ramus fractures (*yellow arrows*)
B-C: Inlet and outlet view radiographs showing left posterior SI joint injury (*red ovals*)

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

LC III: right-sided LC injury and left-sided APC injury



D: Multiple CT scan images showing right-sided LC injury with sacral fracture and left-sided APC injury with SI joint widening.
E–G: 3D CT scan reconstructions of AP, inlet, and outlet views with right sacral fracture (*yellow arrows*), left SI joint injury (*red arrows*), and left ramus fractures (*green arrows*).

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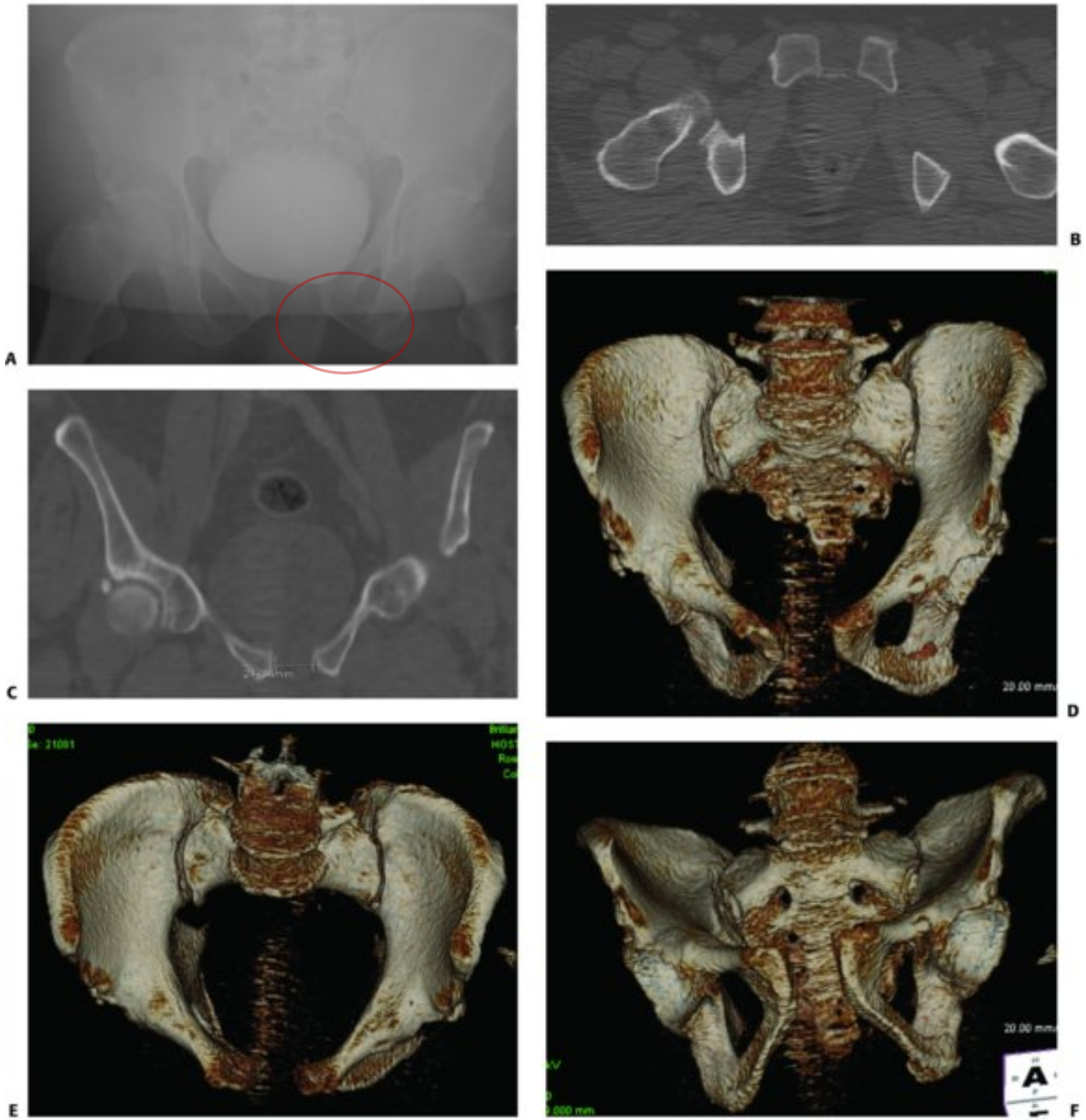
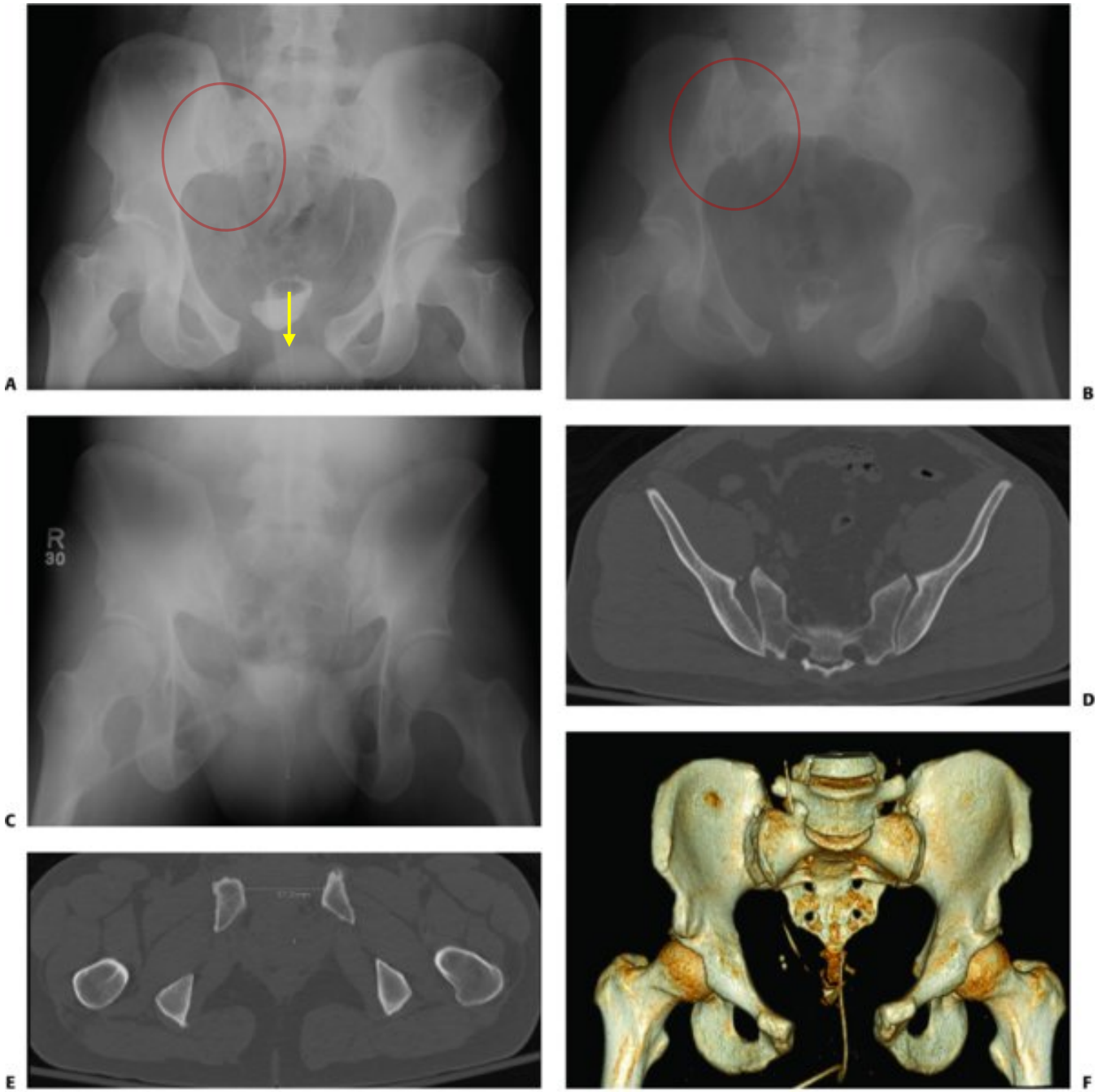
APC I



A: AP radiograph showing widened symphysis (*red oval*).
B, C: CT scan axial and coronal cuts showing measurement of <2.5 cm at symphysis.
D–F: 3D reconstructions of AP, inlet, and outlet views. Note the left ramus fracture with external rotation displacement.

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

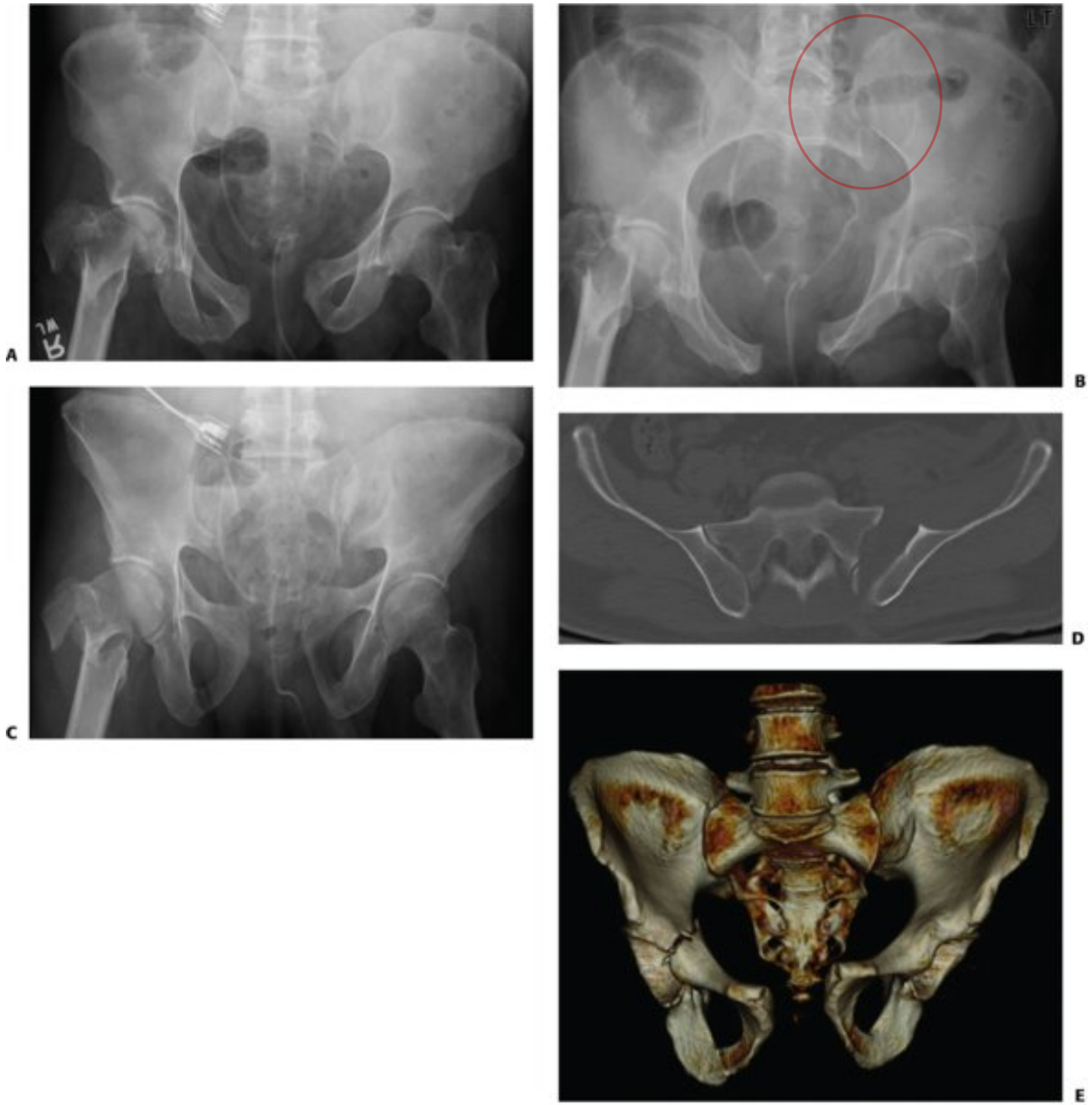
APC II



A–C: AP, inlet, and outlet view radiographs showing symphysis diastasis (*yellow arrow*) and right SI joint injury (*red ovals*).
D: CT scan posterior axial cut showing widening of right SI joint.
E: CT scan anterior axial cut showing more than 5.7 cm of widening.
F: A 3D reconstruction of AP view.

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

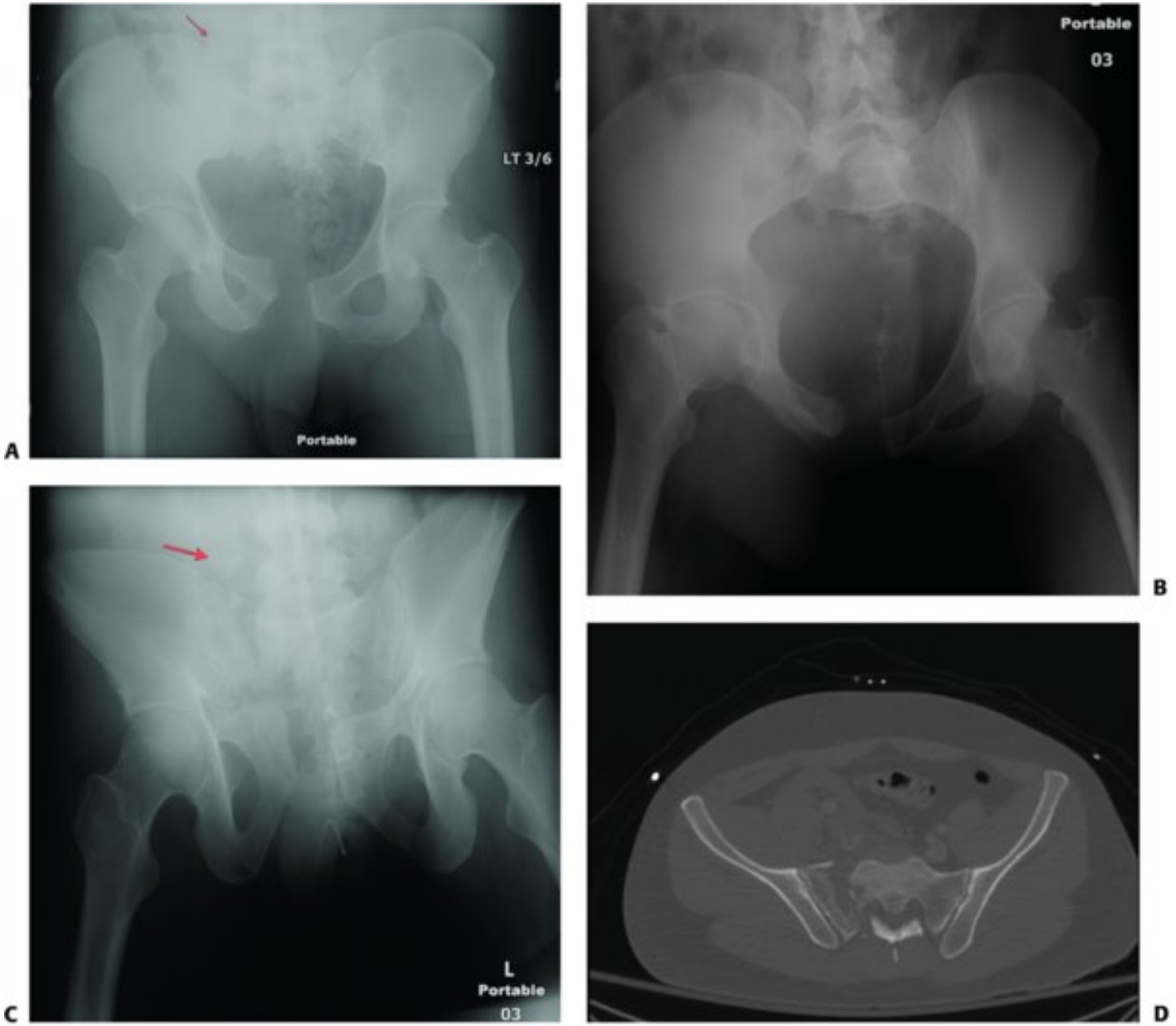
APC III



A–C: AP, inlet, and outlet view radiographs showing symphysis disruption and left SI joint dislocation (*red oval*).
D: CT scan showing complete left SI joint dislocation.
E: A 3D CT reconstruction of the AP view.

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

VS



A–C: AP, inlet, and outlet view radiographs showing vertical displacement of right hemipelvis through a complete sacral fracture and transverse process fracture avulsion (*arrow*).
D: Axial CT cut showing complete sacral fracture.

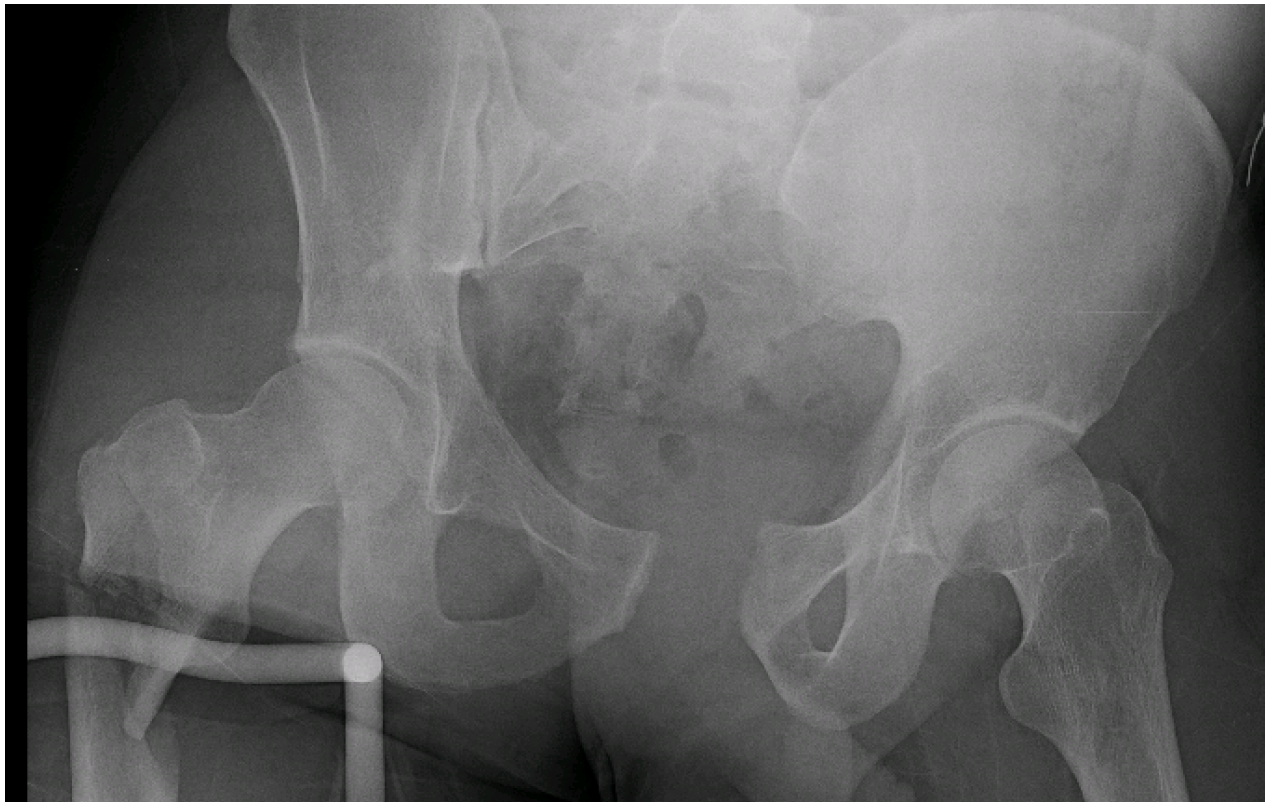
Agarwal A, 49:Pelvic ring injuries, Rockwood and Green's Fractures in Adults, 9e, Tornetta et al (eds), Wolters Kluwer 2020.

VS

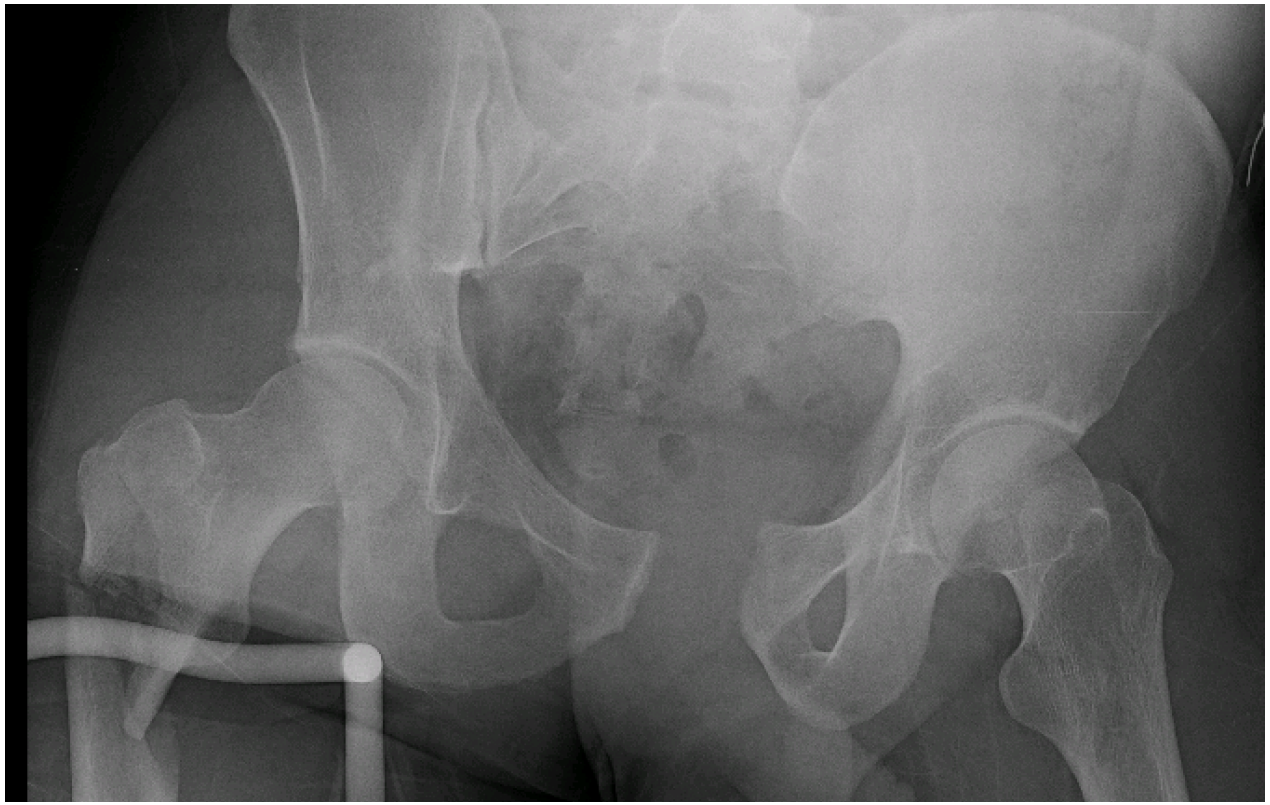
E: Coronal CT cut showing complete sacral fracture with vertical displacement of hemipelvis
F, G: 3D CT scan reconstructions of inlet and outlet views.

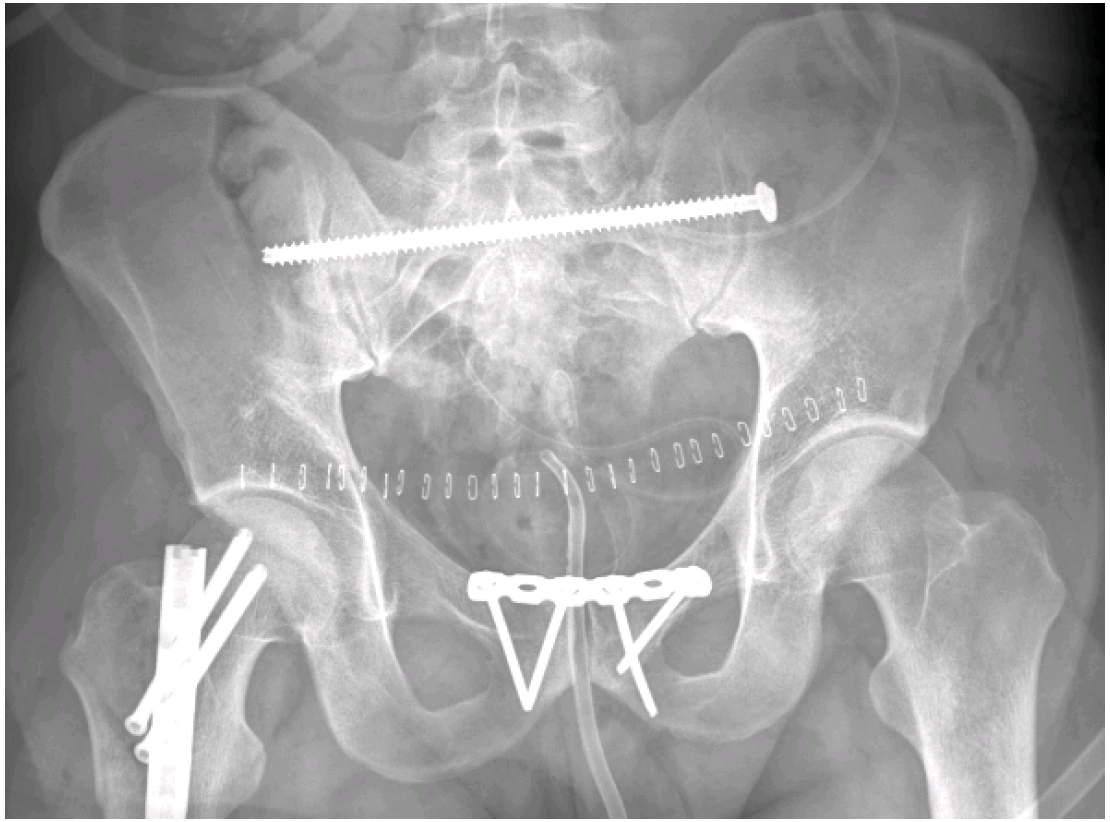
Agarwal A, 49:Pelvic ring injuries, Rockwood and Green's Fractures in Adults, 9e, Tornetta et al (eds), Wolters Kluwer 2020.

34 yo male s/p MVA



34 yo male s/p MVA





How do we get there?

Patient arrives in Trauma Bay

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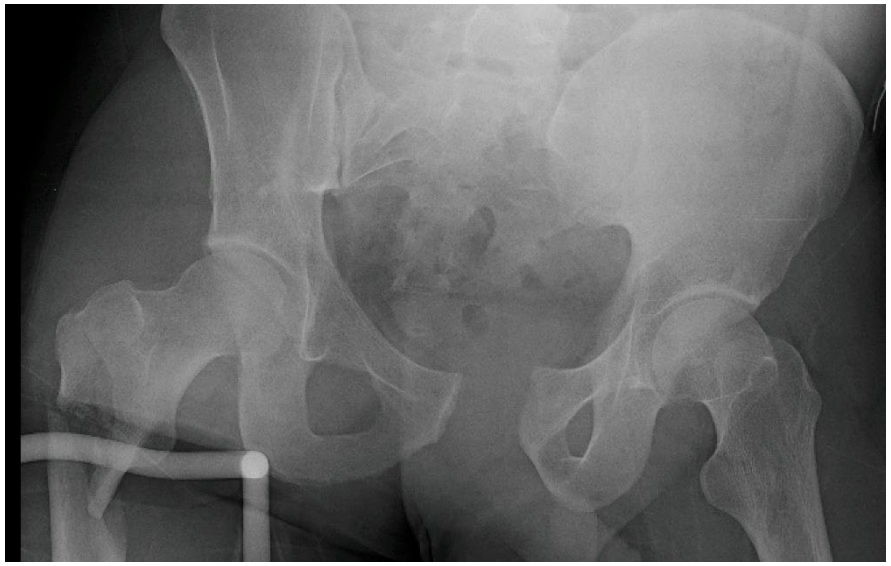

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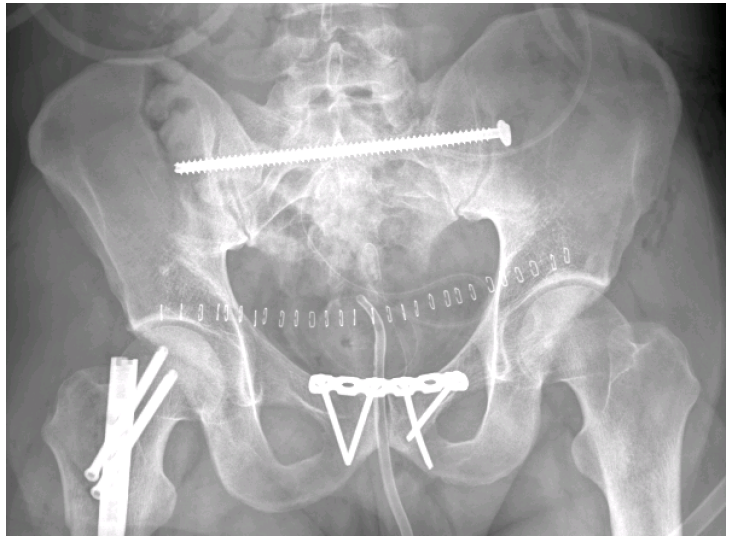
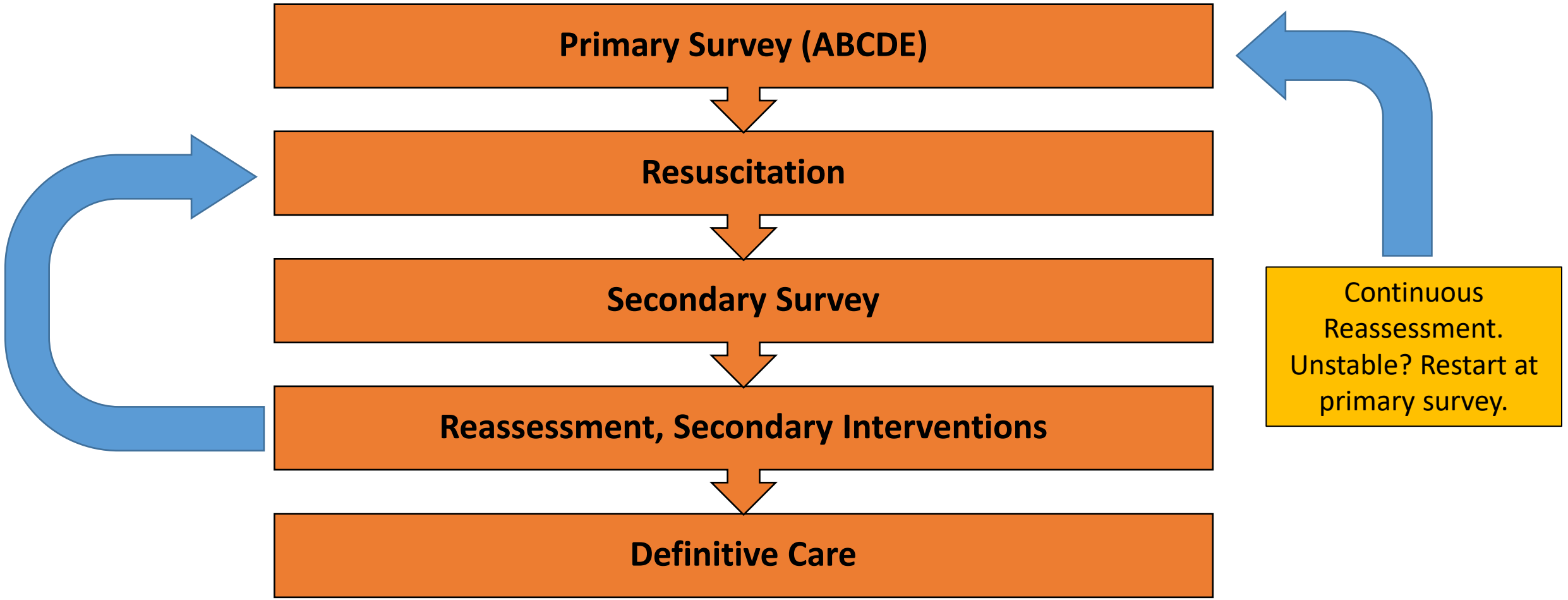


Principles of ATLS



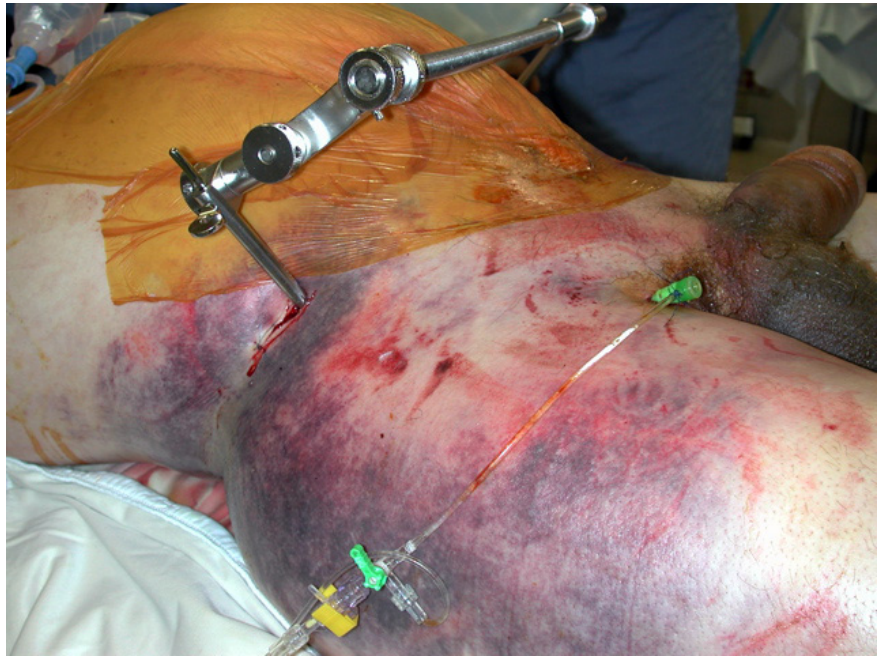
Primary Survey – ABC, DE

- **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



Courtesy of Sean Nork, MD

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

Images courtesy of Sean Nork, MD

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

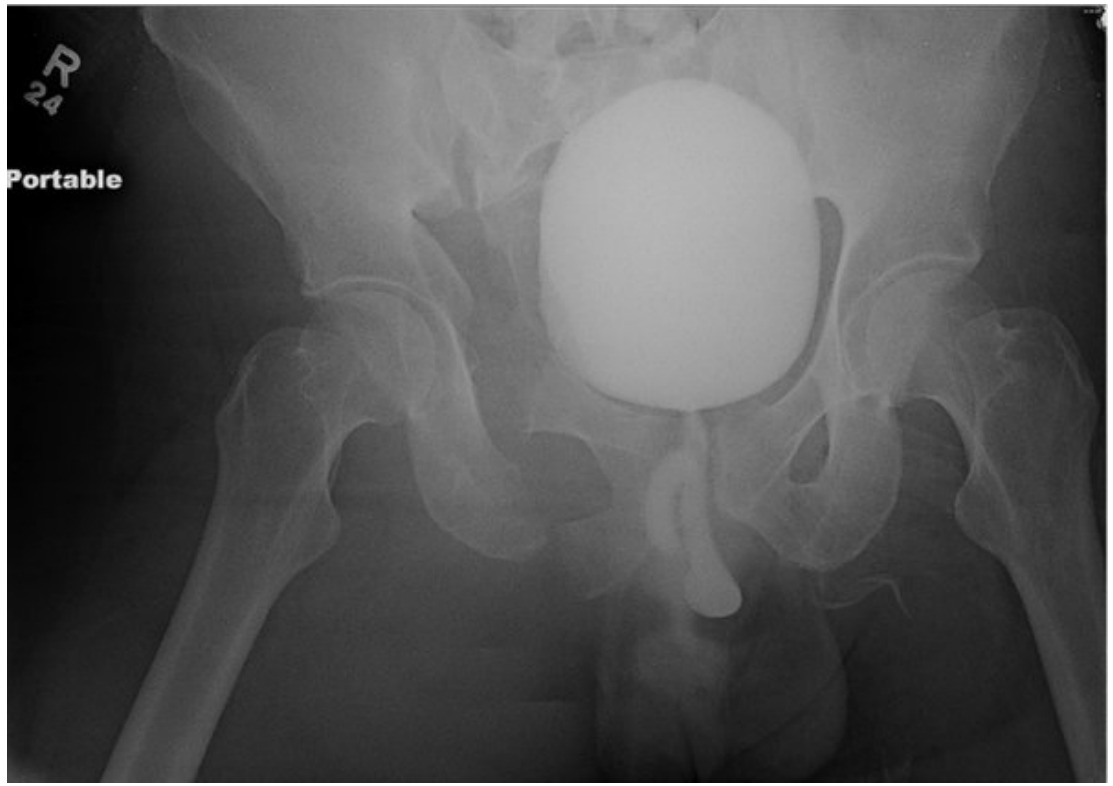
Open wound in groin with APC injury

Urologic Injury

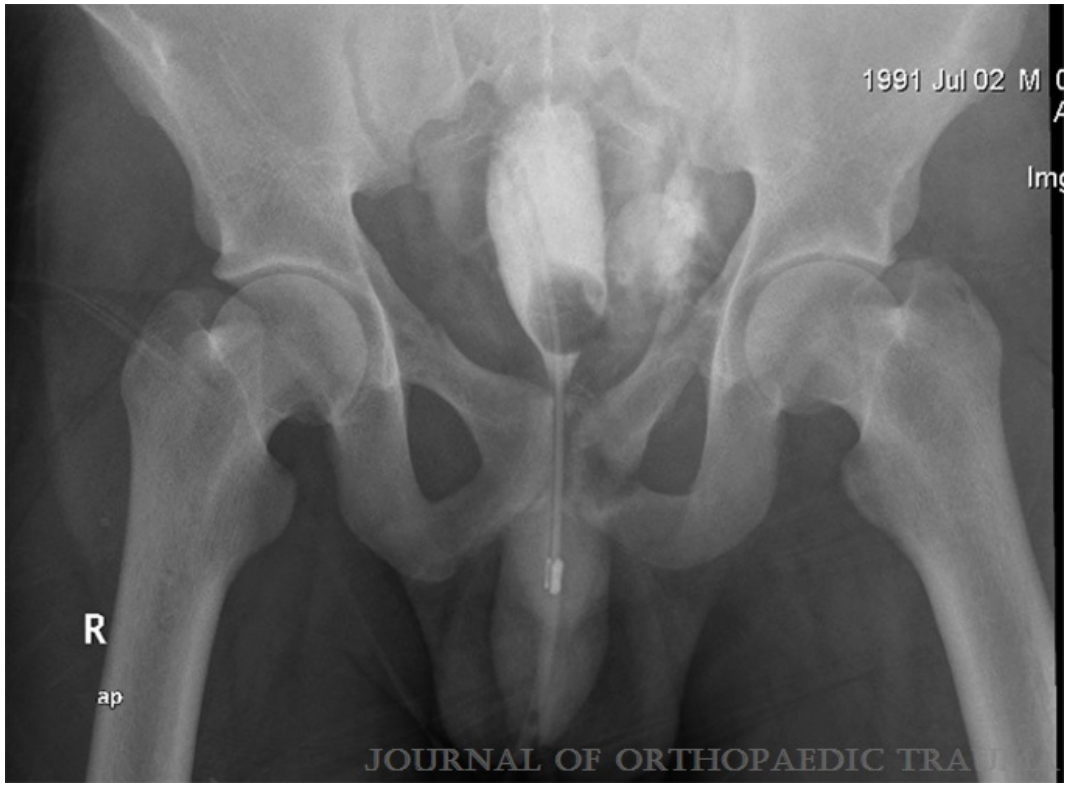
- Incidence: 6-15%
- Males have higher incidence of urethral injuries compared to females
- Bladder injuries: 60% extraperitoneal, 30% intraperitoneal, 10% both
  - Increased mortality with bladder rupture

- Microscopic or gross hematuria?
  - Cystogram
- Blood at urethral meatus?
  - Retrograde urethrogram

Urologic Injury



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

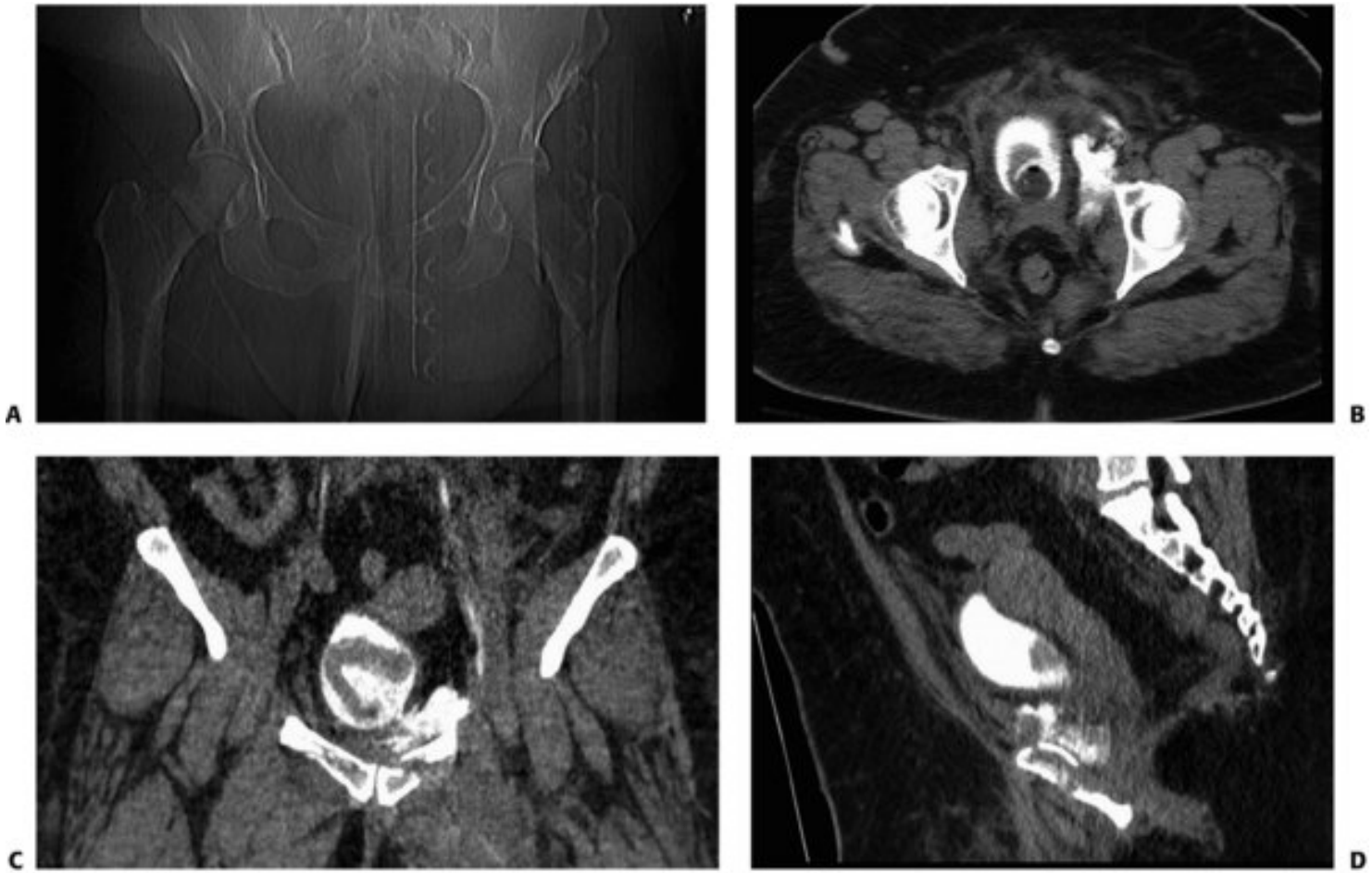


B. Cystogram showing bladder rupture with contrast extravasation

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

Figure B: Alexander G, et al. Septic arthritis of the hip after nonoperative treatment of a pelvic fracture associated with bladder rupture. J Orthop Trauma, 26(5):e40-e42, May 2012.

Urologic Injury



A: Contrast extravasation in obese female patient indicating bladder rupture.
B–D: Because of the size of the patient and poor plain imaging, suspected bladder rupture is confirmed with CT cystogram.

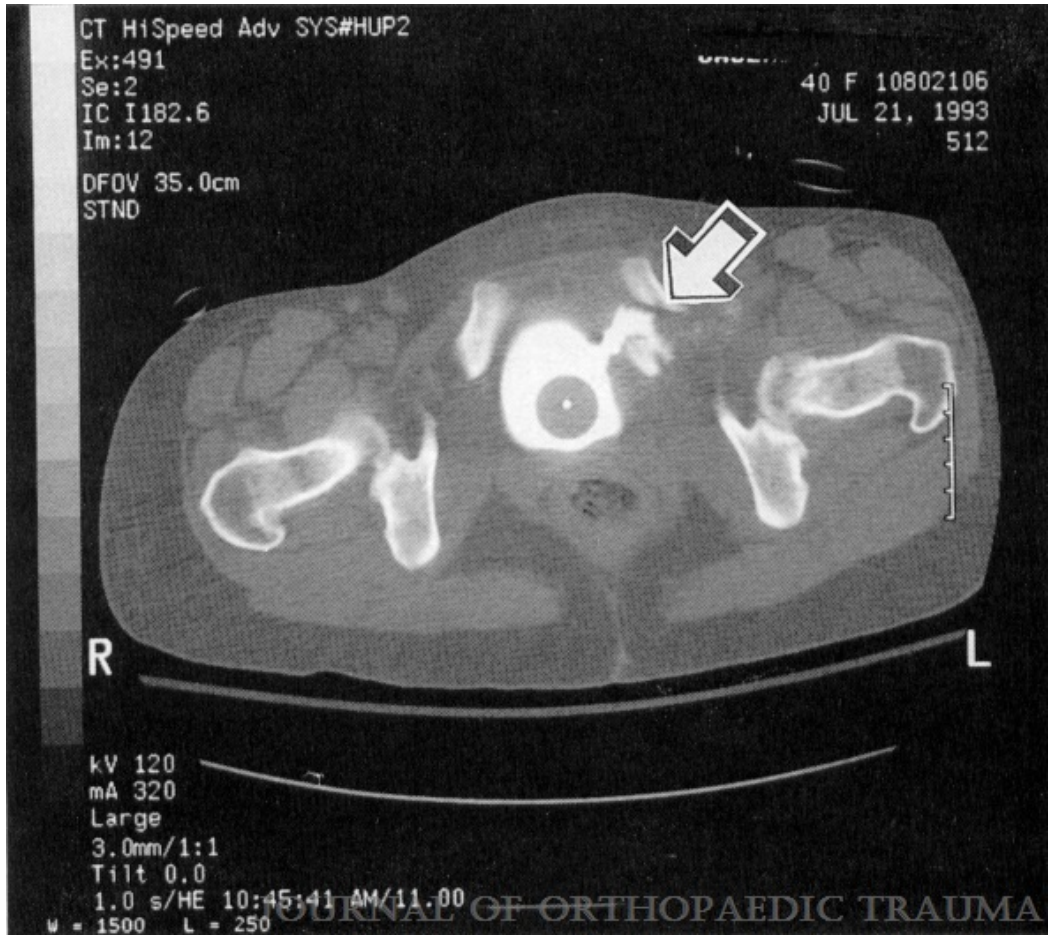
Agarwal A, 49:Pelvic ring injuries, Rockwood and Green's Fractures in Adults, 9e, Tornetta et al (eds), Wolters Kluwer 2020.

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.

Wright DG, et al. Case report: pelvic and bladder trauma: a case report and subject review. J Orthop Trauma, 10(5):351-354, July 1996.

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

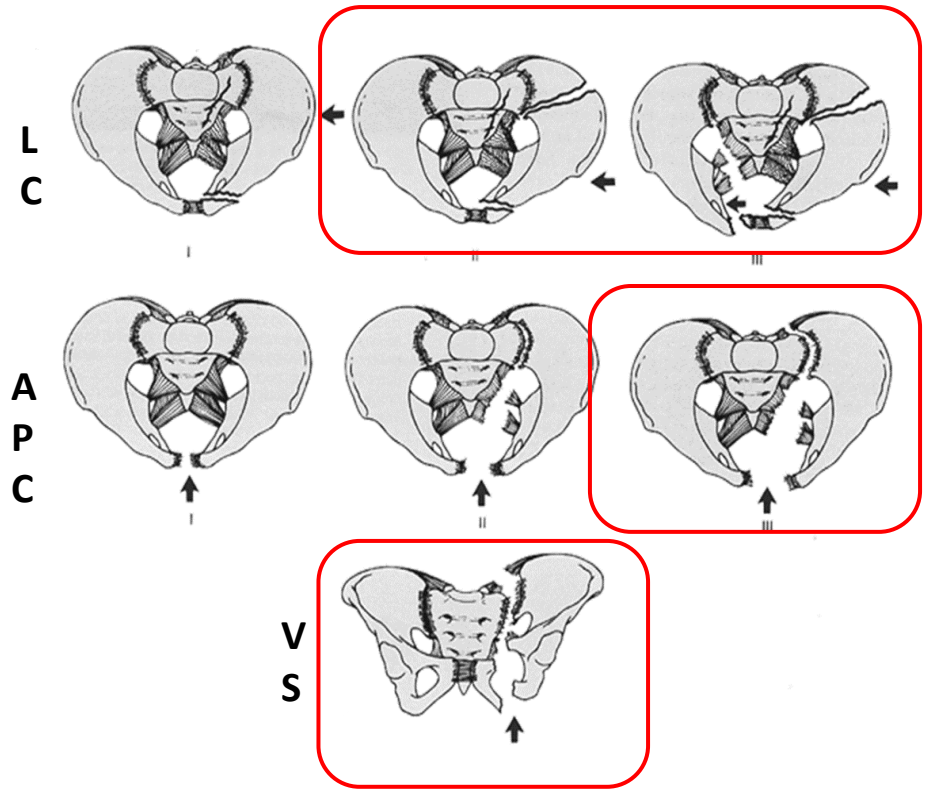
- Some degree of hemorrhage expected from fractured bone

Shock (SBP<90) on presentation
Early transfusion requirements

Increased Mortality

Hemorrhage and Pelvic Fractures

- 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 <u>any</u> pattern

Hemorrhage Control

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

Hemorrhage Control

- Pelvic Containment
    - Binder, Sheet, External Fixation, C-clamp, Internal Fixation

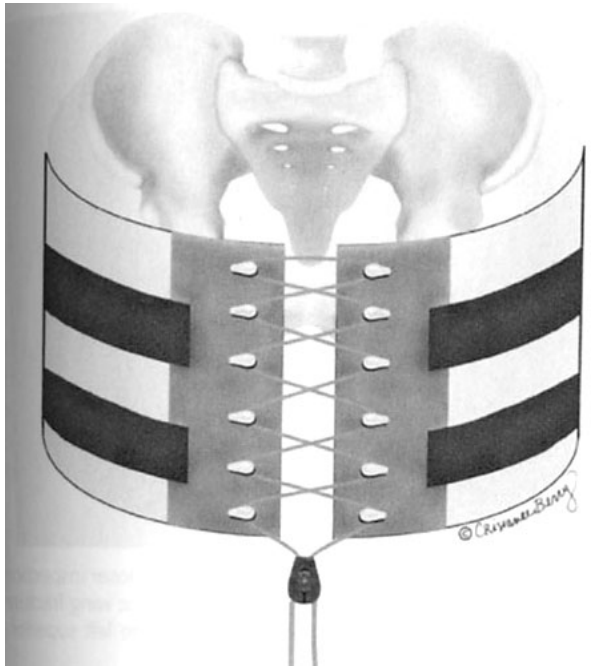
➢ Reduces pelvic volume to allow for tamponade effect

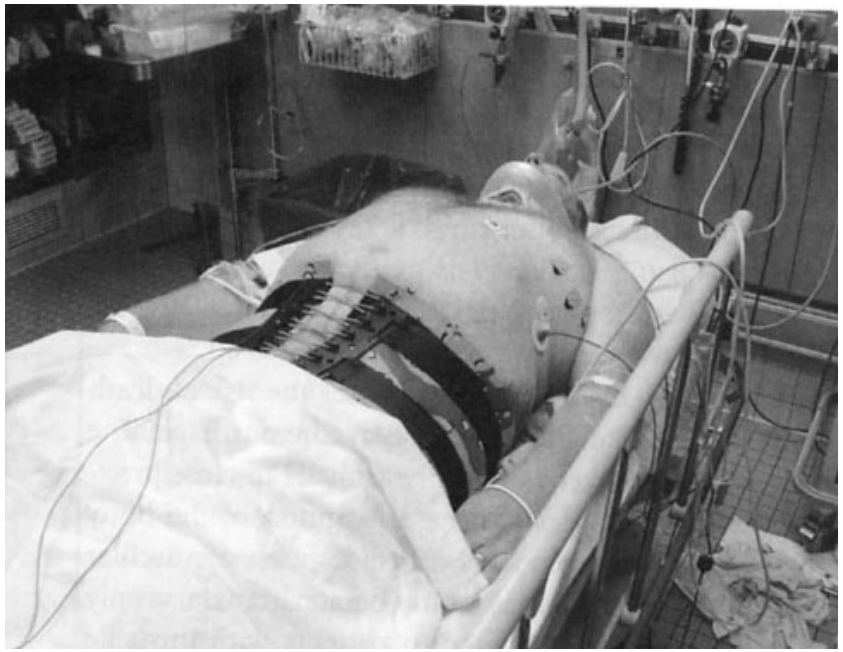
➢ Stabilizes pelvic injury to allow for clot formation

** Uncontrolled arterial bleeding can overwhelm tamponade effect

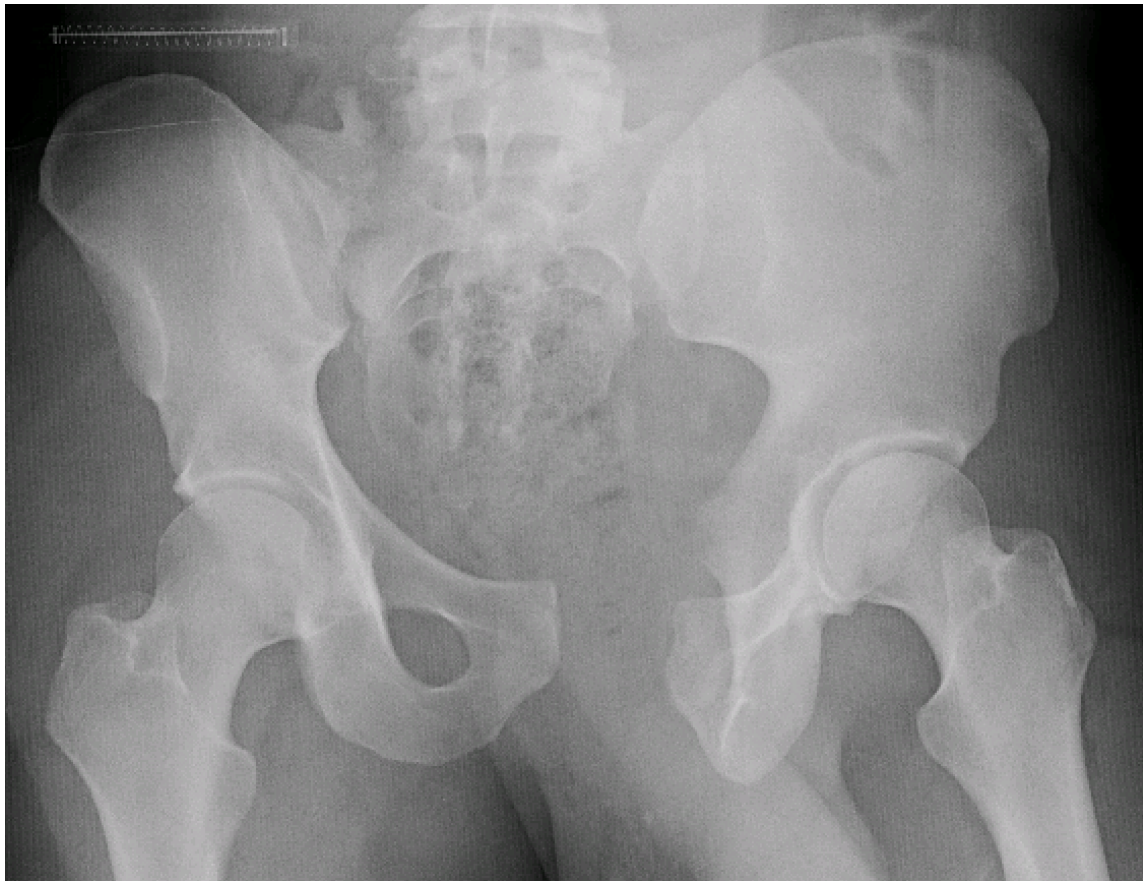
Pelvic Binder

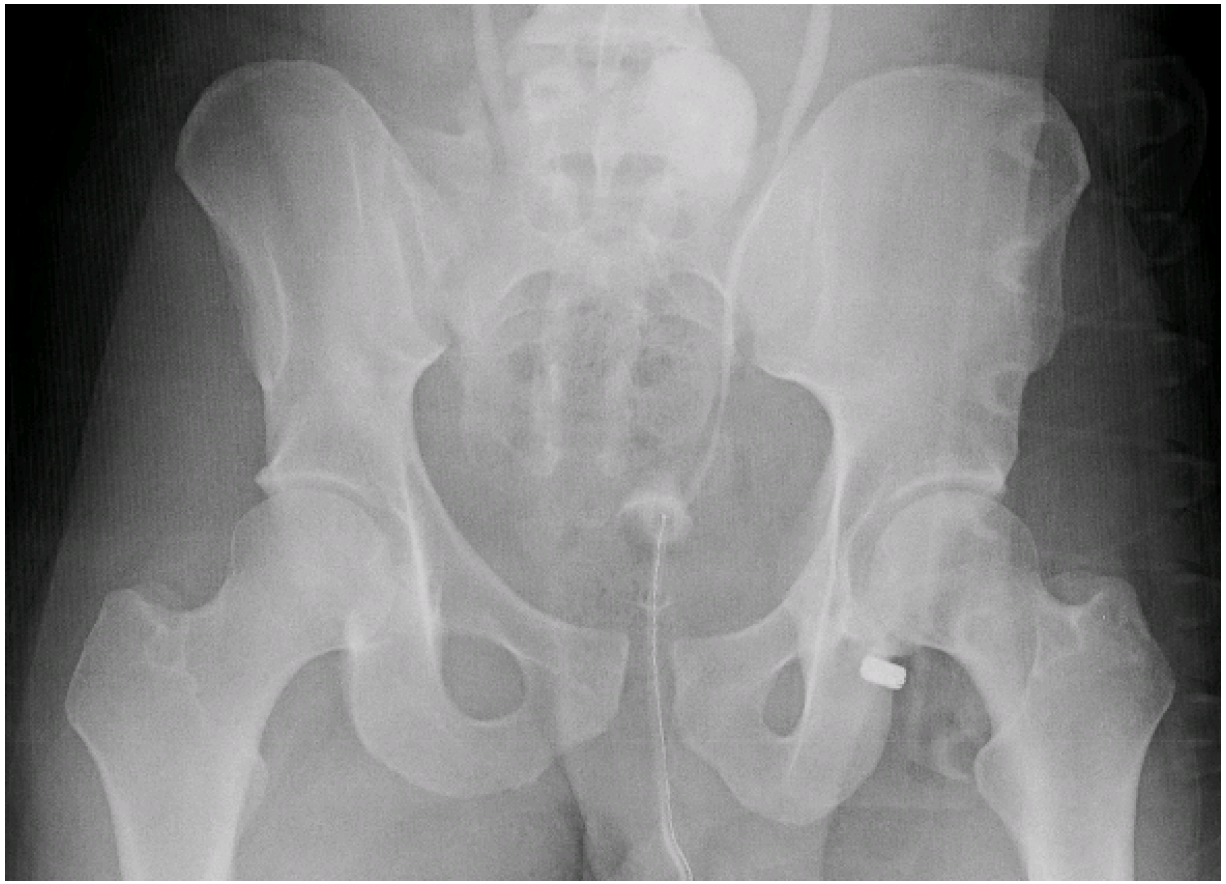
- Several commercially available options
- Easily applied by EMS and ER providers
- Must be properly positioned, centered on greater trochanters



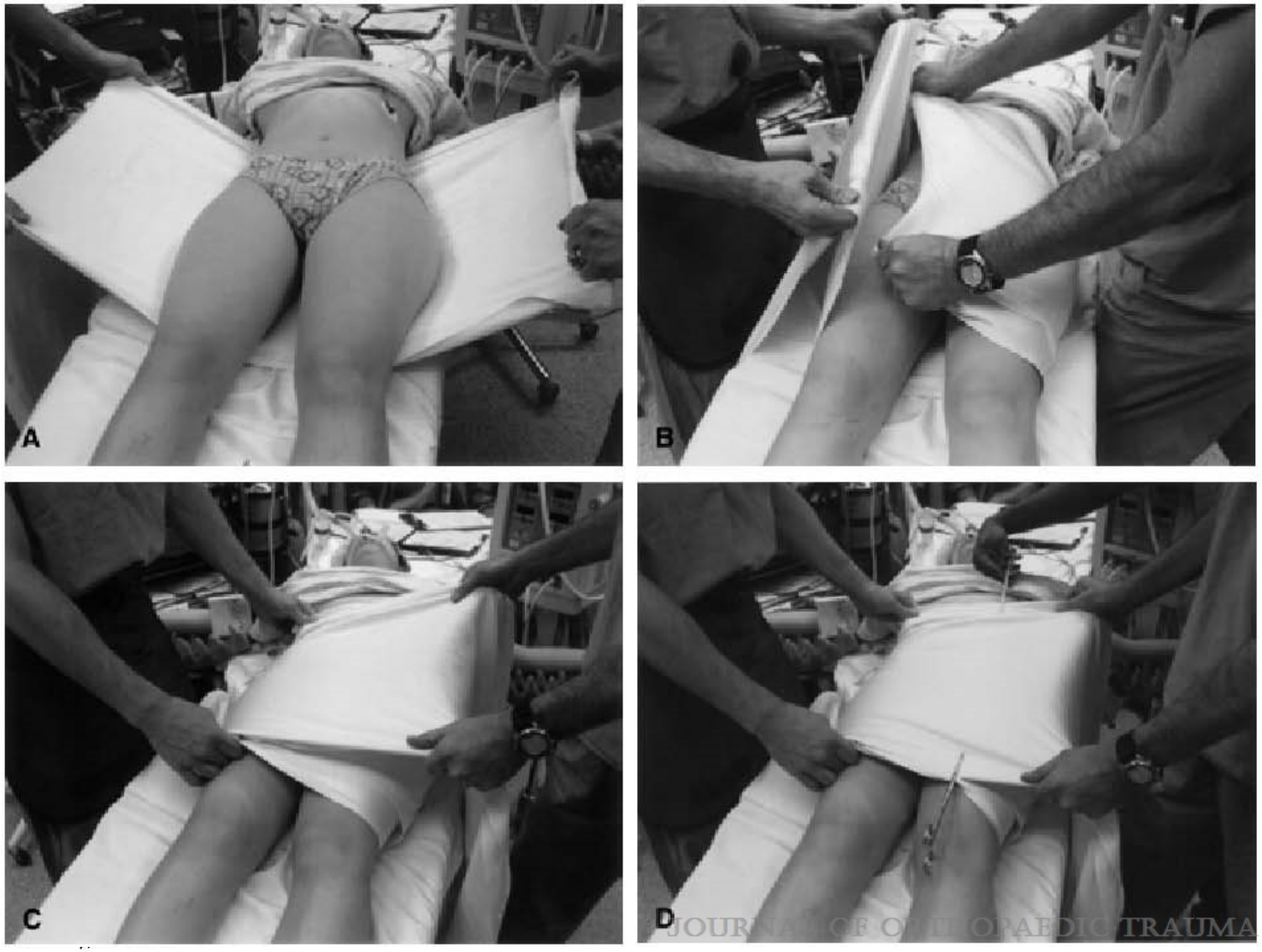


Pelvic Binder





Pelvic Antishock Sheet Binder



Circumferential pelvic antishock sheeting is applied in this example patient. The patient's clothing should be removed before application. Two people needed for application.

A. The sheet is positioned beneath the patient's pelvis smoothly.
B,C. The ends of the sheet are crossed in an overlapping manner anteriorly and are pulled taut.
D. Clamps secure the smooth and snug sheet.

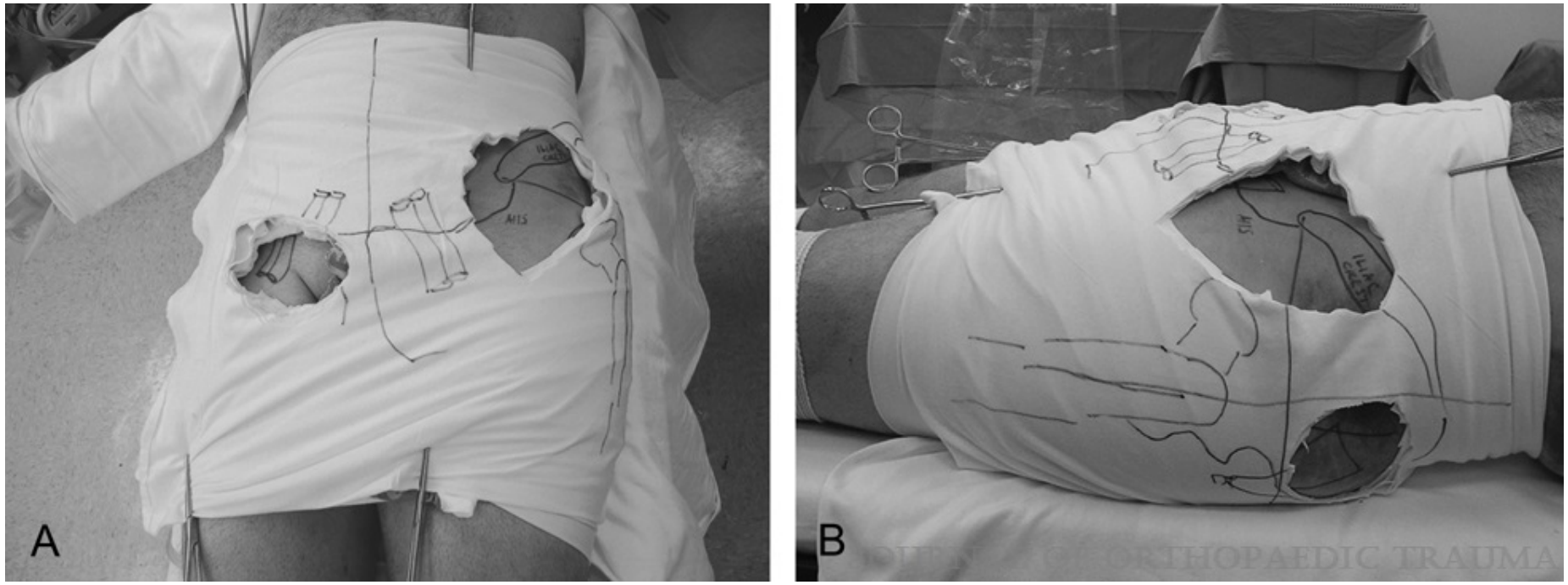
Routt CM, et al. Circumferential pelvic antishock sheeting: a temporary resuscitation aid. J Orthop Trauma, 16(1):45-48, January 2002.

Pelvic Antishock Sheet Binder

Insert video from Harborview/Routt of sheeting technique
-Need to confirm how to do this and permissions

https://www.uwmedicine.org/provider-resource/videos/pelvic-sheeting-for-immobilization

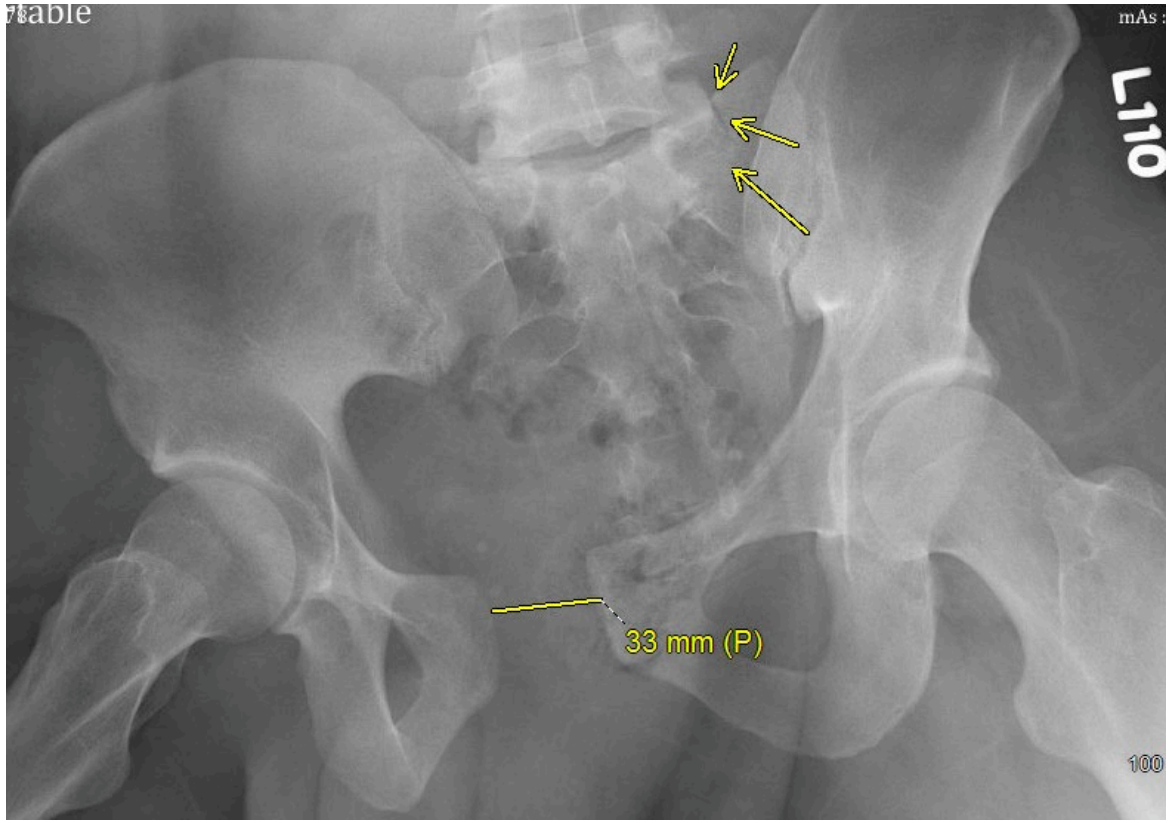
Pelvic Antishock Sheet Binder



Anterior view of the femoral vascular and anterior external fixation pin working portal (A), and lateral view demonstrating the iliosacral and antegrade ramus screw portals (B).

Routt CM, et al. Circumferential pelvic antishock sheeting: a temporary resuscitation aid. J Orthop Trauma, 16(1):45-48, January 2002.

Pelvic Antishock Sheet Binder



Beware of skin necrosis with binder or sheet placement

-Can occur as quickly as 24hrs

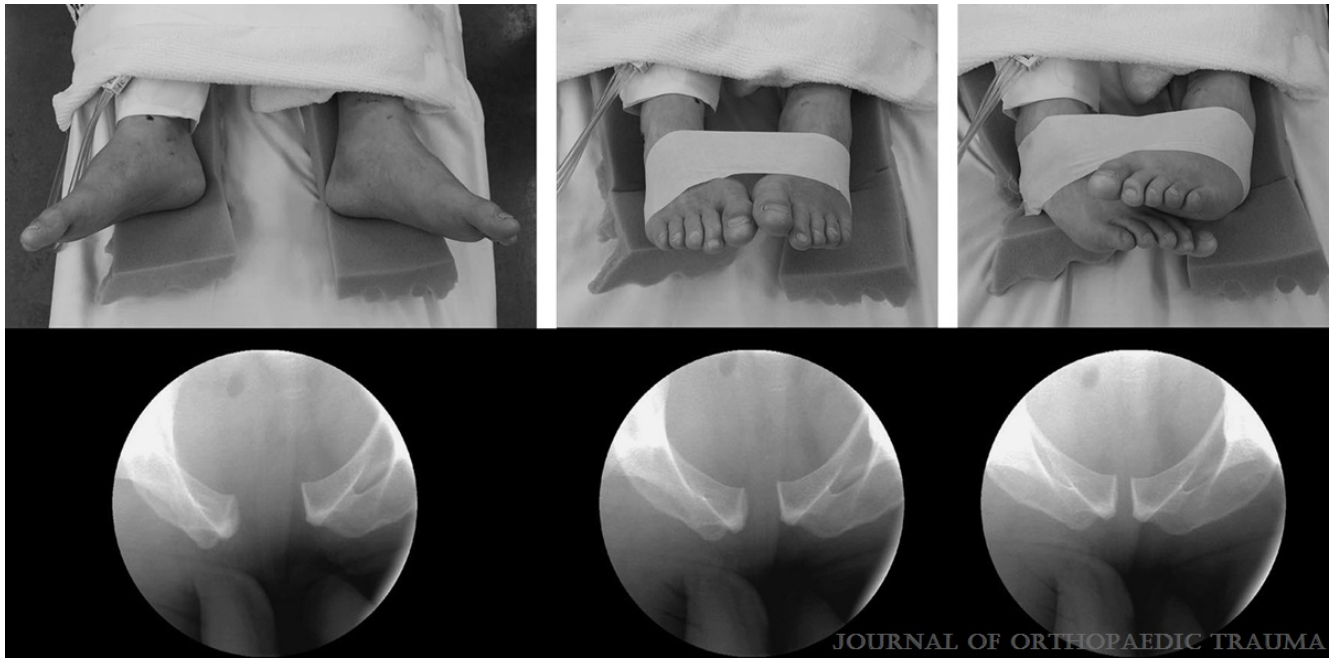
-Must formulate timely plan for removal and pelvic fixation

Images demonstrating skin necrosis following antishock pelvic sheeting

Schaller TM et al. Skin breakdown following circumferential pelvic antishock sheeting: a case report. J Orthop Trauma, 19(9):661-665, October 2005.

Taping lower extremities

Another method for stabilizing the pelvis and decreasing pelvic volume



As the lower extremities are taped in progressively more internal rotation, the pelvic reduction improves. The position of the feet in the upper row corresponds to the fluoroscopic images in the lower row.

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.

External Fixation

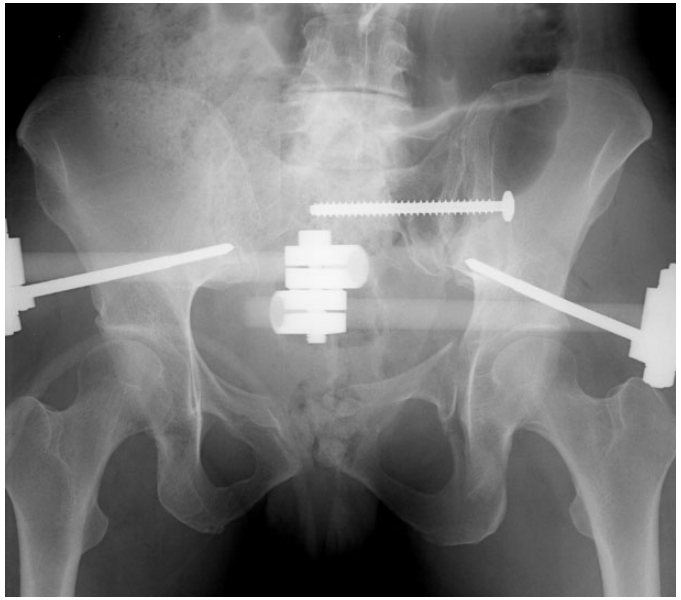
Placement Options

- AIIS
- ASIS
- C-clamp

Clinical Application

- **Resuscitative**
- Augmentative
- Definitive

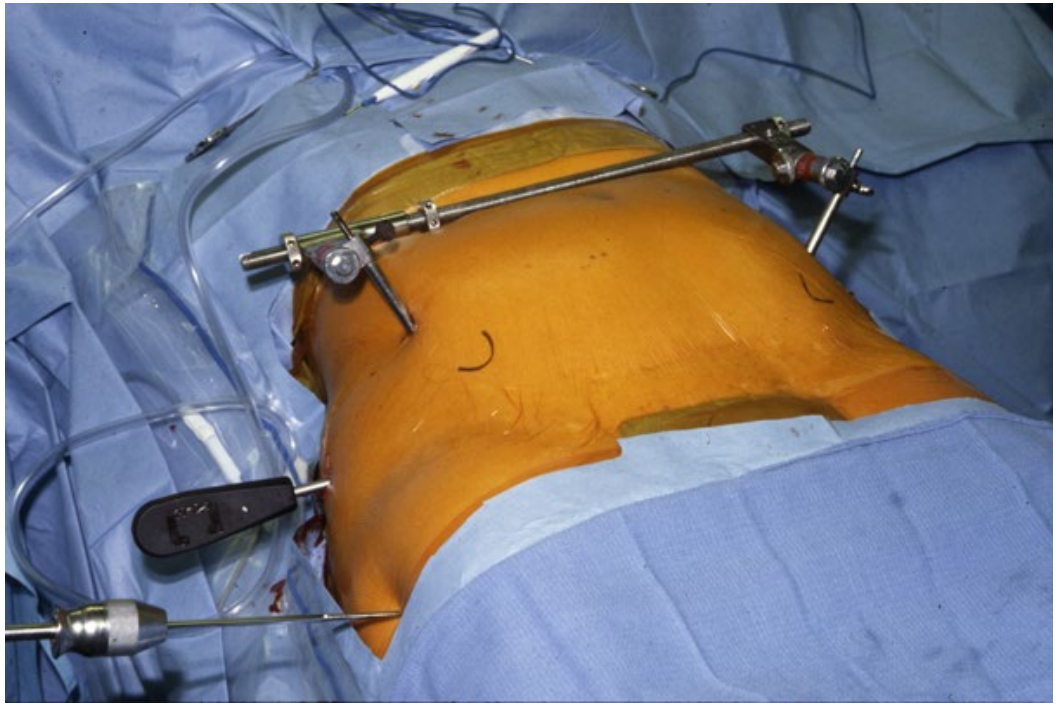
- All options can be very effective when posterior ring is intact
- AIIS placement
  - Helpful with vertically and rotationally unstable patterns
  - Allows easier access to pelvis/abdomen
  - Tolerated better by patients – allows them to sit upright
  - Increased control of the ring



Courtesy of Sean Nork, MD

ASIS Technique

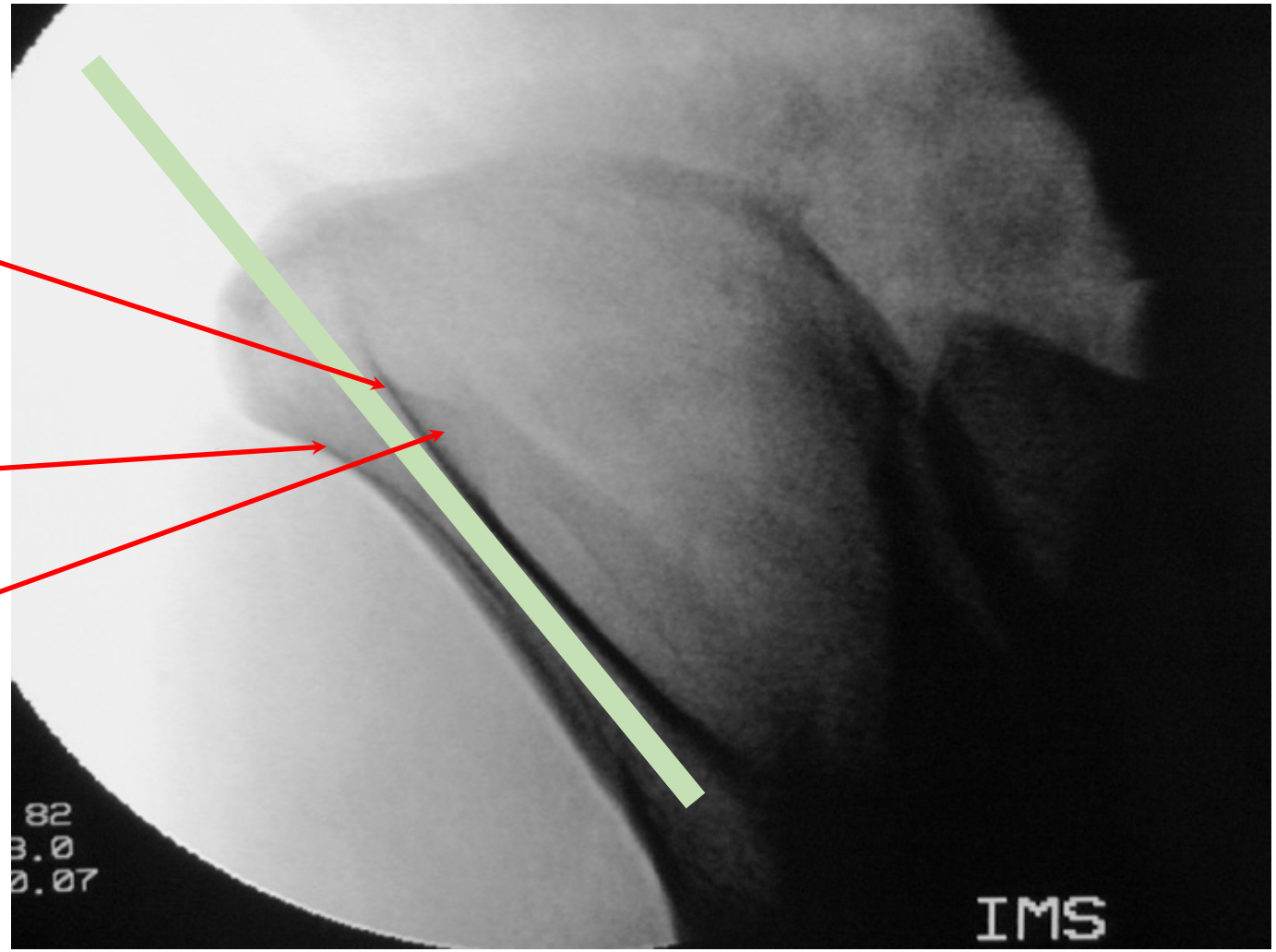
- Fluoro guidance
- 3-5cm posterior to ASIS
- Along gluteus medius pillar
- Incisions directed toward final pin location
- Pin entry at junction of lateral 2/3 and medial 1/3 of iliac crest
- Aim 30-45 degrees towards hip joint
- Pillar is “thin” – pin can easily violate medially or laterally or be “in-out-in”



Courtesy of Sean Nork, MD

ASIS Technique

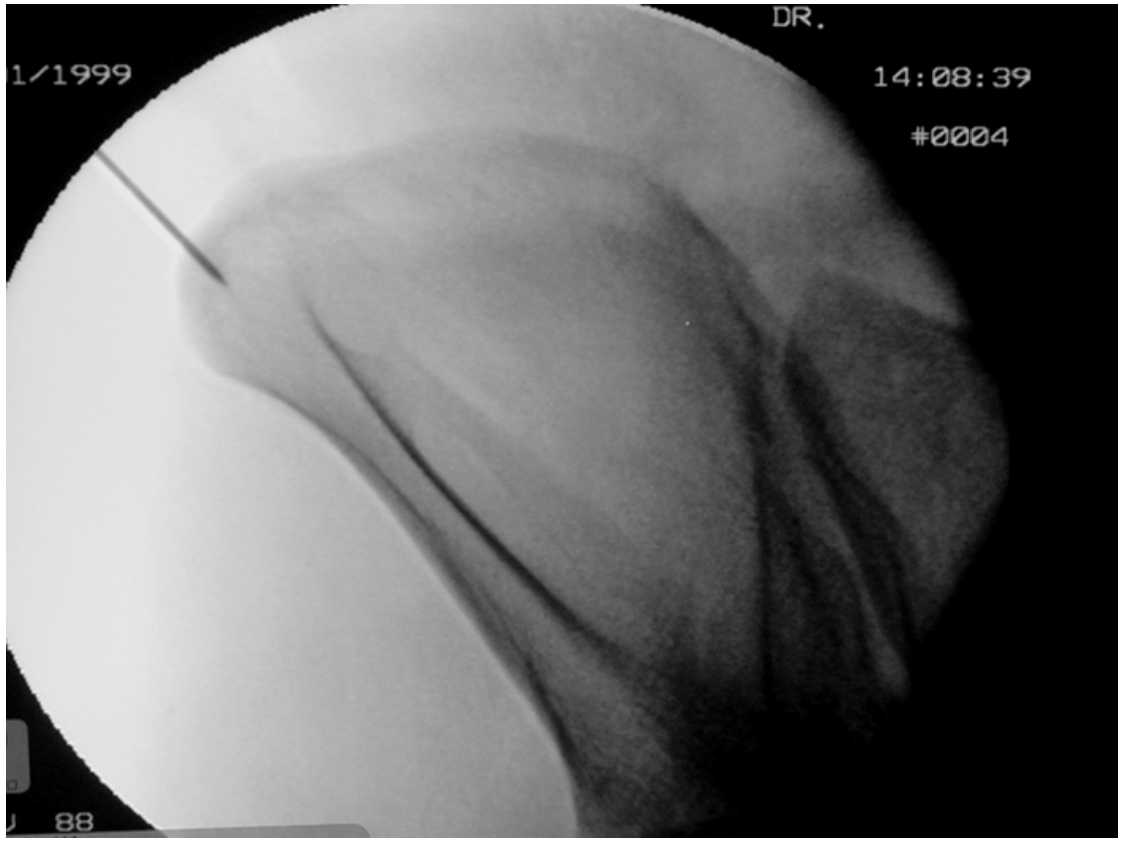
- Inner Table
- Outer Table
- ASIS

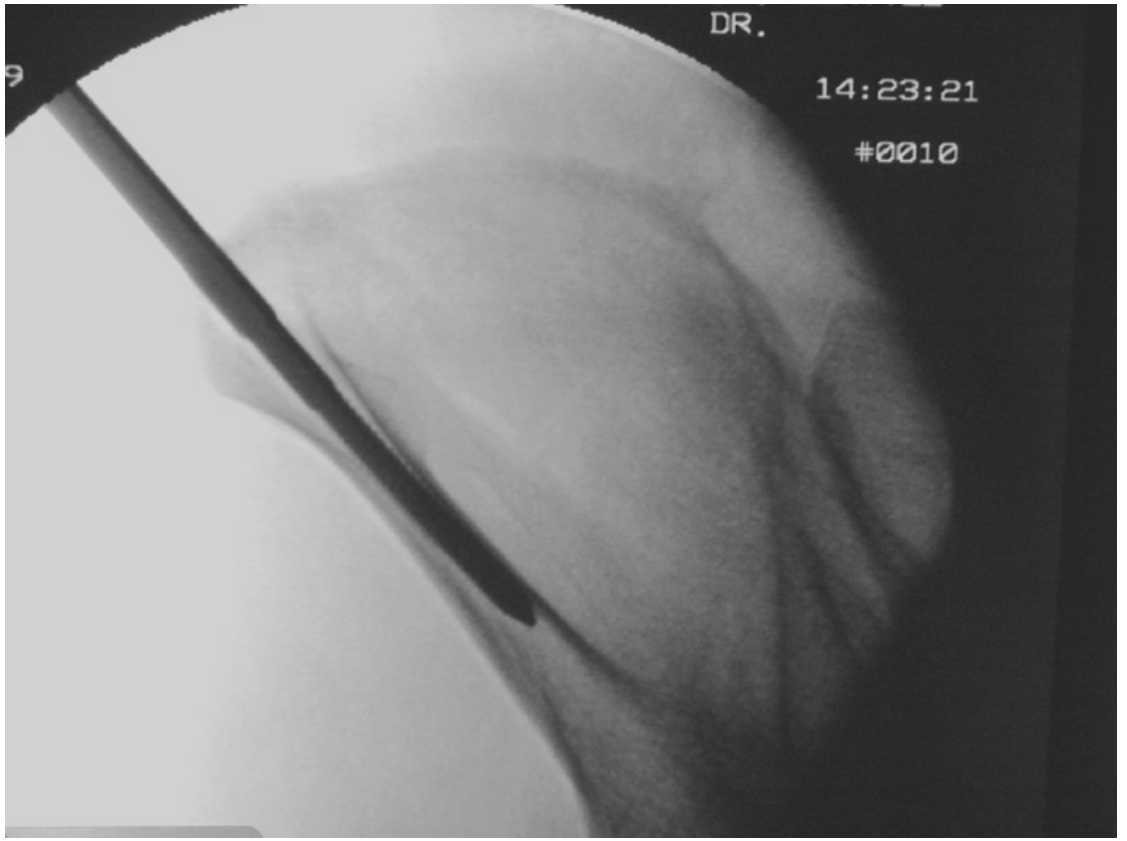


Outlet Oblique View

Courtesy of Sean Nork, MD

ASIS Technique



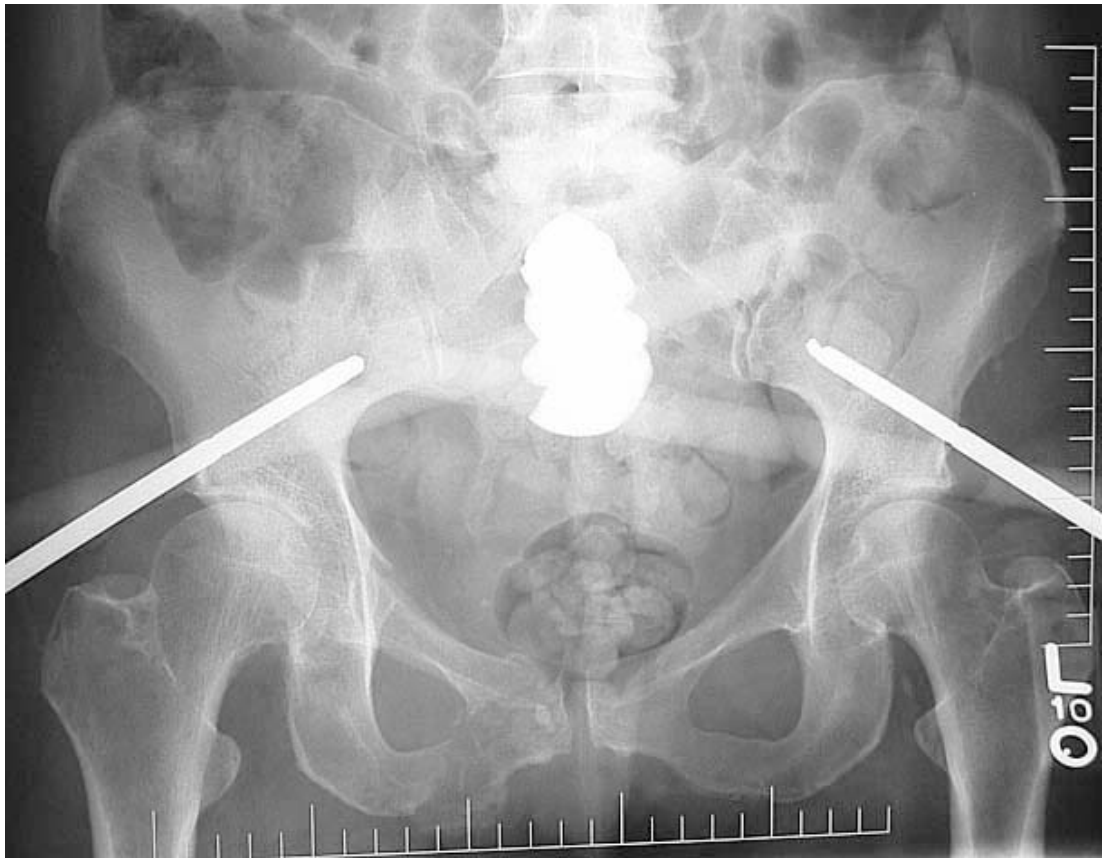


Tip: Localize with k-wire

Images courtesy of Sean Nork, MD

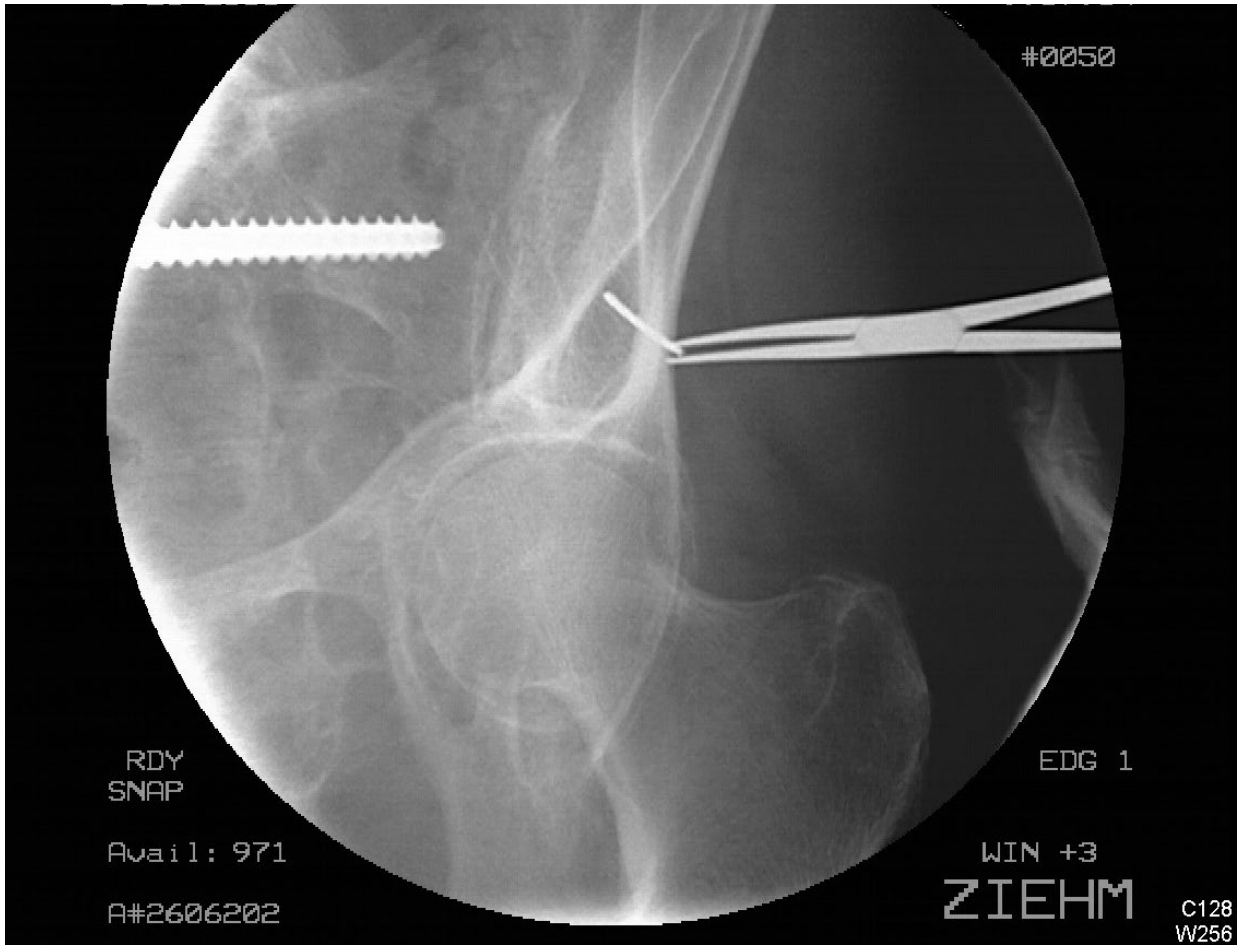
AIIS Technique

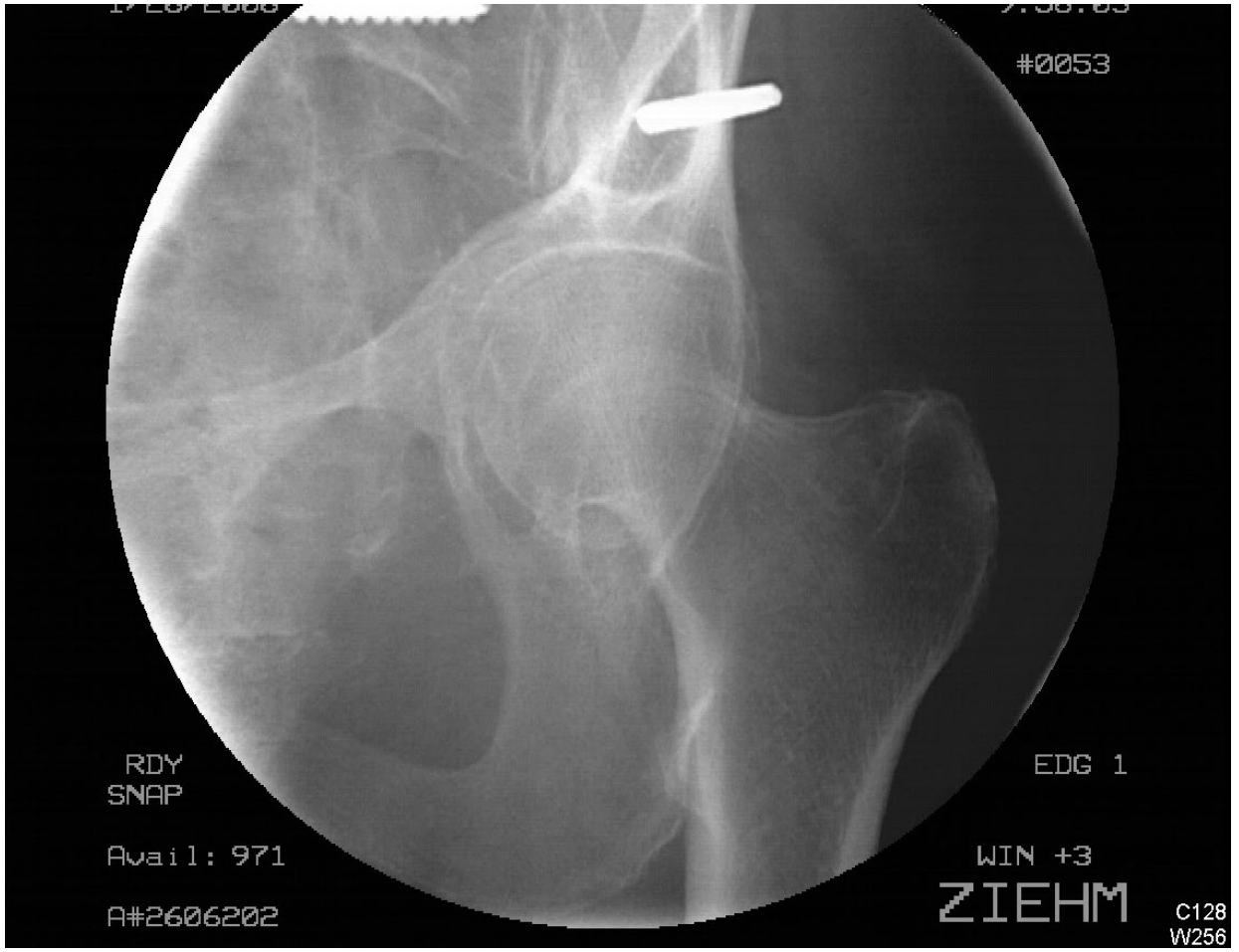
- Fluoro dependent
  - Obturator outlet oblique – entry and direction
  - Iliac oblique – positioning superior to sciatic notch
  - Obturator inlet – confirm depth
- Localize with k-wire
- Incision directed towards final position
- Blunt dissection down to AIIS
- Incisions directed toward final pin location
- Use fluoro views to direct path



Courtesy of Sean Nork, MD

AIIS Technique





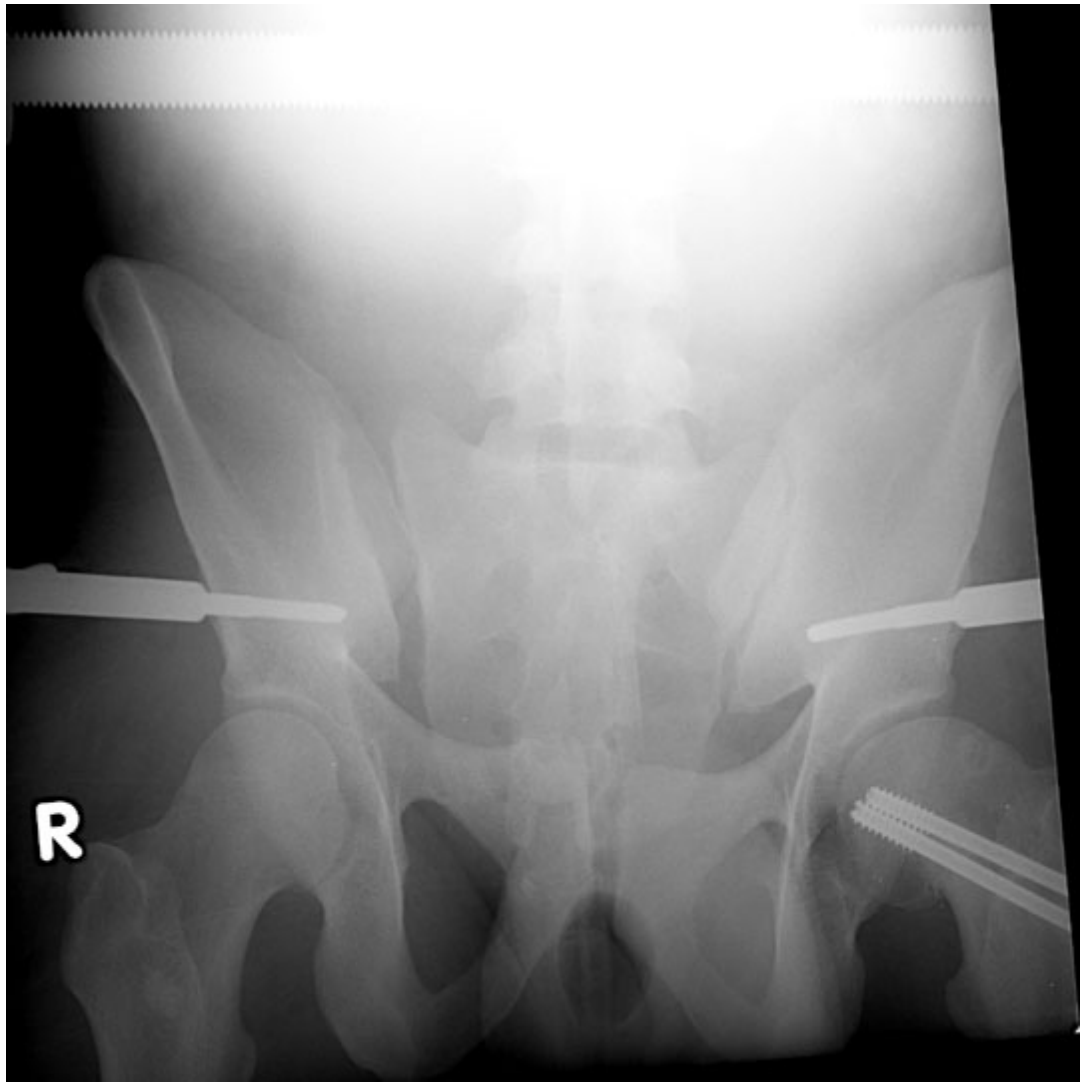
Images courtesy of Sean Nork, MD

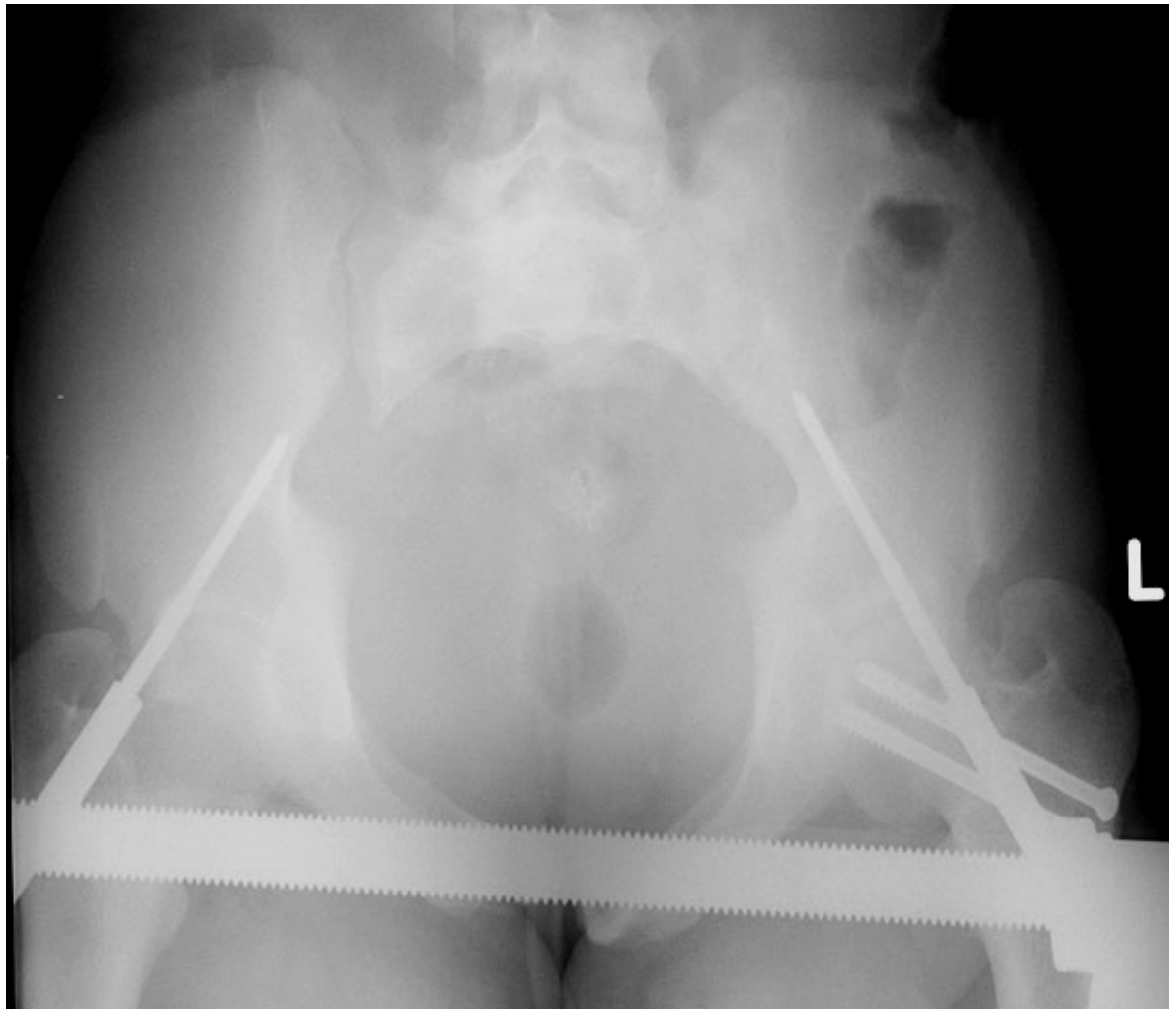
Outlet Obturator Oblique

Iliac Oblique

Obturator Inlet Oblique

Images courtesy of Sean Nork, MD





Images courtesy of Sean Nork, MD

AIIS Technique

Insert OTA video of supra-acetabular exfix placement

https://otaonline.org/video-library/45036/procedures-and-techniques/multimedia/16731357/percutaneous-supra-acetabular-external-pelvic

Anti-Shock C-Clamp

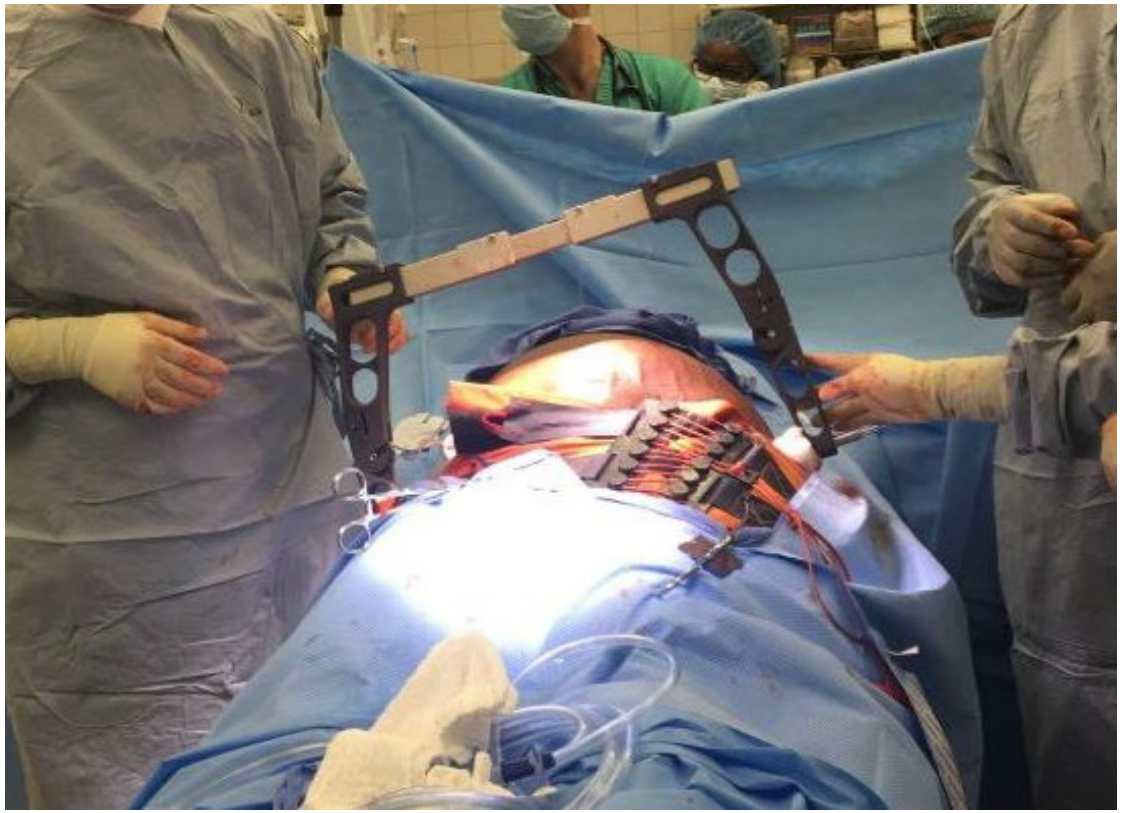
- Improved control of posterior pelvic ring
- Allows unrestricted abdominal access
- Recommend fluoro guidance for placement, although can be placed blindly if emergently indicated
- Pin placement on external iliac fossa
- Iatrogenic injury due to mal-positioning is concern

Courtesy of Sean Nork, MD

Anti-Shock C-Clamp

Images courtesy of Thomas Moore Jr, MD

Anti-Shock C-Clamp



Images courtesy of Thomas Moore Jr, MD

Pelvic Packing

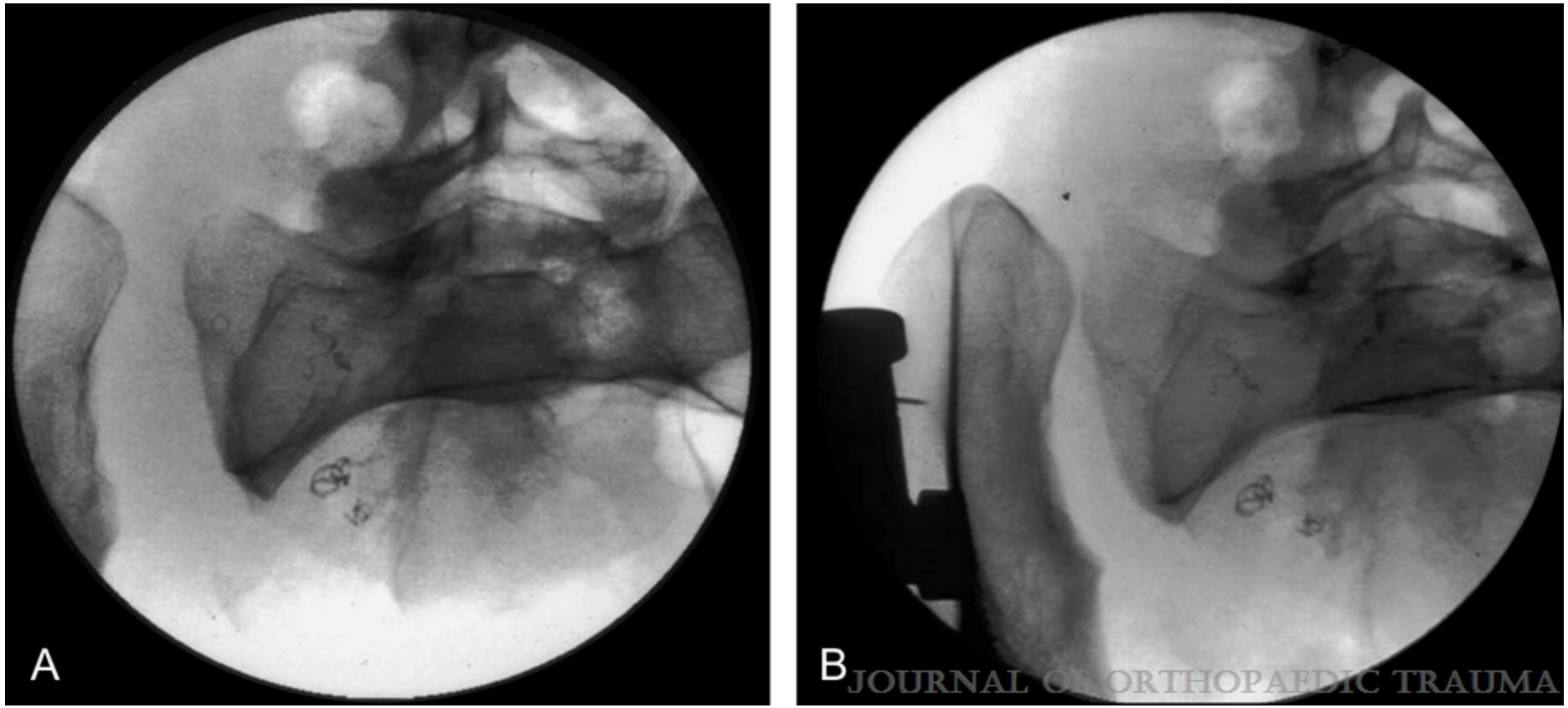
- Can be done in conjunction with ExLap
- To be effective, must have pelvic stability (ExFix or C-clamp)
- Limited centers perform this routinely in USA
- Pack in space of Retzius, paravesicular gutters, true pelvis

Courtesy of Sean Nork, MD

Resuscitative SI Screw Placement

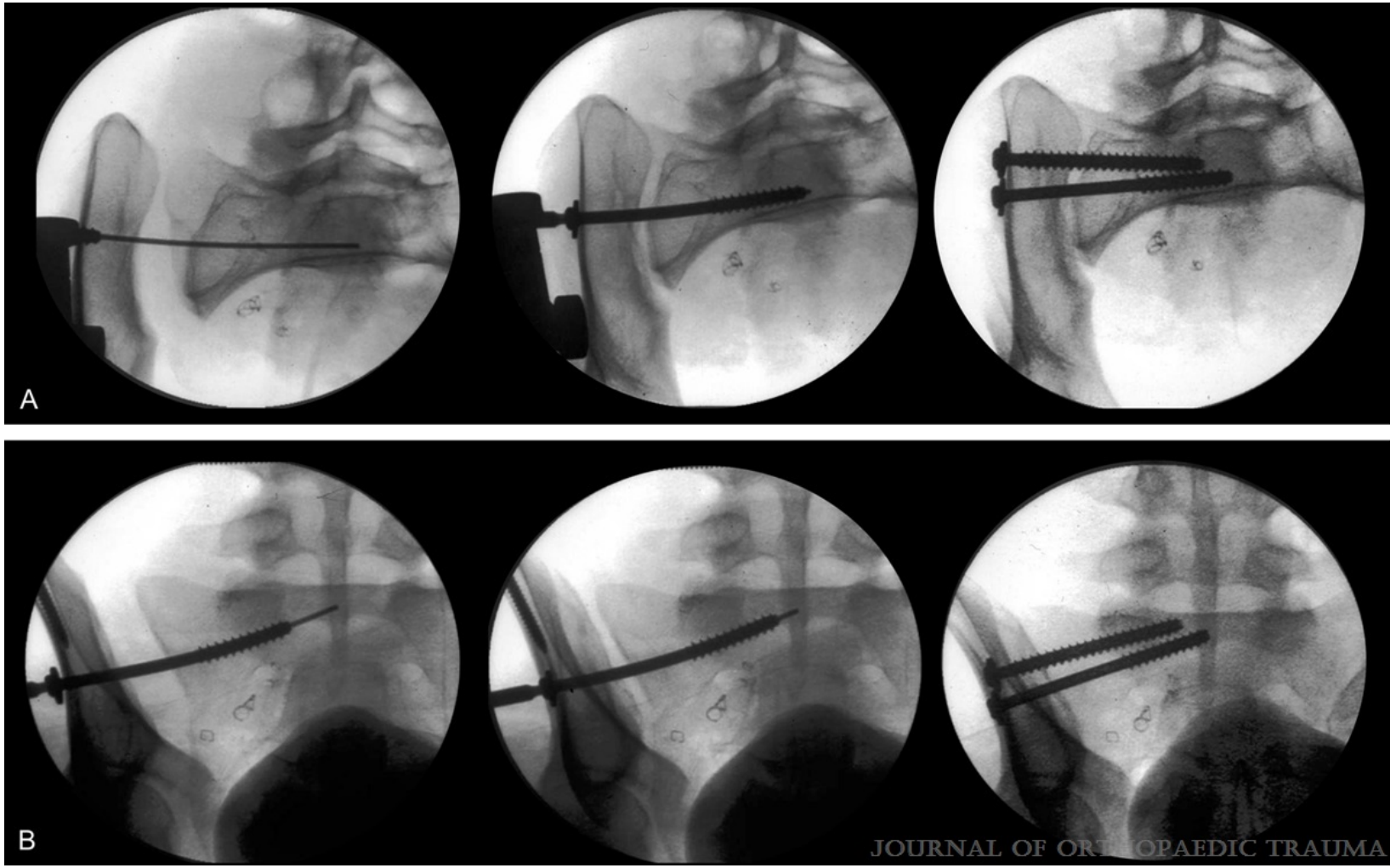
- As alternative to external fixation, c-clamp or binders, can emergently place SI screws to effectively reduce pelvic volume
- In experienced hands, can be done as quickly as other methods of stabilization

Resuscitative SI Screw Placement



Case example of patient with unstable pelvic fracture and pelvic hemorrhage. Both circumferential pelvic sheet and anterior pelvic compressor were ineffective in reducing the pelvis and controlling bleeding. Pelvic inlet fluoroscopic view demonstrates significant sacroiliac joint displacement (A). After placement of anterior pelvic compressor, reduction was improved but still inadequate (B).

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



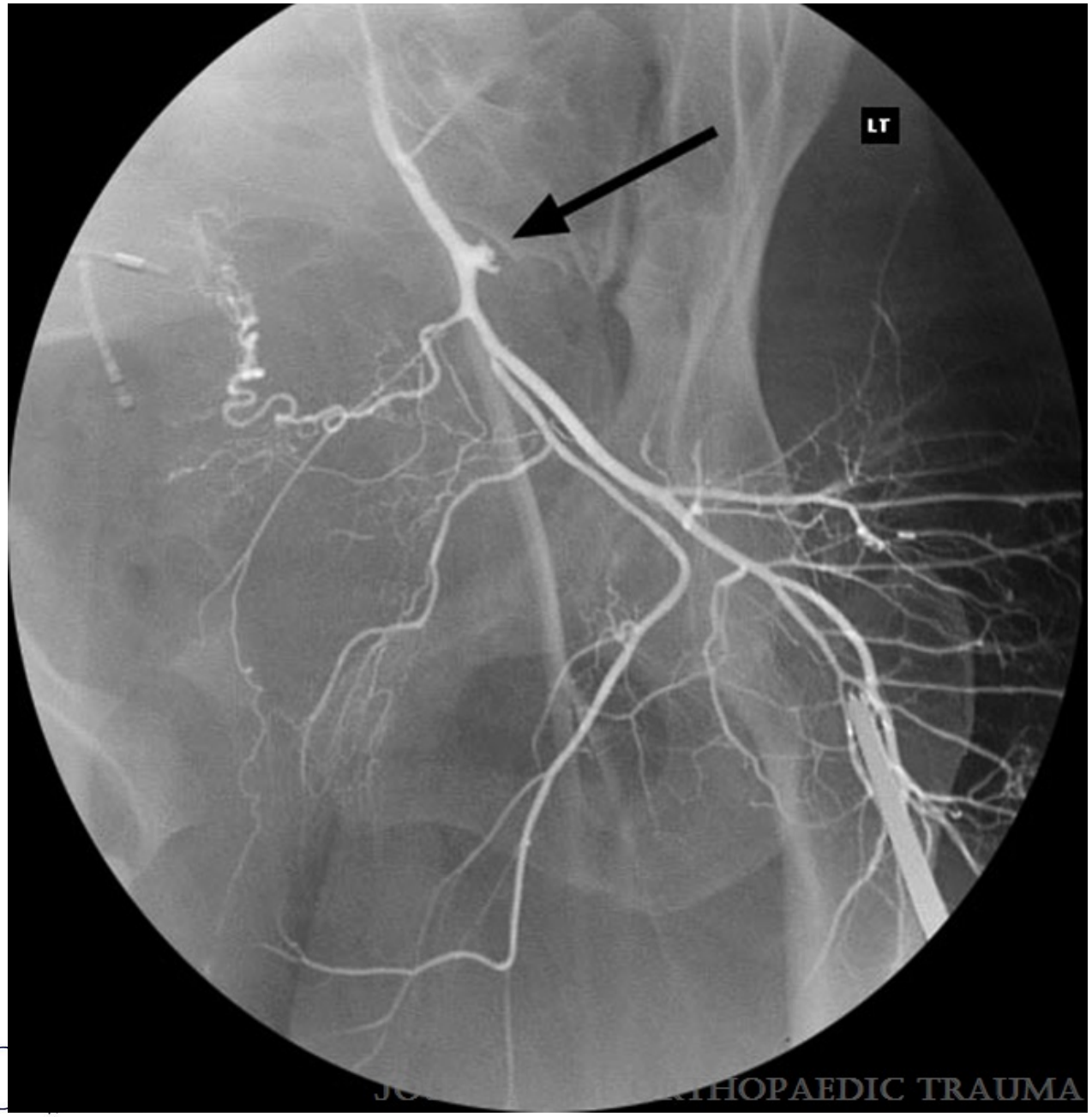
The patient underwent antishock iliosacral screw procedure to reduce wide sacroiliac diastasis, as seen on pelvic inlet view (row A) and pelvic outlet view (row B). Starting points and orientations of two screws were planned to allow balanced reduction of sacroiliac joint and safe screw placement.

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

Role of Angiography

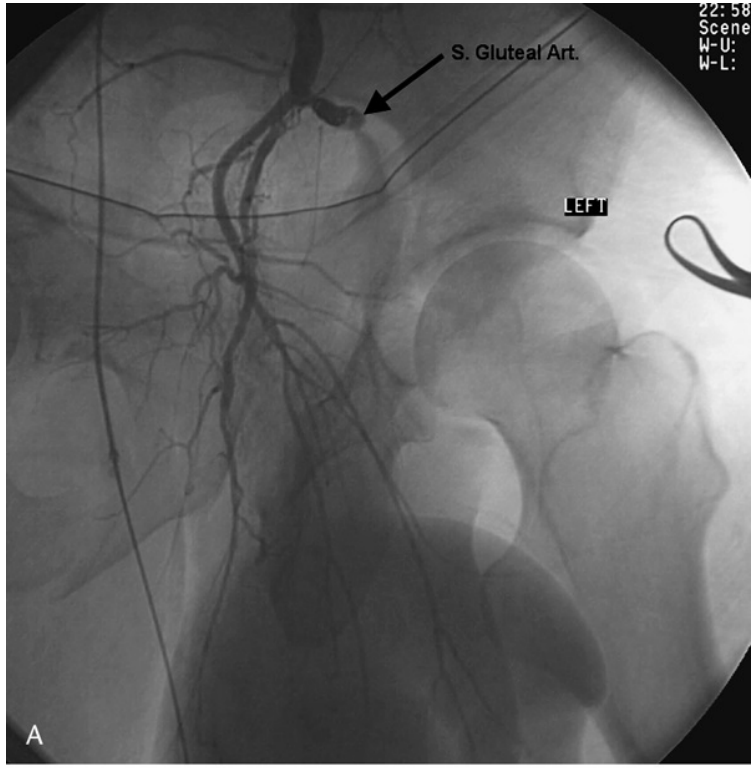
- Institution dependent, but trend toward more utilization
- Historic effectiveness questioned given pelvic bleeding more commonly venous
- Evidence supports angiography in the persistently unstable patient with pelvic fracture
- If CT shows contrast extravasation, proceed with angio

- Majority of arterial injuries involve internal iliac and its branches
  - Superior gluteal, internal pudendal, obturator



Emergent angiography demonstrated left superior gluteal artery disruption (arrow) and multiple areas of petechial bleeding.

Gardner MJ, et al. Percutaneous pelvic fixation using working portals in a circumferential pelvic antishock sheet. J Orthop Trauma, 23(9):668-674, October 2009.



A. Angiography shows that the most brisk bleeding is from the left superior gluteal artery.

B. Status postembolization, with coil in the superior gluteal artery (solid arrow). Bleeding also noted from anterior division of the internal iliac artery (dashed arrow).

Schaller TM, et al. Skin breakdown following circumferential pelvic antishock sheeting: a case report. J Orthop Trauma, 19(9):661-665, October 2005.

Role of Angiography

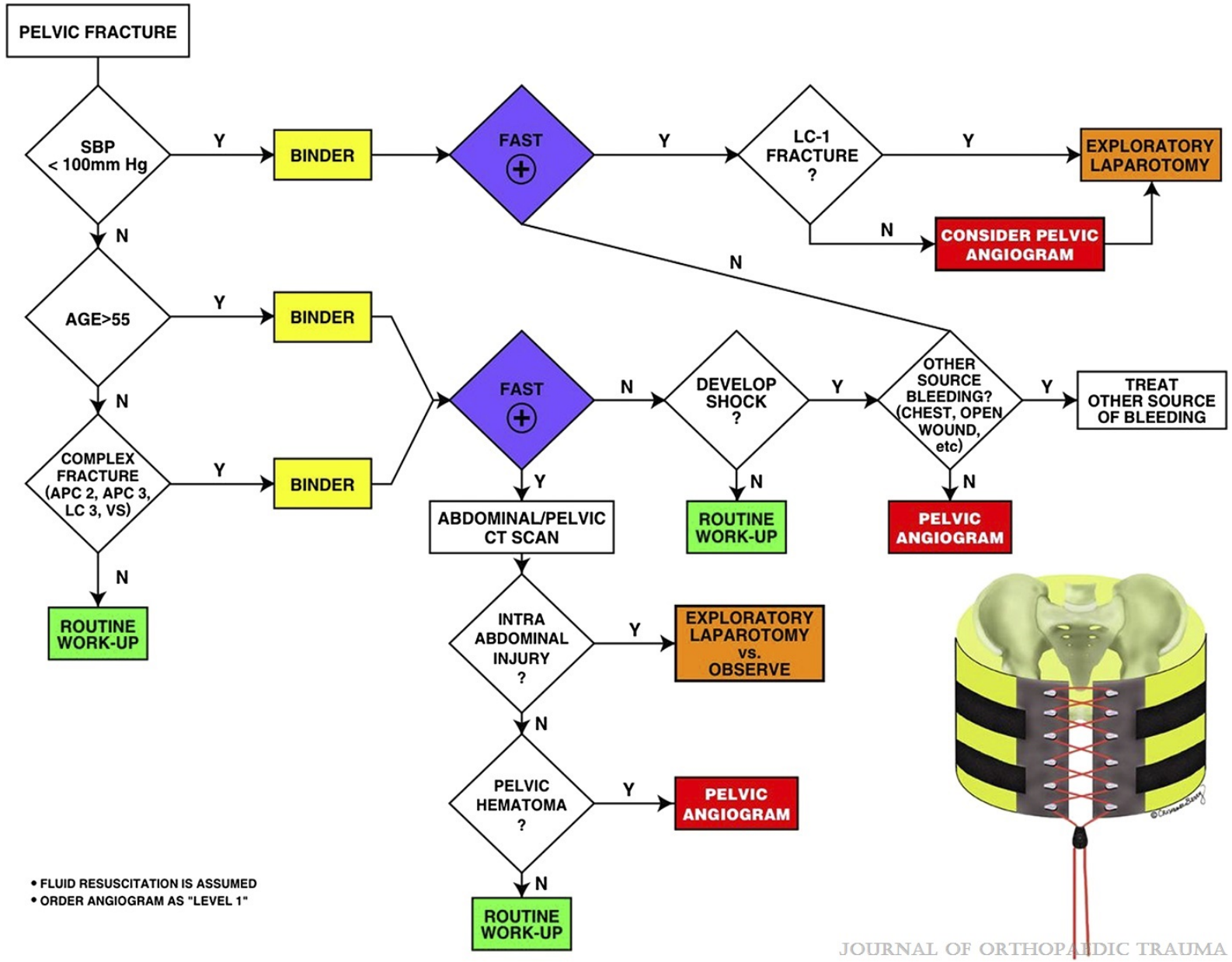
Hypotensive with stable fracture pattern

- **Look for other source of hemorrhage**
- **Proceed to laparotomy**

- **Hypotensive with unstable fracture pattern**
- **Transient responder after binder placement**
- **CT evidence of contrast extravasation**

- **Proceed to angio**

Example of a Successful Pelvic Hemorrhage Protocol



JOURNAL OF ORTHOPAEDIC TRAUMA

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.

A multidisciplinary approach at a Level 1 Trauma Center coordinated by trauma surgeons and orthopaedic traumatologists has resulted in improved patient survival.

- Improved protocols and system resources
- Reduced early deaths from exsanguination
- Reduced late deaths from multiple organ failure

Summary

- Understand fracture patterns and related anatomy
  - Combine knowledge of fracture, patient's condition, physical exam and available resources to determine next step in care
- Be prepared to intervene to stop hemorrhage
  - Use any method that is best suited for the patient, surgeon and institution
- Management of hemodynamically unstable pelvic ring patient is a multi-disciplinary event with coordinated care between services