Management of Pediatric Orthopaedic Trauma Urgencies/Emergencies

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Disclosures / Conflicts

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The Pulseless Pediatric Supracondylar Humerus Fracture

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SCH and Vascular Injury

WHITE + PULSELESS = IMMEDIATE EXPLORATION

PINK + PULSELESS = ????
* Watchful waiting? * Exploration?

AAOS CPG SCH Fx

• In the absence of reliable evidence... emergent closed reduction of displaced pediatric SCH Fx be performed in patients with decreased perfusion of the hand.
  - Strength of Recommendation: Consensus

• In the absence of reliable evidence...open exploration of the antecubital fossa be performed in patients who have absent wrist pulses and are under-perfused after reduction and pinning of displaced SCH Fx.
  - Strength of Recommendation: Consensus
AAOS CPG SCH Fx

• "We cannot recommend for or against open exploration of the antecubital fossa in patients with absent wrist pulses but with a perfused hand after reduction of displaced pediatric supracondylar humerus fractures."
  – Strength of Recommendation: Inconclusive

Conflicting Literature - Pulseless, Pink Hand (PPH)

• 33/1255 children (2.6%) pulseless
  – 24 pulseless, "well perfused"– observed
  – 9 pulseless, "poorly perfused"
  • 4 – vascular repair
  – Conclusion = pink, "well perfused" with fx reduction alone
    – Choi et al, JPO, 2010

• Literature review: 331 pulseless SCH
  – 98 pulseless, perfused after CRPP, 70% of these had documented brachial artery injury
  – 54 revascularized pts – 91% patent with 1y FU
    – White et al, JPO, 2010

Pink, Pulseless SCH
- TSRH/ CMC experience
  (Weller, et al- OTA podium 2011; currently in press, JBJS)

• 54 pink, pulseless (6% of 873 t3 SCH Fx)
• 9% (5/54) required exploration/ revascularization after urgent fracture fixation
Results: 5 vascular explorations

- 54 pulseless
- 26 restored palpable pulse
- 20 restored Doppler pulse pink hand
- 4 Unknown postop exam
- 4 immediate vascular procedure
- 19 regained palpable pulse
- 1 deteriorated, required vascular exploration

Patients Requiring Vascular Surgery (n=5)

<table>
<thead>
<tr>
<th>Post-Reduction Exam</th>
<th>Surgical Intervention</th>
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<tbody>
<tr>
<td>Patient 1, Pink hand, nondopplerable pulse</td>
<td>Intimal tear resected with primary repair; angiogram done</td>
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<tr>
<td>Patient 2, Brisk capillary refill, nondopplerable pulse</td>
<td>Patch angioplasty with saphenous graft</td>
</tr>
<tr>
<td>Patient 3, Sluggish capillary refill, nondopplerable pulse</td>
<td>Thrombosed brachial artery; saphenous graft repair (interpositional)</td>
</tr>
<tr>
<td>Patient 4, Open fracture (grade 2); pink hand, nondopplerable pulse</td>
<td>Brachial artery laceration with primary repair</td>
</tr>
<tr>
<td>Patient 5*, Brisk capillary refill and triphasic Doppler; deteriorating exam postoperatively</td>
<td>Thrombosed brachial artery; saphenous graft bypass (9hrs post reduction)</td>
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PPH SCH and the Doppler

All pink / pulseless after CRPP but no dopplerable signal

- Role of the Doppler for intraoperative assessment / serial examinations on floor
Incidence of Nerve Injury (Any Distribution)
P < 0.0001

<table>
<thead>
<tr>
<th>Pulse</th>
<th>Neurologically Intact</th>
<th>Nerve Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonpalpable (n=54)</td>
<td>37 (69%)</td>
<td>17 (31%)</td>
</tr>
<tr>
<td>Palpable (n=80)</td>
<td>730 (91%)</td>
<td>70 (9%)</td>
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Nerve injuries 3 times more common in t3 SCH Fx with non-palpable pulses

Compartment Syndrome

- Difficult exam in kids!
- 5 P’s- NOT RELIABLE!
- Increasing analgesia needs is the most sensitive indicator of compartment syndrome! (Bae and Waters JPO 2001)
- Tell parents that if there is pain, swelling that does not resolve with pain meds, elevation, RETURN TO ED!

“Take Home” Bullet Points

- Timely reduction/fixation necessary
- Post-fixation, a PPH may be observed closely in the hospital for return of palpable pulses (q6-8 h for 24-48h)
- Persistent loss of Doppler signal of radial pulse highly suspicious for vascular injury
- 9% of PPH underwent vascular repair in our cohort – consider transfer of the pulseless SCH patient (from the ED) if vascular surgery not available at your hospital
Pediatric Femoral Neck Fractures

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A spectrum of pathology....

...with lot’s of things to worry about!

- Avascular Necrosis
- Nonunion
- Malunion
- Varus Collapse
- Premature Physeal Closure

<1% of All Pediatric Fractures
Delbet Classification


AO Pediatric Classification of Long Bone Fractures

Type I
Mid-cervical

Type II
Basicervical

Type III
Trans-trochanteric

AO Pediatric Classification of Long Bone Fractures

Frequency

AVN

Yeranosian et al. JBJS Br 2013
The Role of Capsular Decompression

Fractures of the Hip in Children and Adolescents
S. Terrance Canale, MD*

Decompression decreased AVN rate from 42% to 24%

Decompression and Stable Internal Fixation of Femoral Neck Fractures in Children Can Affect the Outcome

No AVN in 10 Displaced Fractures (8 Transcervical)
“Early decompression...contributed to a lower complication rate.”

Decompression decreased AVN rate from 42% to 24%

No Relationship between Decompression and AVN Rate
Decreased Time to Surgery (<12 HRS) = Lower AVN Rate
Better Quality Reduction = Lower AVN Rate

Femoral Neck Fractures in Pediatric Patients
30 Years Experience at a Level I Trauma Center

M. Wade Shreder, MD; David J. Junczynski, MD; Anthony A. Stearns, MD; William J. Slaight, MD; and George J. Wullemers, MPH

No Relationship between Decompression and AVN Rate
Decreased Time to Surgery (<12 HRS) = Lower AVN Rate
Better Quality Reduction = Lower AVN Rate

Delayed Union and Nonunion: 6.5% to 23%

Fractures of the Neck of the Femur in Children*

By A. H. Clay, M.D. and Stuart L. Weinreb, M.D.

Fractures of the Neck of the Femur in Children: A Long-Term Follow-up Study

Delayed Union and Nonunion: 6.5% to 23%
Coxa Vara

- Overall Incidence = 18.5%
- Little Remodeling of Proximal Femoral Physis
- Long Term Implications?
  - Impingement
  - Labral Pathology
  - Osteoarthritis
  - Leg Length Difference

Yerasosian et al. JBJS Br 2013

Treatment Options

- Spica Cast w/o Reduction
  - Young Patients w/o Displacement
  - Subacute Fractures
  - Remodeling with Growth?
- Compression Screw Fixation + Decompression
  - Nondisplaced Fractures
  - Incomplete / Stress Fractures
  - Skeletally Mature Patients
- Side Plate and Screws + Decompression
  - Displaced Fractures
  - “Anti-Valgus” Device
  - Screw Fixation across Physis?

Reduction

Closed vs. Open Reduction?

Choice Varies with Fracture and Surgeon
Little Literature to Guide Reduction Choice
Is Fluoro Adequate to Assess Adequacy of Reduction?
Implant Options

- Cannulated Screws
  - Allow Compression
  - Mandate Anatomical Reduction
  - Poor Control vs. Varus

- Sliding Hip Screw
  - Anti-Rotational Screw
  - Compression with Weight Bearing
  - Consider Pauwels Angle

- Locking Side Plate
  - Stable Fixation
  - Limits Varus Collapse
  - Currently No Ability to Compress

Post-Operative Care

- Role of Supplemental Spica Cast?
- Toe Touch Weight Bearing: Minimum 6 Weeks
- Progression to FWB: 6 Weeks – 12 Weeks
- Return to Activity: When Radiographically Healed

- Hardware Removal?
  - Older Patients – NO
  - Younger Patients – YES (Minimum 1 Year)

- Nonunion: Valgus Osteotomy

- Long Term FU for AVN and Physeal Arrest

Distal Femoral Physeal and Tibial Tubercle Fractures

Lane Wimberly, MD

Texas Scottish Rite Hospital for Children
Children's Medical Center Dallas
Distal Femur Fractures - Classification

- Salter-Harris
  - I  25%
  - II  60%
  - III  5%
  - IV  10%
  - V  1%

Distal Femur Fractures - Mechanism

- Valgus force
  - Blow to the lateral knee
  - Salter Harris II or III

- Hyperextension force
  - Epiphysis displaced anterior by gastrocnemius
  - High suspicion for vascular injury
Physeal Fracture Treatment Principles

- General anesthesia/sedation
- Traction with manipulation
- Manipulation after 10 days -> growth arrest
  - Anecdotal?
- Anatomic reduction S-H III/IV
- Avoid physis if possible, non-threaded pins if cross physis

Non-operative Treatment

- Casting
  - Non / minimally displaced S-H I/II
  - Careful follow-up with pinning if any displacement
  - Body habitus a consideration
Operative Treatment

- Reduction, percutaneous pinning
- Displaced S-H I/II with small fragment
- Knee immobilizer/cast/hinge knee brace
- Pins out with early callus
- Consider burying pins under skin

Operative Treatment – SH I/II

- Closed percutaneous screw fixation
- Need large metaphyseal fragment
- Cannulated screws (4.5/6.5 mm)
- Immobilize in Extension

Operative – SH III/IV

- Open reduction to assess articular congruity
- Careful screw placement
Operative – SH III/IV

- Consideration for arthroscopic assistance

Complications of Distal Femoral Fractures

- Common
  - 40% of all patients (Arkader, JPO 2007)
- 69% of complications = physeal arrest
  - Distal femur = 9mm growth per year
- Complications related to:
  - Higher S-H classification
  - Displacement of fracture
  - Surgical Treatment

Growth Arrest

- Occurs despite appropriate treatment
- Treatment
  - Bar resection
  - Hemiepiphysodesis of affected side
  - Contralateral epiphysodesis
  - Osteotomy
  - Lengthening
Tibial Tubercle Fractures

- Most anterior aspect for tibial epiphysis
- Multiple ossification centers appear between 8-14 years of age
- Cartilage at tubercle fuses last
- Patellar tendon insertion onto tubercle matures
- Retinacular fibers reinforce insertion
  - May permit + SLR
  - May tear from the anterior compartment

Tibial Tubercle Fractures

- Usually occur with jumping, eccentric contractures
- Questionable Osgood-Schlatter association
- Beware of compartment syndrome
  - May be before or after treatment
  - We do not allow these patients to go home from the ED or OR
Watson-Jones Classification

- Type 1
  - Minimally displaced
- Type 2
  - Displaced, below epiphysis
- Type 3
  - Displaced, involving epiphysis
  - Meniscal entrapment possible

Treatment

- Any displaced injury requires operative management
  - Usually open reduction and internal fixation
  - Consideration for fasciotomy
  - Repair of related retinacular or extensor mechanism injury
  - Immobilization of choice
  - Some non-displaced injuries can have interposed extensor mechanism
    - Palpate for defect at insertion site

Controversies

- Recurvatum deformity
- Compartment release
- Beware extension into epiphysis and meniscal entrapment
Thank You!