Controversies in Pediatric Supracondylar Humerus Fractures

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No disclosures for this presentation

Agenda

• A basic review of supracondylar humerus fracture
  – Anatomy
  – Classification
  – Treatment

• A Biased and Personal Take on Controversies
  – Type II – to cast or pin?
  – Timing of treatment – immediate or delayed?
  – Vascular Injury – The pink pulseless hand
Background

- Supracondylar humerus fractures are one of the most common types of fractures in children – 60% of all elbow trauma in children
- Extension type most common (95%)
- Risk of neurovascular injury, compartment syndrome

Supracondylar Humerus Fractures Classification

- Type 1 – Non-displaced
- Type 2 – Angulated/displaced fracture with intact posterior cortex
- Type 3 – Complete displacement, with no contact between fragments
- Type 4 (new) – Instability in flexion and extension intraoperative

Elbow Fractures Radiograph Anatomy/Landmarks

- Anterior Humeral Line – Drawn along the anterior humeral cortex
  - Should pass through the middle of the capitellum
    - >5 y/o, 100% falls on middle 1/3
    - Variable in very young children
      - <2 y/o, 30% fall on anterior 1/3

Credit:
- Rogers et al, Radiology 1998
- Herman, et al JBJS 2009
- Ryan et al, JPO 2016
Importance of True Lateral Xray

- Indistinct capitellum
- Malrotated image

Radiograph Measurements

- Baumann's angle
  - Shaft-capitellar angle (>75° = varus)
  - Wide range of normal

- Medial impaction and varus position increases Bauman's angle

Type 1
Non-displaced

- Look for fat pad
  - Posterior fat pad elevation, 76% have occult fracture

- Treat with cast immobilization for 3 weeks

Image Credits:
1) Mohammad et al JPO 2009
2) AO Surgery Reference

Type 2
Angulated/displaced fracture with intact posterior cortex

Caution - Type 2 – Coronal plane is important too

Type II fracture with medial impaction – not recognized and varus / extension not reduced

Type 2 Treatment Goals

• Restoration of alignment in the lateral view (anterior humeral line intersect capitellum)

• Restoration of bauman’s angle and clinical carrying angle

• Hold the reduction
Type 2 - Treatment

- Closed reduction & casting

  vs

- Closed reduction & percutaneous pinning

Controversy #1

Do all type II supracondylar humerus fractures need pins?

Casting can work in select patients...

Spencer et al, JPO 2012

- 189 type II fractures treated with closed reduction & casting
  - 79% maintained reduction
  - Loss of reduction associated with:
    - Rotation
    - Persistent extension post-reduction

- Bottom line:
  - Some type II's can be treated with casting

<table>
<thead>
<tr>
<th>TABLE II: Multivariate Logistic Regression Analysis for Subsequent Conversion to Surgical Treatment Among the 189 Patients Who Did Not Receive Initial Surgical Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiographic Features</td>
</tr>
<tr>
<td>-----------------------</td>
</tr>
<tr>
<td>Initial rotational deformity</td>
</tr>
<tr>
<td>Pronounced anterior bowing</td>
</tr>
</tbody>
</table>

Note: For each non-inferiority characteristic, use the | symbol to indicate the non-inferiority margin.
Proponents of Operative Treatment

- Principles
  - Decreased loss of reduction
  - Decreased radiographic follow up
  - Low complication rate from pinning

- Douglas et al, JOT 2013
  - 29 type II SCHs → closed reduction and casting
    - 48% lost reduction, > 5 degrees (mean 12 degrees)
    - Position of casting & initial displacement didn’t matter

- Skaggs et al, JPO 2008
  - 189 type II SCHs → CRPP
    - 0% loss of reduction, clinical varus, or ROM loss (6 weeks post pin-removal)
    - 2.1% pin site infection rate (4/189)

Proposed Algorithm

Conclusion

- Personal preference —
  - Too much to think about
  - Pin all type 2 supracondylar humerus fractures
    - Prevents need for repeated radiographic follow ups
    - Minimizes loss of reduction and extension/varus deformity
    - Pin complication rate acceptable
**Type 3**
Complete displacement, with no contact between fragments

- Higher risk of neurologic and/or vascular compromise
  - 10-20% (Sethi et al, BMJ 2016)
- Risk of compartment syndrome
- Treat with closed reduction & percutaneous pinning
  - Rarely, open reduction

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**Type 3 - Neurovascular Anatomy**

- Median / AIN injury 59% of all nerve injuries
- Artery close proximity to median nerve
- Brachial artery draped across proximal fragment
  - Tethered by supratrochlear artery
- Urgency of CRPP depends on vascular status / compartment syndrome risk

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**Type 3, Caution**

- Important to assess and document **preoperative** status on nerve function & vascular status!!
  - Cases of median nerve and brachial artery entrapment at fracture site s/p reduction (Fournier et al, BMJ Case Rep 2015; Thorleifsson et al, AOTS 1988)
Type 3 Initial Presentation

- Pulse absent, poorly perfused hand
  - **EMERGENT** reduction / pinning

- Pulse absent, well perfused hand
  - **URGENT** reduction / pinning

- Pulse present, well perfused hand
  - How long can these wait for reduction/pinning

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A quick word about Pulseless Poorly Perfused Hand On Presentation

Choi et al, JPO 2010
- Pulseless SCH w/ white hand
- → observe CLOSELY postop for deterioration

Controversy #2
- Do type III supracondylar humerus fractures with intact pulse and perfused hand need urgent surgical treatment?
Proponents of early treatment
Louizou et al, Injury 2008
• Meta-analysis favored early treatment (<8-12 hrs from presentation)
  – Delaying treatment associated with increased risk of open reduction

A Closer Look at the Largest Study
Walmsley et al, JBJS UK 2006
• < 8 hr, 11% open reduction
• > 8 hr, 33.3% open reduction
• Outlier
  – ~ < 15 % open reduction rate in other studies

Proponents of Delayed Treatment
<table>
<thead>
<tr>
<th>Study</th>
<th>Timing Groups (Mean)</th>
<th>% open reduction</th>
<th>Other Complications/RoM/Ra diographs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kronner et al (JCO 2013)</td>
<td>Early &lt; 12 hrs (7.4) Late &gt; 12 hrs (16)</td>
<td>Early: 7.4% Late: 12.2% P = 0.37</td>
<td>No difference</td>
</tr>
<tr>
<td>Gupta et al (JPO 2004)</td>
<td>Early &lt; 12 hrs Late &gt; 12 hrs</td>
<td>Early: 0% Late: 6% P = 0.24</td>
<td>No difference</td>
</tr>
<tr>
<td>Leet et al (JPO 2002)</td>
<td>Spectrum (correlation analysis = no correlation)</td>
<td>Overall: 0.6%</td>
<td>No difference</td>
</tr>
<tr>
<td>Lyengar et al (JOT 1999)</td>
<td>Early &lt; 8 hr (5.3) Late &gt; 8 hr (22.1)</td>
<td>Early: 13% Late: 17% P = 0.47</td>
<td>No difference</td>
</tr>
</tbody>
</table>

• No difference in rate of open reduction
• No difference in quality of reduction
• No difference in eventual functional outcomes
Delivering treatment of supracondylar fractures in children

Ramachandran et al, JBS UK 2008

- What can we learn from patients who got compartment syndrome?
  - 11 patients with type III SCHs w/ intact pulse on presentation who developed compartment syndrome
  - Mean time from injury to surgery 22 hours
  - On presentation warning signs
    - Severe swelling in 10/11
    - Puckering in 2/11
    - Ecchymosis in 7/11
  - Use clinical judgment – take warning signs into account

Conclusion

- Personal bottom line
  - In well perfused, intact pulse case without other risk (severe swelling, ecchymosis, puckering) factors, OK to wait until next morning
    - Would you want your child waiting with severe swelling/ecchymosis/puckering?
    - Still attempt to perform CRPP as soon as reasonably possible

Surgical Treatment of Supracondylar Humerus Fractures

- Positioning
  - Radiolucent small hand table
    - OK to use fluoroscopy as table
  - Axilla at the edge of bed

Surgical Treatment of Supracondylar Humerus Fractures

• Step 1:
  – Milk Brachialis,
  • get tethered soft tissues out of way to reduce risk of neurovascular entrapment
  (Image credit: Skaggs et al, Masters Techniques in Orthopaedic Surgery, Pediatrics, 2015)

• Step 2:
  – Traction
  – Reduce in coronal plane
  – Check fluoroscopy
  (Image credit: Skaggs et al, Masters Techniques in Orthopaedic Surgery, Pediatrics, 2015; Flynn et al, Lovell and Winters Pediatric Orthopaedics, 2014)

• Step 3:
  – Correct rotation
  – Flexion maneuver w/ direct thumb pressure on distal fragment
  • Don’t be overly aggressive (iatrogenic type IV)
  (Image credit: Skaggs et al, Masters Techniques in Orthopaedic Surgery, Pediatrics, 2015)
• Step 4
  – Check transcondylar view
  – Verify reduction on lateral view
    • External rotation @ shoulder
    • Move the humerus!

• Step 5
  – Place percutaneous pins in the transcondylar view
  – Maximize divergence of the pins

• Personal preferred technique:
  – Lateral only pins
  – Two lateral pins for type II
  – Three lateral pins for type III
Surgical Treatment of Supracondylar Humerus Fractures

Step 7
- Check pulse!
- Do not leave OR until hand is well perfused

Scenarios after successful closed reduction & pinning

Pulse Intact

SUCCESS

Pulse Gone, white hand

FAILURE

?Pulse Gone, Pink hand?

Scenarios AFTER CRPP, with 2012 AAOS Guidelines

1) Intact pulse → done
2) Absent pulse, well perfused

Pulseless and perfused hand after reduction/pinning → Open exploration vs observation?
   → Strength of Recommendation: Inconclusive
3) Absent pulse, poorly perfused

Pulseless and decreased perfusion to hand after reduction/ pinning → Open exploration of the antecubital fossa
   → Strength of Recommendation: Consensus
Pulseless but perfused after reduction: Observe?

Weller et al, JBJS 2013

• 54 pulseless type III supracondylar humerus fractures
• All underwent reduction & pinning

• SAFE: Pink, but dopplerable pulse afterwards - observe patients 24-48 hours
• UNCLEAR: Role of Doppler signal in pink perfused hand
  – Everyone without doppler signal had true brachial artery finding

Pulseless but perfused after reduction: How do they do?

Scanell et al, JBJS 2013

• 20 patients u/p CRPP for pulseless perfused SCH fx
  – Mean 20 months f/u
• Outcomes:
  – 17/20 (85%) – Early palpable pulse after reduction
  – 20/20 (100%) – Palpable pulse at final follow up
  – Duplex scan:
    • 14 patent brachial artery
    • 5 occlusion / 1 stenosis of brachial artery
  – Clinical exam:
    • No difference in circumference, length, ROM, grip strength, muscle endurance compared to uninjured side
  • Patency rates of trochlea / distal humeral chondrolysis

1) Collateral flow around elbow allows for palpable pulse
2) Observed pink pulseless do OK clinically in medium term
3) Need longer term follow up!
• Prevent ischemic contracture long term

• Blakey et al JBJS UK 2009
  - 26 patients referred after treatment of pulseless perfused SCH fx
  - 23/26 patients had evidence of ischemic contracture upon referral

Pink Pulseless Hand – Other helpful tests?

• Bae et al: “We recommend surgical exploration in patients with pink pulseless hand if there is any evidence of altered perfusion (after CRPP)
  – ischemic pain, sluggish capillary refill, abnormal doppler signal)

• Adjuncts
  - Doppler for pulse
  - Pulse oximetry waveform?

Conclusion

• Observe pink pulseless hand 24-48 hours, with serial checks for compartment syndrome and vascular compromise
  - Be weary of nerve injury that mask a good examination

• Use best judgment to assess adequacy of perfusion
  - Doppler? Pulse Ox?

• Be Ready to Intervene!

• Still need longer f/u and more objective ways to assess adequacy of perfusion