Trauma to the pelvic ring: management in 2012

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Objectives

At the end of this presentation, the participant will comprehend:

- pelvic ring anatomy: osseous and soft tissue
- injury mechanisms and their impact on the pelvic ring
- management of acute bleeding in pelvic trauma
- The surgical approach to pelvic ring stabilization
- Outcomes following pelvic ring trauma
Trauma Room

- Intubated with good AE
- BP 90/40  HR 140  GCS 8
- No external bleeding
- Pelvis “mobile”
- Transient response to IV fluid bolus
- RBC transfusion started
Trauma Room

- CXR: normal
- FAST: normal
- AP pelvis
Fracture classification

A B C
B type: rotational instability

APC

LC
C type: vertical instability
Associated Injury - anatomic

Hemorrhage
Neurologic
Urologic
Gynecologic
Gastrointestinal
Soft Tissue
Associated Injury - mechanistic

**Lateral Compression:**
- Abdominal visceral injury
- Head injury
- Few pelvic vascular injuries

**AP Compression:**
- Urologic injury
- Hemorrhage/ pelvic vascular injury:
  - APC2-10%, APC3-22%
## Blood Replacement / Mortality vs Mechanism

<table>
<thead>
<tr>
<th>Mechanism</th>
<th>Units RBC</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral Compression</td>
<td>3.6</td>
<td>14%</td>
</tr>
<tr>
<td>Combined Mechanical</td>
<td>8.5</td>
<td>-</td>
</tr>
<tr>
<td>Vertical Shear</td>
<td>9.2</td>
<td>25%</td>
</tr>
<tr>
<td>AP Compression</td>
<td>14.8</td>
<td>25-37%</td>
</tr>
</tbody>
</table>

J Trauma Jul, 1990
Hemorrhage - Treatment

- Laparotomy with direct vessel ligation
- Pelvic Binder
- External Fixation/C-clamp
- Laparotomy with retroperitoneal packing
- Angiography/Embolization
- Acute ORIF pelvic ring
Options: Ex-Fix

Osseous Ex-fix

C- Clamp
Retroperitoneal Packing

Infraumbilical rectus splitting approach (midline or Pfannensteil)

Pack laps into
  space of Retzius
  Paravesicular gutters
  “Filling” the true pelvis

Requires bony stability
Angiographic Embolization

- Hypotension with normal pelvic volume
- Transient responders
- Persistent Hypotension
  - Fluid resuscitation
  - Mechanical Stabilization
CT extravasation
Value of “Contrast Sign”

Predictive value of a positive test: 80%
Predictive value of a negative test: 99%

Conclusion:
“CT contrast extravasation (CE) virtually always represents rapid arterial bleeding”
Kimbrell et al: Arch Surg 2004

- Angio 92 patients -> 55 (60%) embolizn
- Age > 60: 94% embolizn (vs 50%)
- 2/3 patients > 60 yo = norml BP @ admission
- Embolization -> 100% efficacy

Velmahos J Trauma 2002
Pelvic hemorrhage volume


pelvic hemorrhage volumes > 500cc on CT had 5 X RR of pelvic arterial injury

NB: bladder displacement
‘Posterior’ external fixation

‘C-clamp’

• posterior pins ilium
• rationale:
  – Improved posterior compression
Complications AE- OTA 2008

2 studies (45/ 88:

- acute renal failure: 9%
- gluteal necrosis 6-9%
- deep post-op wound inf 8-9%

* Increased risk with bilat IIA embolization
Treatment
Anterior vs posterior pelvic ring

ORIF anterior
ORIF posterior
Percutaneous SI screws

Ex-fix vs ORIF

Illustrator: Karl Wesker
LC- Crescent fracture
Outcomes
German Multi-center Trauma Registry

![Bar chart showing Neurologic Damage for Types A, B, and C with Type C having the highest moderate to severe cases.]

- Type A
- Type B
- Type C
German Multi-center Trauma Registry

Within 5mm residual displacement
German Multi-center Trauma Registry

Moderate to severe Pain

Type A
Type B
Type C
Complex

Pain
Neurologic Injury

IN C TYPE, UNSTABLE
40% nerve injury, continuing pain
Pelvic ring injuries. A long term functional outcome study


- **80 patients** treated with external fixation
- Seen at 5 yr f/u
- SF-36, IPS, Sexual function
- **25% impaired sexual function**
- No difference in outcome by Tile types or non-displaced vs displaced
Effect Of Trauma And Pelvic Fracture On Female Genitourinary, Sexual, And Reproductive Function

• Copeland et al; J Orthop Trauma. 1997 Feb-Mar;11(2):73-81

123 subjects with pelvic fx, 118 controls genitourinary symptoms; 21% fx vs 7% control

Dysparunia more common with residual displacement 43% vs 25%

Increased rate of C-section (48%)
Male Sexual Function After Pelvic Fracture

- Ozumba et al; Orthopedics. 2004 Mar;27(3):313-8

51 male pelvic fx patients interviewed 2 years post injury and compared to 53 men with ankle fx

Pelvic fx scored worse:
- Sex drive
- Erection
- Ejaculation
- Satisfaction
Specific Fracture Configurations Predict Sexual and Excretory Dysfunction in Men and Women 1 Year After Pelvic Fracture

• Wright, JL J Urol. 2006 Oct;176(4):1540-1545

1,160 eligible patients 292 (26%) had pelvic fractures

Sexual dysfunction was reported in 21% vs 14% of those with vs without pelvic fractures

Bowel or bladder incontinence was reported in 8% vs 4%
Post-Traumatic Stress Disorder after Orthopaedic Trauma


580 orthopaedic trauma outpatients
PTSD questionnaire

295 (51%) met criteria for PTSD
Summary

Pelvic anatomy is complex, involves osseous and soft tissue injuries.

Haemorrhage can be managed using multiple modalities.

Reduction and fixation tactic will depend on injury pattern.

Significant multisystem morbidity awaits a high percentage of patients.
Acute ORIF

- Rarely indicated
- Usually anterior ring
- Usually in combination with laparotomy
- Must facilitate, not hinder resuscitation
Results of Treatment of Pelvic Fractures

R.G. Wilber M.D.
Case School of Medicine
Metro Health Medical Center
University Hospitals of Cleveland
Confounding Variables

- Pelvic Instability
- Associated injuries
  - Head
  - Chest
  - Abdominal
  - Pelvic
Pelvic Stability

- Fixation pattern
- Late displacement
- Loss of fixation
- Residual deformity
Comprehensive Evaluation of Outcome?

- Reduction
- Pain
- Nerve injury
- RTW
- Sexual function
- Emotional health
pelvic fractures  surgery  emergency surgery

1998 - 2005

Johannes Reuger
Hamburg Trauma Registry
Pelvic Fractures: Frequency and Lethality

No Complex Pelvic Trauma

Complex Pelvic Trauma

Complex Pelvic Trauma: unstable

Hemipelvectomy

AG Becken / DGU & AO
1991-1993 n=1722
Thromboembolism

• Pelvic/Polytrauma
  61% distal veins
  29% pelvic veins
  Goerts 1994

• Isolated Pelvis
  12% distal veins
  White 1990

• Isolated Pelvis
  10% distal veins
  Gruen 1995

• Isolated Pelvis (MRI)
  24% thrombi
  45% pelvis
  Helfet 1995/1996

Pulmonary embolism
  2-10%

Lethal PE
  0.5-2%
Infections

- **Symphysis** 3-13% (Becker 1996, Pohlmann 1997)
  - 3.4% (AG-Becken 1998)
  - 12% (Hannover 1998)
  - 6% (Hannover 1998)

- **SI Joint anterior** 2-5% (Berner 1982, Laqnge 1985, Pohlmann 1997, Ragnarsson 1993)

Functional Outcome after Pelvic Fracture Non Operative Tx

• Huittinen, Slatis  Acta 1972
  – 65 patients treated nonoperatively
  – 30 Type C fracture patterns
  – Pelvic Obliquity 32%
  – Nerve Pain/Dysfunction 48%
  – Disabling LBP 17%
Functional Outcome after Pelvic Fracture Ex Fix Tx

• Kellam  CORR 1989
  – 53 patients treated with ExFix alone
  – 77% incidence of pain requiring analgesics with >1 cm residual displacement
  – Only 31% of type C fractures had subjective normal function
Functional Outcome after Pelvic Fracture

- Tornetta, Matta  CORR 1996
  - 23 patients with Tile B injuries and ORIF
  - <2 mm residual displacement
  - 22 no or min pain, no limitations and returned to work
Radiographic Versus Clinical Results

- Radiographic Result
- Clinical Result
POHLEMANN, T ET AL
INJURY 27 SUPP. 2 B 31-8, 1996

58 PATIENTS

TYPE B 79% G-EX.
TYPE C 27% G-EX.

IN SPITE OF 80% HEALED
WITH MINIMAL DEFORMITY
Functional Outcome of Open Reduction and Internal Fixation for Completely Unstable Pelvic Ring Fractures (Type C)

- Kabak et al; J Orthop Trauma • Volume 17, Number 8, September 2003 (Erciyes University, Kayseri, Turkey)

- Review of 40 patients with Tile C fractures (2 open)
  - 25 C1
  - 6 C2
  - 9 C3
- 7 associated nerve injuries
  - 2 L4-5
  - 3 L5-S1
  - 1 S1-S2
  - 1 S2-S4
Functional Outcome of Open Reduction and Internal Fixation for Completely Unstable Pelvic Ring Fractures (Type C)

- Kabak et al; J Orthop Trauma • Volume 17, Number 8, September 2003
- 2 ARDS
- 2 DVT
- 2 Pneumonia
- 2 Sacral decubitus
- 2 Deaths
  - PE
  - Sepsis in open pelvic fx
Functional Outcome of Open Reduction and Internal Fixation for Completely Unstable Pelvic Ring Fractures (Type C)

- Kabak et al; J Orthop Trauma • Volume 17, Number 8, September 2003
- Review of 40 patients with Tile C fractures (2 open)
  - Anterior and posterior pelvic fixation
    - 30 anterior ORIF
    - 5 perc SI screws
    - 3 prone sacral bars
    - 2 SI screws + sacral bar
Functional Outcome of Open Reduction and Internal Fixation for Completely Unstable Pelvic Ring Fractures (Type C)

- Kabak et al; J Orthop Trauma • Volume 17, Number 8, September 2003
- Anterior approaches
  - 7 superficial infections (23%)
- Posterior sacral bar + SI screw fixation fixation (100%) - all had skin contusion
  - 3 deep infections
  - 2 superficial infection
Functional Outcome of Open Reduction and Internal Fixation for Completely Unstable Pelvic Ring Fractures (Type C)

• Kabak et al; J Orthop Trauma • Volume 17, Number 8, September 2003

• Anterior approaches
  – 2 iatrogenic L5 nerve palsies (7%) both recovered
• 11/36 (31%) had pain @ 12 mo
• Unable to correlate displacement with pain

<table>
<thead>
<tr>
<th>TABLE 2. Correlation of Pain with Posterior Pelvic Displacement</th>
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<tbody>
<tr>
<td>Posterior Pelvic Displacement</td>
</tr>
<tr>
<td>-------------------------------</td>
</tr>
<tr>
<td>Initial displacement</td>
</tr>
<tr>
<td>≥15 mm</td>
</tr>
<tr>
<td>Pelvic pain</td>
</tr>
<tr>
<td>No pelvic pain</td>
</tr>
<tr>
<td>&lt;15 mm</td>
</tr>
<tr>
<td>Pelvic pain</td>
</tr>
<tr>
<td>No pelvic pain</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Pelvic pain</td>
</tr>
<tr>
<td>No pelvic pain</td>
</tr>
<tr>
<td>After reduction</td>
</tr>
<tr>
<td>Reduction excellent (&lt;4 mm)</td>
</tr>
<tr>
<td>Pelvic pain</td>
</tr>
<tr>
<td>No pelvic pain</td>
</tr>
<tr>
<td>Reduction good (4–10 mm)</td>
</tr>
<tr>
<td>Pelvic pain</td>
</tr>
<tr>
<td>No pelvic pain</td>
</tr>
<tr>
<td>Reduction fair (10–20 mm)</td>
</tr>
<tr>
<td>Pelvic pain</td>
</tr>
<tr>
<td>No pelvic pain</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Pelvic pain</td>
</tr>
<tr>
<td>No pelvic pain</td>
</tr>
</tbody>
</table>

*Only 36 patients were evaluated due to 2 deaths and 2 lost to follow-up.
Functional Outcome of Open Reduction and Internal Fixation for Completely Unstable Pelvic Ring Fractures (Type C)

- Kabak et al; J Orthop Trauma • Volume 17, Number 8, September 2003
- 14/32 (43%) had sexual dysfunction
  - Correlated with anxiety and depression
- Pain was inversely related to RTW
- 26/36 returned to original job
  - 2 retired secondary to pain
  - 3 worked part time
Neurological Damage In Pelvic Injuries: A Continuous Series Of 50 Pelvic Injuries Treated With An Iliosacral Screw

- Tonetti et al; Rev Chir orthop Reparatrice Appar Mot. Apr;90 (2):122-31
- 44 patients with 50 injuries
- 52% neurological injury, permanent deficits in 22%
- 13/50 screws extra-osseous (26%)
- 7/44 iatrogenic nerve injuries (16%)
“Implant Failures” or Secondary Loosening

- Pelvic B/C 13.6% (0 with ant/post fixation)
  Lange Hansen 1985
- Anterior SI Plates 1/29 screw breakage
  Ragnarsson 1993
- SI screws 1/11 displacement
  Ward 1987
- SI screws 1/15 loosening
  Moore 1995
- SI screws 1/36 loosening
  Tosounides 2004
Vertical shear injuries: is there a relationship between residual displacement and functional outcome?

- Nepola et al; J Trauma. 1999 Jun;46(6):1024-9
- 33 patients with Tile C VS injuries reviewed
- SF-36, IPS
- Pelvic injuries showed no correlation between functional outcome and residual vertical displacement
Vertically Unstable Pelvic Fractures Fixed with Percutaneous Iliosacral Screws: Does Posterior Injury Predict Fixation Failure?

- Griffin et al; J ORTHO TRAUMA 2003; 17:399-405
- Compared 32 dislocations of SI joint to 30 vertical sacral fractures
- All repaired with closed reduction and percutaneous iliosacral screw fixation
- Failure rate:
  - 4 / 30 (14%) vertical sacral fractures displaced
  - 0 / 32 SI joint dislocations displaced
Outcomes of Open Pelvic Fractures: Brennerman et al, J Trauma, 1997

• 44 patients, 4% of all PF 1987-95
• average age 30
• greater
  – boney injury
  – transfusion requirements
• 27/44 survivors >4 years
• chronic disability, pain, employment opportunity loss
Complications Associated With Surgical Stabilization Of High-grade Sacral Fracture Dislocations With Spino-pelvic Instability

- Bellabarba C
- Spine. 2006 May 15;3
- Review of 19 patients with sacral fracture dislocations and cauda equina
- Surgical decompression
- Spino-pelvic fixation
Complications Associated With Surgical Stabilization Of High-grade Sacral Fracture Dislocations With Spino-pelvic Instability

- Bellabarba C
- Spine. 2006 May 15;3
- 74% dural tear or nerve root avulsion
- Wound “disturbances” in 26%
- No chronic infections
- Fixation fracture in 31%
- 1 year f/u pain VAS avg 5.5
Summary

- Severely injured patients
- High incidence of long term disability and pain which increases with severity
- Frequently associated with stress disorder and sexual dysfunction
- Generally difficult to get them back to work
REDUCTION SEQUENCE
REDUCTION SEQUENCE
Type of Fixation is changing with screws becoming more popular and familiar
Vaginal Injuries

I&D in the OR

And early repair of vaginal lacerations
Rectal Wounds

- Rectal wounds:
  - Divert or repair
  - If they get diverted don’t forget the distal segment washout
Role of a Colostomy

Earlier studies recommended an early colostomy for all wounds to decrease pelvic sepsis and mortality

- Now moving towards more selective use:
  - Selective diversion for wounds very close to the pooper
  - Do it early
  - Do not accept continuous poop in the wound
Pelvic Stability

- Fixation pattern
- Late displacement
- Loss of fixation
- Residual deformity
Neurologic Injury

POHLEMANN
MATTA
TORNETTA
MOED
SCHIED & TILE

etc, etc, etc

IN C TYPE, UNSTABLE
40% nerve injury, continuing pain
Vertically Unstable Pelvic Fractures Fixed with Percutaneous Iliosacral Screws: Does Posterior Injury Predict Fixation Failure?

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Anterior-Posterior Compression
Lateral Compression
Vertical Shear
Goal:
Identify the 10% that require embolization
First post-op X-ray 6 weeks later
Fixation of pelvic ring

Generalizations

- Majority *do not* require ORIF
- Rarely indicated emergently
- Joint dislocations *do* require fixation
- If unstable:
  - Necessary to determine if anterior ring, posterior ring or both require stabilization.
Fixation of pelvic ring

Generalizations

• If deemed necessary, Rotational injuries can be stabilized in the majority of cases with anterior or posterior fixation, less commonly both

• Globally unstable fractures can be treated with only posterior fixation
  – Anterior fixation indicated with symphysis dislocation, others may be relative
Anterior Ring Fixation

Generalizations

- Definitive treatment
  - Rotationally unstable injury (Type B)
  - Esp. ER injuries (APC II)
- Adjunctive fixation
  - Globally unstable injury (Type C)
  *May facilitate posterior reduction in rare circumstances
B Type Fractures

• External Rotation Injuries
  – “Open Book” Injury (B1)

• Internal Rotation Injuries
  – “Lateral Compression” (B2-1, B2-2)
• Tile:
  - Added concept of stability
    • Rotational
    • Vertical
Anteroposterior Compression Fracture of Pelvis
(Open Book Fracture)

Forceful frontal impact causes anteroposterior compression of pelvis.
APC Injuries

• Associated injuries:
  – Brain, abdominal, visceral, pelvic vascular injury
• Death usually from hemorrhage from visceral and pelvic vascular injuries
• Vertical anterior fracture lines
APC1

- Symphysis widened 1-2 cm
- Posterior ligaments intact
- Usually rx'd nonop
- Pelvic vascular injury= 6.5%
APC 1
APC II

- > 2.5 cm diastasis
- ST, ST, anterior SI ligaments disrupted
- Posterior SI ligaments intact
- Rotationally unstable, vertically stable
APC 2
APC 2

- Internal iliac vessels stretched and at risk for injury
- Emergent ex fix for hemodynamic instability
- Definitive rx with anterior plate only or ex fix
- 10% vascular injury
APC3

- Complete disruption of ligaments
- No vertical displacement (seen in VS)
- Common in pedestrians
- Greatest 24 hour fluid requirement
APC III

- Emergent ex fix for hemodynamic instability
- Definitive fixation: anterior and posterior fixation
- 22% pelvic vascular injury
- Lap: 20%
- Mortality: 20%
APC 3
Lateral Compression
Lateral Compression Injury (Overlapping Pelvis)

Caused by forceful blow to side of pelvis.
LC injuries

- Horizontal anterior fracture lines
- High incidence of brain and abdominal injuries
- Death: usually brain injury
LC1

- Sacral impaction
- Usually treated nonop
LC1

- Posterior vessels are shortened
- Anterior branches @ risk
LC2

- Crescent fracture of the iliac wing
- Definitive rx with ORIF
- Pelvic vascular injury: 8%
LC3

- "Roll over" injury
- LC1 or LC2 on the side of impact
- Contralateral APC injury
- Pelvic vascular injury: 23%
Vertical Shear

Vertical Shear Fracture (Malgaigne Fracture)
VS

- Associated injuries- similar to LC
- Vertical and rotationally unstable
- Vertical displacement- differentiates from an APC3
- Usually results from a fall from a height
Vertical Shear

- Emergent ex fix for hemodynamic instability
- Definitive rx- anterior and posterior ORIF
- Pelvic vascular injury- 10%
Anterior External Fixation

- Indications:
  - APC2
  - APC3
  - LC2
  - LC3
  - Vertical shear
Posterior External Fixation: C Clamp

- Pins placed at level of SI joint
  - ? increased posterior stability/compression
  - ? quicker
  - ?easier:
    - sciatic notch
    - into abdomen through iliac wing
Posterior External Fixation

- **Contraindication:**
  - iliac wing fracture

- **Complications:**
  - Intra-abdominal pins
  - Intra-articular pins
  - Sciatic notch
Internal Rotation Injury

• **Anterior Ring**
  - Rami fractures
  - Locked Symphysis Dislocation

• **Posterior Ring**
  - Sacral fracture
  - SI fx-dislocation
Internal Rotation Injury Treatment

- Majority Nonoperative
- Occasionally Anterior Ring treated operatively to correct deformity
- Sacral fractures treated non-operatively
- SI fracture-dislocation consider operative stabilization
C Type Injuries

- Iliac Fractures
- Sacroiliac Dislocations
- Sacroiliac Fracture-Dislocations
- Sacral Fractures
C Type Injuries

- Reduction and stabilization of posterior ring
- Anterior ring based on the location
Next Step?

• External fixation

• OR for Ex- Fix plus pelvic packing

• Angiographic embolization
Does External Fixation Work?

Acute mortality associated with injuries to the pelvic ring: the role of early patient mobilization and external fixation.

Riemer J Trauma 1993

Mortality: 41% → 21%

“Orthopedic stabilization of major skeletal injuries should be viewed as part of patient resuscitation, not reconstruction.”
**Does External Fixation Work?**

**Volume changes within the true pelvis during disruption of the pelvic ring--where does the haemorrhage go?**

Moss Injury 1996

"Our finding was that the increase in the volume of the true pelvis which occurs in a fracture with massive diastasis is much smaller than previously assumed."
Does External Fixation Work?

- Does **not** tamponade RP bleed

Grimm
J Trauma 1998
Mar;44(3)
Does External Fixation Work?

Mortality in retroperitoneal hematoma.

J Trauma 1984

43%

57%
Does External Fixation Work?

Skeletal Deformity Following External Fixation of the Pelvis

“The authors found 67% of the patients had worsening of the deformity posteriorly.”

Matta
American Academy of Orthopaedic Surgeons
1998 Annual Meeting - Scientific Program
What Will Ex-Fix Accomplish?

**Bleeding control:**

- Cancellous bone surface
  - 
- Venous plexus
  - 
- Arterial rupture
  - ✗
What fracture types need it in the acute setting?

“Indications”:

- LC2
- LC3
- APC2
- APC3
- Vertical shear
Is Fracture Pattern Predictive of Arterial Injury?

Poster #36 - Therapeutic Embolisation of Major Pelvic Fractures

Keating OTA 1997

"The fracture morphology was not a reliable guide to the associated vascular injury".
How long and where to apply?

• ER or OR?

• 20 mins / 45 mins / 60 mins?
Arterial Bleeding - Clues to its Presence

Early Detection of Arterial Bleeding in Acute Pelvic Trauma
Stephen JT 1999

Sens = 80%
Spec = 98%
+ Likelihood ratio = 40.4
Arterial Bleeding - Clues to its Presence

External Fixation or Arteriogram in Bleeding Pelvic Fracture: Initial Therapy Guided by Markers of Arterial Hemorrhage

Miller J T 2003

Non-Response to initial resuscitation

Sens = 100%
Spec = 30%

(44% +ve angio had fractures amenable to EF)
Angiographic Embolization?
Is Angiographic Embolization Effective and Safe?

100 patients: 65 pelvic fx and 35 organ injury
Prospective study
Ongoing bleeding post-op; slow continuous bleeding in non-op.

Efficacy: 95%
Safety: 94%

Velmahos JT 2002
Pelvis Fracture → Complete Evaluation Including CT Scan

→ Hypotension

→ Wrap Pelvis with Sheet/Binder

Ultrasound/Diagnostic Peritoneal Lavage

Grossly Positive

→ Laparotomy (with EX-FIX if amenable fracture)

→ Stable

Yes

→ ICU

No

→ Angiography

Grossly Negative

→ Sustained Response to Initial Resuscitation?

*Yes

→ Fracture Amenable to EX-FIX?

Yes

→ EX-FIX

No

→ ICU

→ Angiography

No (Arterial Bleeding Likely)

→ Angiography

*Scanning evaluation including computed tomography may also be done at this time.
Conclusion

- External fixation should still be used in the resuscitation phase in PF with HD instability
- Sheets / binders should be used first
- Non-response suggests arterial bleeding and requires angiographic embolization
- Formal external fixation for definitive treatment of pelvic injury
Thank You