Pediatric Pelvis and Acetabulum Fractures

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Disclosure

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Objectives

• Differences between pelvis and acetabulum fractures in children and adults
• Review the clinical assessment of pelvis and acetabulum fractures
• Establish emergency treatment for pediatric pelvis and acetabulum in children
• Discuss definitive treatment of pediatric pelvis and acetabulum fractures
• Identify complications associated with pediatric pelvic and acetabular fractures
Unique Pediatric Considerations

• Greater plasticity of the pelvic bones
• Greater elasticity at the SI joint and pubic symphysis
  • Allows greater energy to be dissipated before fracture
    • 10,000 N to break the pelvis of 1-year kid compared to 3000-6000 to cause fracture of 14-years
  • Higher likelihood of a single fracture of the ring
  • Can have significant intrapelvic injury with nondisplaced fractures
• Presence of apophyses
  • Growth plates are weaker locations/more susceptible to injuries
    • Allow for occurrence of avulsion fractures
Patho-anatomy

• The pelvis has three primary ossification centers joined at the triradiate cartilage (TRC)
  • Ilium
  • Pubis
  • Ischium
• TRC fuses at 12-14 years
Pelvic fractures
Epidemiology

• Rare injuries
  • Less than 1% of all pediatric fractures

• Found in 5% of admitted children to Level I trauma centers with blunt trauma

• Mortality is high as high 25%
Mechanism of Injury (MOI)

• MVC:
  • Occupants of wheeled vehicles

• Auto vs Pedestrian
  • Struck by motor vehicle while riding bike or motorcycle

• Fall from heights
Associated injuries

• Found in 58% to 87% of cases
• Most common associated injury is another fracture
• Associate with approximately half of children with pelvic fractures
  • Lower extremity
  • Spine
  • Traumatic brain injury (TBI) ----9%-50%
    • Leading cause of death
  • Thoracoabdominal injuries-----14% -33%
    • 2\text{nd} leading cause of death
Associated injuries

• Open fractures
  • Rare occurrence
  • High rates of infection
  • Must be identified promptly and treated with I&D and repair

• Peripheral nerves injuries occur in ~3% of cases

• Vascular injuries are found in less than 1%
  • Compared to 3.4% in adults

• Low rates of hemorrhage in children due to:
  • Good vascular response by vascular constriction in response to hemorrhage
Associated injuries

• Rectal or vaginal lacerations (2%-18%)
  • Most seen in open fractures
  • Rare in children

• Genitourinary injuries (urethral and bladder lacerations) (4%)
  • Hematuria is present in up to 50% of pediatric pelvic fractures
  • 17% have a GU injury
Morbidity and Mortality

- Significant hemorrhage requiring transfusion occurs in up to 30%
  - Anterior and posterior injury
  - Unstable injuries

- Mortality rates of 2-12%
  - “Demetriades, J Trauma 2003, Heinrich SD 1994, JBJS A’’
Initial Evaluation and Management

• ATLS protocol:
  • Primary survey
    • Airway
    • Breathing
    • Circulation
    • Disability
    • NV exams

• GCS score: reliability of clinical exam is decreased when GCS <13
Initial inspection

• Complete evaluation of pelvis and perineum area
  • Lacerations
  • Ecchymosis
    • MUST log-roll the patient for complete inspection

• Morel-Lavallee lesion
  • Shearing off of skin and subcutaneous tissues from underlying muscles
    • Creates a large space which allows hematoma accumulation
Initial Evaluation

• Palpation of pelvic bony landmarks
  • ASIS, AIIS, iliac crest, symphysis pubis
    • Manual manipulation should be carefully performed when needed
      • Painful
      • Can potentially disrupt a clot
        • Lead to further intrapelvic bleeding
Initial Evaluation

• Inspect the perineum
  • Genitourinary evaluation
    • Urethral injury ➔ blood at the meatus, gross hematuria
      • Retrograde urethrogram indicated if urethral injury suspected
    • Higher rates in males
  • Bladder injury
    • Intra- and/or extra-peritoneal injuries
    • Cystogram used for diagnosis

• Rectal evaluation
  • Digital rectal exam indicated in high-risk scenarios
    • Widely displaced fractures with blood in the perineum
Imaging

- AP pelvis XR obtained on all polytrauma patients
  - Component of initial trauma radiograph series
  - ATLS protocol

- Additional images obtained when hemodynamically stable
  - Inlet
  - Outlet
  - CT scans
    - Improved visualization of SI joints and sacrum
    - Helpful for pre-operative planning
    - 3D reconstructions
Fractures Classification

- Modified Torode and Zieg classification:
  - Type I
    - Avulsion fracture
  - Type II:
    - Iliac wing fractures
  - Type III:
    - 56% of all pediatric pelvic fractures
    - IIIA—Stable anterior ring disruption
    - IIIB—Stable anterior and posterior ring disruption
      - Increased need for transfusion, increase length of stay, more frequent admission to ICU, more associated injuries
  - Type IV
    - Unstable ring disruptions
Fracture Classifications

• Based on skeletal maturity
  • Immature
    • Open triradiate cartilage (TRC)
    • Rarely require surgical intervention
  • Mature
    • Closed triradiate cartilage (TRC)
    • Classified and treated as adults
Tile Pelvis Fractures Classification in adults

Type A: Pelvic ring stable
  A1: fractures not involving the ring (i.e. avulsions, iliac wing or crest fractures)
  A2: stable minimally displaced fractures of the pelvic ring

Type B: Pelvic ring rotationally unstable, vertically stable
  B1: open book
  B2: lateral compression, ipsilateral
  B3: lateral compression, contralateral or bucket handle-type injury

Type C: Pelvic ring rotationally and vertically unstable
  C1: unilateral
  C2: bilateral
  C3: associated with acetabular fracture
Treatment

• Life threatening hemorrhage must be addressed
  • Follow ATLS protocol

• Multidisciplinary approach for associated injuries:
  • Head
  • Thoracoabdominal injuries
  • Urogenital injuries
Initial Treatment

• Resuscitation
• Resuscitation
• Resuscitation
  • ABCDEs of ATLS
• Hemodynamically unstable patients:
  • Other sources of bleeding should be rule out 1st
  • Pelvic binder or sheet at the *level of greater trochanters*
    • Binder vs sheets application varies among institutions
  • Pelvic ex fix if hemodynamic instability persists
  • IR embolization indications
    • Arterial bleeding
    • Patient with hemodynamic instability and no other sources identified
Treatment of Pelvic Ring Fractures

- Isolated iliac wing fractures: (Torode and Zieg type II):
  - Rare (5%-14%)
    - More commonly seen in conjunction with additional pelvic fractures
  - Treatment guided by associated injuries
    - Pelvic ring injury
    - Abdominal injury

- Fractures are treated non-operatively
  - Partial WB with crutches

- ORIF is rarely needed
Treatment of Pelvic Ring Fractures

• Simple ring fractures (Torode & Zieg IIIA & IIIB)
  • Stable fractures
  • Typically, minimally displaced

• Non-WB vs protected-WB
  • Close radiographic follow up to monitor fracture displacement
    • ORIF may be needed to aid in mobilization and pain control
    • Spica cast may be useful in younger kids to enforce restrictions

• Expect recovery in 6-8 weeks
Treatment of Pelvic Ring Fractures

- Widening of the symphysis pubis
  - Usually associated with posterior ring injuries

- Plain radiographs and CT are helpful
  - Look for posterior involvement

- Consider fixation if
  - Widening >2.5cm
  - Stress films demonstrate >1cm difference
Treatment of Pelvic Ring Fractures

- Fractures near or through the sacroiliac (SI) joint:
  - Most are Type IIIB fractures
  - Disruption can occur thru the chondro-osseous physis instead of SI joint
  - Crescent fractures may be associated with rotational instability

- Stable, minimally displaced fractures are treated non-operatively
  - Non-WB x 4-6 WEEKS
  - Spica cast is occasionally needed in young children
Treatment of Pelvic Ring Fractures

- Unstable ring fractures (Torode & Zieg IV)
  - Double anterior ring disruptions (straddle injuries)
    - Beware of associated bladder injury
    - Produces a floating anterior segment
  - Weightbearing progressed as pain improves
  - Typical recovery in 6-8 weeks
Treatment of Pelvic Ring Fractures

• Unstable ring fractures (Torode & Zieg IV)
  • Anterior and posterior ring disruptions (double ring injuries)
    • Often associated with vertical instability (Malgaigne type)
    • Highest association with intra- and retroperitoneal bleeding
      • Intra-abdominal injuries may guide treatment

• Minimally displaced fractures
  • Weightbearing restrictions with close radiographic follow-up
  • Spica cast in young children if needed for activity restrictions
Treatment of Pelvic Ring Fractures

- Unstable ring fractures (Torode & Zieg IV)
  - Anterior and posterior ring disruptions (double ring injuries)
    - Closed reduction and spica casting
      - Symphyseal disruptions
    - Skeletal traction
      - Vertical displacement
      - Traction required for 2-4 weeks until early healing occurs
  - ORIF
    - Relative indications
      - $\geq 1.1$ cm of pelvic asymmetry is present
      - $\geq 2$ cm of displacement
    - Techniques and approaches similar to adults
      - Implant and fixation modifications needed in young children
Treatment of Pelvic Ring Fractures

• Pelvic asymmetry
  • Difference in length between two diagonal lines drawn from the border of the sacroiliac joint to the contralateral triradiate cartilage
    • Keshishyan et al. CORR 1995
  
• This deformity does not remodel

• Differences >1cm have been found to result in poor outcomes
  • Smith et al. JBJS 2005
Treatment of Pelvic Ring Fractures

• Unstable ring fractures (Torode & Zieg IV)
  • Multiple crushing injuries
    • Highest association of massive hemorrhage
    • High rate of concomitant GI or GU injury
      • Requires multidisciplinary approach
    • Associated injuries often times guides treatment

• Treatment principles include
  • Stable pelvic fixation
    • Internal and/or external fixation
  • Multiple debridements (when associated with open fractures)
  • Soft-tissue management
  • Vigilant observation for infections
Treatment of Considerations

• Pediatric pelvic fractures require **less surgical fixation**
  • Decreased association with severe hemorrhaging
    • Less need for surgical fixation to control bleeding
  • Thick periosteum and strong ligaments restrict amount of displacement
    • Decreases fracture motion and increases fracture healing
      • Decreases need for prolonged immobilization
Treatment of Considerations

• Pediatric pelvic fractures possess some remodeling potential
  • Less need for anatomic reduction
  • Pelvic asymmetry, SI joint malposition, acetabular orientation DO NOT remodel

• Long term morbidity is low after pediatric pelvic fractures
Complications

- Pelvic deformity
  - Nonstructural scoliosis
- Limb length discrepancy
- Low back pain
- Sacroiliac pain
- Genitourinary complaints
  - Erectile dysfunction, incontinence
- Psychiatric disturbance
  - Post-traumatic stress disorder (PTSD)
  - Depression
Pelvic avulsion fractures

• Classified as pelvic fractures
  • Accounts for up to 15% of all pelvic fractures
  • Differ greatly from more traumatic pelvic ring injuries
• Commonly occur between the age 11-17
  • When secondary ossification centers are present
Pelvic avulsion fractures

- Frequently associated with sporting activities
  - Forceful contraction of large muscles during rapid acceleration or deceleration moment
    - Muscles crossing both hip and knee joints
    - Muscles originating on a pelvic apophysis
  - Results in an avulsion of a secondary ossification center
Pelvic avulsion fractures

• Most commonly presents in the outpatient setting
• Present with localized swelling/tenderness at site of avulsion
• Hip motion is limited due to guarding
• Pain ranges from mild to severe
• Pain exacerbated when involved muscle put on stretch
  • Ischial spine avulsion fractures—hip flexion and knee extension produces pain
    • Puts hamstring musculature on stretch
Pelvic avulsion fractures

- Radiographs are typically sufficient

- Comparison views may be helpful
  - AP pelvic radiographs allow for identification and comparison

- Children with delayed presentation of these fractures may mimic malignancy so MRI may be needed
  - Thorough H&P is vital
  - Possible lab work
Treatment: Avulsion fractures

- Non-OP treatment successful in almost all patients
  - Rest followed by structured rehab

- Operative Rx for avulsion fractures:
  - Surgical consideration for ischial tuberosity with
    - Displacement over 15-20 mm
      - Goal is to avoid late symptoms
    - Late surgery considered in setting of
      - Chronic pain
      - Symptomatic prominence after healing
        - Anterior hip impingement with HO from AIIS fracture
      - Concern about labral involvement
Acetabulum fractures
Acetabular fractures

• Acetabulum fractures uncommon in children
  • 2-17% of pediatric pelvic fractures
    • Overall, 0.5-0.7% of pediatric fractures

• Involves the triradiate cartilage (TRC) in skeletally immature
  • Composed of
    • Ilium
    • Pubis
    • Ischium
  • Closes at 12-14 years of age

• Potential for growth arrest after injury
  • Acetabular deformity
  • Acetabular dysplasia

Mechanism of Injury

• Most associated with high energy trauma
  • MVCs
  • Auto vs pedestrian

• Less commonly seen with low energy sports injuries

• Specific fracture pattern based on position of the leg at the time of impact
  • Direction of the force will determine
Classification

• **Watts classification:**
  • Type A – Small fragments after hip dislocation
  • Type B – Stable linear fractures without displacement
  • Type C – Linear fractures with hip joint instability
  • Type D – Fracture secondary to central fracture-dislocation of the hip
Classification

• Bucholz classification
  • According to Salter-Harris (SH) classification
    • SH I or II—shearing mechanism
    • Favorable prognosis
    • SH V—crush injury
      • Poor prognosis with frequent growth arrest

• Adult classification can be applied in more mature patients
  • Letournel & Judet

Imaging

• AP of pelvis
• Judet views
  • Obturator oblique
  • Iliac oblique
• CT scan
  • Useful in more mature patients
• MRI
  • Useful in evaluating TRC
  • Accurate size assessment of cartilaginous posterior wall fragments
Treatment

• Goals of treatment
  • Restore articular congruity
  • Preserve alignment of triradiate cartilage

• Non-operative treatment
  • Minimally displaced (<2mm)
    • Non-weightbearing x 6-8 weeks
    • Close radiographic follow up
    • Spica cast used if child is unable to comply with weightbearing restrictions
  • Excellent outcomes expected if joint congruency maintained
Treatment

• ORIF
  • Joint displacement >2mm
  • Joint instability (posterior or anterior wall)
  • Incongruent joint
    • Bony fragments or soft tissue retained within articular surface
  • Malalignment of TRC
    • Displacement may lead to growth arrest
      • Subsequent dysplasia
• Approach and fixation similar to adults
  • Cartilaginous fragments might require suture fixation
Complications

• Outcomes are typically good if a congruent, stable joint is maintained

• Patient should be informed about possibility of growth arrest
  • TRC arrests can lead to subsequent hip dysplasia and/or hip subluxation
  • MRI is useful tool to assess the closure of triradiate cartilage
Take home message

• Pediatric pelvis and acetabulum fractures are rare injuries
• Elasticity of pediatric bone, strong ligaments and the presence of physes distinguish pediatric pelvis and acetabulum fractures from adult fractures
• Non-Op Rx is the main treatment modality
• Pelvic asymmetry and LLD are the main complications of nonoperative treatment
• Operative treatment is indicated in certain situations with marked displacement