Controversies in Orthopaedic Trauma Surgery

Eric G. Meinberg, MD
Associate Clinical Professor
UCSF/SFGH Orthopaedic Trauma Institute

Management of Hemodynamically Unstable Pelvic Fractures

Low-energy Fractures

• Fall from standing height
  – Simple fracture patterns
  – Stable
  – Conservative treatment
High-energy Fractures

• Associated with significant problems
  – 75% abdominal or pelvic hemorrhage
  – 12% urogenital injury
  – 8% lumbosacral fracture
  – 60 – 80% associated fractures
  – 12-25% mortality

Lateral Compression

LC-3
• ‘Windswept pelvis’
• External rotation and disruption of contralateral hemipelvis
• Rollover or crush
  • Unstable

AP Compression

APC-1
• <2.5 cm symphysis disruption
• Ramus fractures
• No posterior injury
  • Stable

AP Compression

APC-2
• >2.5 cm diastasis
• Opening of SI joint
• Floor ligaments torn
  • Rotationally unstable
  • Vertically stable
### AP Compression

**APC-3**
- >2.5 cm symphysis disruption
- Complete rupture of posterior ligaments
- Rotationally and vertically unstable

### Vertical Shear

- Fall from height
- Significant vertical forces
- Anterior and posterior vertical displacement
- Unstable

### Combined Mechanism

- Combination of multiple mechanisms
- Significant associated injuries
- Majority are LC-2 and VS
- Unstable

### Associated Injuries

**AP compression**
- Pelvic floor disruption
- Intra-pelvic and retroperitoneal vascular injuries
- Shock, sepsis, ARDS, death
- 20% mortality

**Lateral compression**
- Pelvic floor is intact
- Decreased intra-pelvic bleeding
- Brain and visceral injuries
- 7% mortality
Immediate Management

- In the field or trauma bay
- Pelvic binder or bedsheets
- Apply around greater trochanters
- Maintains continuous reduction until fixator applied (up to 72h safe)
- May be left on in OR for other procedures
Proper Placement?

- Works like a sheet
- Easy to place by emergency staff
- Less likely to be overtightened
- Low risk of skin necrosis
- Looks ‘official’

Pelvic Binder

- Fast and effective way of pelvic stabilization
- Re-establishes pelvic ring and decreases intrapelvic volume
- Decreases hemorrhage by tamponade, reapproximating fracture edges, decreasing motion

External Fixation

- Temporary fixation of posterior instability and widening
- Act as temporary SI screws
- Applied bedside or OR
- Allows access to abdomen and patient
- Only emergent method to adequately stabilize posterior displacement

C-Clamp
C-Clamp Application

C-Clamp Considerations

- Not readily available
- Requires c-arm guidance for placement
- Contraindicated in ilium fractures
- May over-compress sacrum fractures
- Sciatic nerve, gluteal artery injury reported

Extraperitoneal Pelvic Packing

- Rationale:
  - Only treatment to control bleeding from venous plexus
  - Controls arterial bleeding
  - Enables control of large vessel bleeding
  - Simultaneous treatment of associated abdominal trauma
- Performed after reduction of pelvic volume with fixator
The Case for Pelvic Packing

• 20 patients with pelvic disruption
• Mean ISS 41.2
• C-clamp applied in the ER
• Lactate q30 min.
• Pelvic packing for persistent bleeding (non decreasing lactate)

The Case for Pelvic Packing

• Pelvic packing in 14
• 4 patients died (20%)
• Lactate levels predicted mortality

Preperitoneal Pelvic Packing for Hemodynamically Unstable Pelvic Fractures: A Paradigm Shift

Cothren, Osborn, Moore, Morgan, Johnson, Smith, MD

The Journal of TRAUMA 2007

Transfusion requirements Pre – packing compared with subsequent 24 hrs were significantly less (12 versus 6; p 0.006)
Preperitoneal Pelvic Packing for Hemodynamically Unstable Pelvic Fractures: A Paradigm Shift

Cothren, Osborn, Moore, Morgan, Johnson, Smith, MD

The Journal of TRAUMA  2007

25% Mortality

Institutional Protocols

- Biffi et al: J Orthop Trauma 2001
- Evolution of a multidisciplinary clinical pathway for the management of unstable patients with pelvic fractures

<table>
<thead>
<tr>
<th>Problem</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>31% → 15%</td>
</tr>
<tr>
<td>Death by exsanguination</td>
<td>1%</td>
</tr>
<tr>
<td>Multi-organ failure</td>
<td>12% → 1%</td>
</tr>
<tr>
<td>Death within 24h</td>
<td>16% → 5%</td>
</tr>
</tbody>
</table>
Institutional Protocols

- ATLS - identify pelvis as source
- Temporary pelvic volume reduction
- Acute external fixation +/- traction
- Laparotomy +/- pelvic packing
- Pelvic angiography & embolization

Who should get angiography?

- Concerns:
  - Venous and fracture (cancellous bone) bleeding account for >90%
  - Arterial bleeding accounts for <10%

Case 1

- 30 year old male
- 1 hour after motorcycle accident
- Initial vital signs:
  - Blood pressure 100/60
  - Heart rate 100
  - Respiratory rate 40
- Acute abdomen, and.....
Emergent laparotomy, ex fix, packing

Classic Indication

- Persistent shock despite treatment

Ongoing ‘Shock’
Case 2

- 70 year old female
- Struck by car
- Initial responder but ongoing low blood pressure
- Only injury...........

Initial treatment

- No need for binder
- Skeletal traction leg
- Transfusion 4 units packed cells and 6L crystalloid first 4hrs

Classic Indications

- Persistent shock despite treatment
- Shock with normal pelvic volume
Ongoing hypotension

9 hours post injury:
- Successful angiographic embolization of obturator artery

‘Clues’ re: need for angio
- transfusion requirements
- contrast extravasation (CE)
- age ≥ 60
- bladder displacement
  - ‘pelvic hemorrhage volume’

Extravasation
- Identification of ‘extravasation’ on contrast CT that correlated with angiographic findings

‘Clues’ re: need for angio
- transfusion requirements
- contrast extravasation (CE)
- age ≥ 60
- bladder displacement
  - ‘pelvic hemorrhage volume’
Age

Kimrell et al: Arch Surg 2004
• angio 92 patients -> 55 (60%) embolization
• age > 60: 94% embolization (vs 50%)
• 2/3 patients > 60 yo = normal BP @ admission
• embolization -> 100% efficacy

Velmahos J Trauma 2002

‘Clues’ re: need for angio

• transfusion requirements
• contrast extravasation (CE)
• age > 60
• bladder displacement
  – ‘pelvic hemorrhage volume’
Angiography/ embolization

- Should be used in a protocol
  - Frequency ≈10%
- Indications
  - ‘clues’
- Avoid bilateral internal iliac a. embolization
- Associated risks:
  - acute renal failure
  - gluteal muscle necrosis
  - deep infection

Damage Control Orthopaedics (DCO)

60’s to 80’s
“The patient is too sick to have surgery”

80’s to the 90’s
“Patient is too sick NOT to have surgery”

- Riska 1976
- Goris 1982
- Meek 1986
- Bone 1989
“Origins of “damage control”

“... temporary stabilization of fractures soon after injury, minimizing the operative time, and preventing heat and blood loss.”

- In severely injured patients, initial orthopaedic surgery should not be definitive treatment
- Definitive treatment delayed until after patients overall physiology improves


Damage Control

- Decompression of body cavities
- Bleeding control
- Repair of hollow viscus injuries
- Stabilization of central fractures
  - Pelvis
  - Femur

Decision Making Must Focus on the Patient as a “Whole”
Orthopaedic Damage Control

- Avoid worsening the patients condition by a major orthopaedic procedure (“2nd Hit”)

ARDS and Multiple Organ Failure

- Cascade of inflammatory reactions
- Exaggerated systemic inflammatory response syndrome (SIRS)
- ARDS and Multiple Organ Failure (MOF)

ARDS and Multiple Organ Failure

- 20 years of data at the Hannover Trauma Center suggest that patients who underwent a major (> 3 hour) operation on PTD 3 – 5 had increased mortality
- Secondary surgical procedure acted as a “second hit”, exacerbating the primed systemic inflammatory response

No Severe Pulmonary Injury

- In patients without severe chest trauma
  - Early IM nailing reduced the length of ICU stay (7.3 days vs. 18.0 days)
  - Reduced the length of intubation (5.5 days vs. 11.0 days)
- In the absence of severe chest trauma primary IM femoral nailing is beneficial

Severe Pulmonary Injury

- In patients with severe chest trauma when IM nailing was performed in the first 24 hours
  - Higher incidence of posttraumatic ARDS (33% vs. 7.7%)
  - Higher mortality (21% vs. 4%)


Treatment Protocol

Temporary External Fixation

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Mean OR Time</th>
<th>Mean Blood Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Fixation</td>
<td>35 min</td>
<td>90 cc</td>
</tr>
<tr>
<td>Reamed Femoral Nail</td>
<td>135 min</td>
<td>400 cc</td>
</tr>
</tbody>
</table>


Temporary External Fixation

- 1.7% infection rate
- One stage conversion considered safe
  - Ex fix on for short time (< 2 weeks)
  - No signs of pin site or systemic infection
  - No loosening of pins

Conclusion: Timing of 2nd Definitive Surgery

- Avoid days 2–4 after injury
- Inflammatory system primed for an exaggerated response
- Wait until day 7 or later

Open Fractures

- Classification
- ER management
  - Wound
  - Antibiotics
- Operative management
  - Debridement
  - Fixation
  - Wound management

Why differentiate?

- Increased infection risk
- Increased healing complications (bone & soft tissue)
Why differentiate?

- Increased infection risk
- Increased healing complications (bone & soft tissue)

Classification

- Attempt to quantify energy imparted—*prognostic*
  - Contamination
  - Deep soft tissue injury/periosteal stripping
  - Fracture pattern
  - Wound size

Gustilo and Anderson

Type 1

- <1cm wound
- Simple fx pattern
- Lower energy
Type II

- 1-10 cm wound
- Simple fx pattern
- Higher energy
- No flaps
- Minimal periosteal stripping

Type III (A, B, & C)

- >10cm wound
- Highest energy
- Worst contamination
- IIIA — adequate soft tissue coverage (CLOSABLE)
- IIIB — soft tissue coverage required (FLAPPABLE)
  - Extensive periosteal stripping
- IIIC — vascular injury requiring repair

Type III (A, B, & C)

- >10cm wound
- Highest energy
- Worst contamination
- IIIA — adequate soft tissue coverage (CLOSABLE)
- IIIB — soft tissue coverage required (FLAPPABLE)
  - Extensive periosteal stripping
- IIIC — vascular injury requiring repair
Classification
Gustilo and Anderson System
• Poor inter-observer agreement
• Useful for communication
• Prognostic

Treatment Goals
• Prevent infection
• Achieve union
• Restore function
ER Management

• Wound:
  – Examine once
  – Take pictures
  – Remove gross debris manually
  – Sterile dressings
    • Avoid betadine - toxic

• Reduce fractures and fracture-dislocations
• Splint
• Assess NV status

ER Management

• Tetanus

• Antibiotics ASAP
  – Reduces risk of infection by 59%
    • Cochrane rev, 2006
  – Infection highly correlated with time from injury to ER (Abx)
    • Pollak, LEAP, JBJS 2010

Antibiotics

Types
- I and II Cephalosporin
- Type III Cephalosporin + aminoglycoside
- Barnyard injury (high risk of anaerobic) + PCN
Antibiotics - duration
• Based on contamination
• “Uncomplicated” wounds
  – Types I & II
  – 24-48 hours
• “Complicated” wounds
  – 48 hours after wound closure
  – 48 hours after last debridement

Antibiotics - duration
• Based on contamination
• “Uncomplicated” wounds
  – Types I & II
  – 24-48 hours
• “Complicated” wounds
  – 48 hours after wound closure
  – 48 hours after last debridement

Antibiotics - duration
• Based on contamination
• “Uncomplicated” wounds
  – Types I & II
  – 24-48 hours
• “Complicated” wounds
  – 48 hours after wound closure
  – 48 hours after last debridement

Antibiotics - caveats
• Aminoglycosides
  – Oto/nephrotoxicity devastating
  – 1.5mg/kg Q8h vs. 5mg/kg Q24h
  – Data is POOR
• Infections are primarily nosocomial
• Zosyn? Cipro?
OR management

- Debridement most critical
- Foreign material and necrotic tissue nidus for bacteria

“Zone of Injury”

“Zone of Injury”

“Zone of Injury”

“Zone of Injury”

Extend the wound!
Debridement

• Systematic
  – Layer by layer
  – Circumferential
  – Excise necrotic skin & sub Q
  – Ground-in particulate debris

Debridement

• Muscle
  – EXPOSE longitudinally
    • Consider future incisions
    • Counter incision for anteromedial tibia
  – Incise fascia to inspect
  – Contractility, color, consistency, capacity (to bleed)
Debridement

• Bone
  – Expose and debride IM canals
  – Remove cortical fragments w/o soft tissues
  – Burr → paprika sign
  – Retain articular fragments when possible
Debridement - timing

- Bacterial adhesion and colonization
- Time dependent
- Adhesion within 3 hours
- After 3 hours stronger bonds
- Best clearance within 3-6 hours

Debridement - timing

- Controversial
- 6 hour dogma from 1898 guinea pig study
- Multiple retrospective studies do not correlate
- LEAP: No correlation with timing
- BUT: No study advocates waiting

Debridement - timing

- Considerations:
  - Difficult to adequately assess wound complexity outside the OR
  - Depends on
    - Contamination
    - Periosteal stripping
  - OR and patient availability
    - Resuscitation

Debridement - cultures

- Pre-debridement
  - 8% actually caused infection

- Post-debridement
  - 25% of organism caused infection

Debridement - cultures

- Pre-debridement
- 8% actually caused infection

- Post-debridement
- 25% of organism caused infection

Not useful


Debridement

Debridement - pitfalls

- Small incisions/extensions
- Leaving questionable tissue
- No delivery of bone ends
- Retaining completely devitalized bone fragments

Irrigation

- Type I: 3L
- Type II: 6L
- Type III: 9L

Irrigation - pitfalls

- No good evidence
- MPRCT underway ("FLOW")
- Typical: "copious"

- Type I: 3L
- Type II: 6L
- Type III: 9L
Irrigation

- No good evidence
- MPRCT underway ("FLOW")
- Typical: "copious"
- Type I: 3L
- Type II: 6L
- Type III: 9L

Pulse lavage
- Microscopic bone damage?
- Drive debris deeper into tissues?
- Cystotubing (low pressure)
- Multiple additives
- Detergents, abx

Local antibiotic cement
- Beads vs. spacer
- High local concentration without systemic effects
- Dead space management
- Block induces biologically active membranes (Masquelet)

Wound Coverage/Closure

- Early is better
- Flap failure rate much higher >7 days
- Older concepts:
  - "loose approximation"
  - Wet-to-dry
  - Exposes wound to hospital environment
  - Wound dessication
Wound Coverage/Closure

- Low complication rate associated with primary closure if:
  - Adequate, thorough debridement
  - Tension-free closure
  - Low risk for anaerobes (e.g., minimal contamination)

VAC

- Isolates and seals wound
- May decrease risk of infection in open tibias
- May decrease need for flap
- Does not permit delay in definitive coverage

Principles - Summary

- Identify injury
- Antibiotics & tetanus early
- Debride!
- Early, aggressive, and meticulous
- Repeat if any question
- Copious irrigation
- Skeletal stabilization

When wound stable
- Wound coverage or early closure

eric.meinberg@ucsf.edu

Orthopaedic Trauma Institute
UCSF + SAN FRANCISCO GENERAL HOSPITAL