OPERATIVE TREATMENT OF INJURIES TO THE CHEST WALL

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Outline

• Background/Literature Review
  – Rib fracture
  – Sternal fracture
• Diagnostic Evaluation
• Indications for operation
• Operative techniques
  – Rib fixation
  – Sternal fixation
• Illustrative Cases
• Outcomes (personal and literature)
• Use in flail chest patients
Background: Rib Fixation

• Until the late 1990’s, there was only a rare report on operative rib fixation

• Beginning in early 2000’s, there has been an ever-increasing experience reported with operative rib fixation

• Over 50 paper published since 2002 in trauma, orthopedic, and thoracic surgery literature
Background: Sternal Fixation

- Richardson published first series using wire-fixation in 1975 for over-riding fragments with severe pain and for non-union

- Occasional reports since with ORIF-plate fixation (largest series Louisville)

- Scattered reports but not robust as with rib fractures
Rib Fixation: Summary of Literature Review

- Only one series of greater than 100 cases
- Rate of fixation of all rib fractures treated ranges from 0.5% to 2.8%
- Most papers do not discuss indications for operation or case selection
- Techniques vary greatly among papers
- Results usually quite good
Diagnostic Evaluation

- With advent of CT scanning of the chest, rib fractures commonly diagnosed.
- 3-D reconstruction is very helpful (essential?) in determining need for operation.
- Key features: number and location of fractures; over-riding of rib fragments.
- Sternal fractures: lateral chest view and CT scan.
Incidence of Boney Chest Injuries

- Rib Fx
- Flail Chest
- Sternal Fx


Rib Fx (Pts)

Flail Chest & Sternal Fx (Pts)
Incidence

- Rib fractures represent most commonly broken bone in the body
- Sternal fractures have increased 7-fold in past 10 yrs. in our hospital
- “Epidemic” of sternal fractures with seat belts and air bags reported in literature
- Most chest wall fractures heal without specific treatment

HOWEVER

- A small subset of pts have severe displaced rib or sternal fractures that are highly symptomatic and do not heal normally
Indications For Fixation of Chest Wall Fractures

• Given that a busy trauma center will see hundreds of rib fractures and a similar number of sternal fractures, the most critical issue hinges on the indications for operation.

• In my opinion, this is a subjective decision. There are no objective scores to aid in the recommendation for fixation.
Generally Accepted Indications For Fixation

• Severe pain with likelihood of non-union (over-riding, unopposed fragments)
• Non-union (as a chronic problem)
• Lung herniation (rare)
• Closing an unstable chest after thoracotomy for another indication
• Flail chest (a complicated topic discussed last)
My Indications for Rib Fixation

- Over 90% of rib fixation done for severe pain with multiple over-riding or unopposed rib segments
- 3 cases of chronic non-union remote from injury
- 1 operation for lung hernia requiring rib fixation
- 6 cases of fixation after thoracotomy for another indication (in several others I considered but wanted to quickly terminate the case)
- 6 cases of flail chest (I worry about these patients)
My Indications for Sternal Fixation

- Patients with severe pain and over-riding rib fragments (over 40 cases)

- 20 cases of chronic non-union (including 4 physicians who reviewed literature!); 14 were initially treated at another hospital
Operative Techniques: Rib Fixation

- Kirschner wires (k-wire) – no personal experience
- Fixation with absorbable plates
- Hardware that is fashioned to the ribs (e.g., low-profile mandibular plates)
- Hardware designed to contour to the rib (e.g., Synthes® system) (no personal experience)
<table>
<thead>
<tr>
<th>PRO</th>
<th>CON</th>
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<tbody>
<tr>
<td>K-WIRE</td>
<td></td>
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<tr>
<td>Less operative exposure</td>
<td>Require removal, erode into adjacent tissue</td>
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<tr>
<td>ABSORBABLE</td>
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<tr>
<td>No removal required</td>
<td>Theoretical risk of non-union; infection resistance</td>
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<tr>
<td>CONFORMABLE HARDWARE</td>
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<tr>
<td>Very robust and reliable</td>
<td>Require bending of the plates; More operative exposure</td>
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<tr>
<td>SYNTHES</td>
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<td>Made to contour to ribs</td>
<td>Not as strong for some severe over-riding ribs</td>
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Operative Technique

- Muscle sparing thoracotomy when possible
- Minimize incision
- Some authors mentioned routine VATS (but I rarely use for this problem)
- Important to obtain solid union with rib opposition
- The injury often has violated the pleura so one must be prepared to enter the chest
Case 1

- 49 year old jockey sustained a fall from his horse at Churchill Downs racetrack
- Lt. chest crushed by stampede
- Sustained 8 rib fractures and flail chest
- Did not require ventilation but borderline respiratory status
- Severe pain with each breath despite thoracic epidural and supplemental narcotics, NSAIDS, Ketamine, Neurontin (pain management team)
Fractured Ribs
Operative Repair

- Required operation on post-op Day 6
- Lt thoracotomy incision
- Fixed 4 ribs with titanium plates and screws
- Pt transferred from ICU in 2 days and discharged in 4 days
Case 2

- 33 y.o. woman sustained a crushed left chest in motor vehicle crash
- Despite thoracic epidural & aggressive pain management, she had borderline pulmonary status due to severe pain
  - Inability to breathe deeply
- Eight rib fx & scapula fx were her only injuries
Operative Technique

Sternal Fixation

• Vertical incision over fracture

• Reduce overriding fragments

• Titanium mandibular plate applied with plate and screws

• 2 plates used
OUTCOMES: RIB FIXATION

- Our unit has done 62 cases of rib fixation
- No deaths or complications
- Usually dramatic pain relief
- Ventilated patients promptly weaned (most were not on ventilator)
- No infections or non-union
- Excellent long-term results (3 plates later removed)
- Mirrors results found in literature
RESULTS: STERNAL FRACTURE

- 1 disastrous result!
- 63 year old man underlying COPD sustained comminuted sternal fracture
- Treated with ORIF with excellent early pain results and started weaning
- Required mechanical ventilation
- Patient self-extubated twice pre-op and post-op #2 and unable to be re-intubated
- Patient died during cricothyrotyotomy
- Death less than a month after abstract submission
Other Results: Sternal Fracture

- Remainder of patients had excellent results
- Good pain relief
- No infection or non-union
- No long-term pain medication use
- 3 plates removed after healing
Indications for Rib Fixation in Flail Chest

- Literature very muddled
- Indications for operation rarely clearly stated
- While results generally good the patients are high selected
- **Proper patient selection is crucial**
Problems With Flail Chest

• Mechanical with chest wall
• Pain preventing adequate ventilation
• Underlying pulmonary contusion
• Associated injuries (e.g., neurologic)
• While fixation may aid first two issues, anesthesia required may worsen the latter two
Randomized Trial

- Australian study randomized 46 patients to fixation versus conventional treatment
- Criteria: no prospect for extubation with next 48 hours
- Ventilator days post-randomization was 6.3 in operative group vs. 7.5 in conventional group (22 operated patients, saved 5 ICU days overall)
- No other differences noted
Selection of Patients for Fixation (My Indications)

• Relatively isolated flail where chest wall mechanics or flail are primary problem

• Avoid operation with major component of pulmonary contusion

• This has resulted in very occasional use