Operative Management of Rib Fractures: One answer to the Opiate Crisis?
Sean A. Nix, D.O. FACOS, FACS
Trauma Medical Director

Disclosure
• I having nothing to disclose
• Ok one thing:

After 100 years it’s time for this to be the standard of care.

Learning Objectives
• Know the history of rib fracture treatment strategies
• Understand the epidemiology of rib fractures
• Know the indications
• Understand basics mechanics of operative rib fixation
• Know the outcomes

Gravity and Motorcycles
How would you treat this patient?
What is the Standard of Care?
Is that good enough?
Can we do better?

Last 100 years of Rib fixation
• Reviewed by Bemelman et al Eur J Trauma and Emerg Surg (2010).
  – The authors reported the early descriptions of “Steering wheel injury”
    • Associated with paradoxical chest wall motion
    • “Floating sternum”
    – Early workers had good descriptions of physiology
    – Had mortality of up to 80% reported in first half of 20th century

Non-Operative
• Ventilators and tracheostomies described by various authors in 1950’s and 60’s (Bemelman et al 2010)
• Termed internal support by authors
• “Iron Lung” described by Hagan in 1945
• “Cape Town Limpet” or suction cup device described in 1963
• Mainstay of treatment of flail chest was
  – Strapping and Sandbagging used for decades
  – Last study published in 1996 comparing external fixation
Operative Rib Fracture Fixation

- Percutaneous

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jones</td>
<td>1927</td>
<td>Bullet forceps and external traction</td>
</tr>
<tr>
<td>Jaslow</td>
<td>1946</td>
<td>Clothes hanger hooks and traction</td>
</tr>
<tr>
<td>Heney</td>
<td>1951</td>
<td>Vidalium screws and 20 pounds traction</td>
</tr>
<tr>
<td>Constantinou</td>
<td>1961</td>
<td>Expanding wire hooks</td>
</tr>
</tbody>
</table>

(Bemelman et al 2010)

Operative Reduction and Internal Fixation

- Completely internal and construct remains in vivo

<table>
<thead>
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<th>Author</th>
<th>Year</th>
<th>Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dor</td>
<td>1967</td>
<td>K-wires: removed after a certain time</td>
</tr>
<tr>
<td>Beltrami and Guernelli</td>
<td>1978 and 1979</td>
<td>2 long internal K-wires</td>
</tr>
<tr>
<td>Landreneau</td>
<td>1991</td>
<td>Metal struts</td>
</tr>
<tr>
<td>Klassen</td>
<td>1949</td>
<td>Bone pegs</td>
</tr>
<tr>
<td>Crutchner and Nolen</td>
<td>1956</td>
<td>Push pins</td>
</tr>
<tr>
<td>Hagen</td>
<td>1945</td>
<td>Suturing</td>
</tr>
<tr>
<td>Landreneau</td>
<td>1991</td>
<td>Metal struts</td>
</tr>
<tr>
<td>Paris</td>
<td>1975</td>
<td>Plates</td>
</tr>
<tr>
<td>Various</td>
<td>1990</td>
<td>Various plates; U-Plates, Medin plates, dedicated rib fixation locking plates</td>
</tr>
</tbody>
</table>

(Bemelman 2000)

Thoracic Trauma

- 1/3 of US hospital admissions
- 20% of all trauma deaths
- Flail in 12 – 25%
  - Current mortality is 10 -15%
  - Up to 100% mortality in patients with severe TBI
  - Dehghan et al reported TBI and Flail mortality of 40%
    (Pettiford, 2007; Schweizger, 2001, Dehghan, 2014)
  - Engel et al reported mortality rates of 10 – 36%

(Engel et al 2005)

Paradoxical Wall Motion

<table>
<thead>
<tr>
<th>Flail Chest</th>
<th>No Flail Rib Fractures</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Need for mechanical ventilation</td>
<td>66%</td>
<td>42%</td>
</tr>
<tr>
<td>Respiratory Complications</td>
<td>54%</td>
<td>20%</td>
</tr>
<tr>
<td>Hospital Stay</td>
<td>10 - 19 days</td>
<td>17 - 19 days</td>
</tr>
</tbody>
</table>

(Schweizger, 2001; Velhemos, 2002)
**NTSDB Study**

Mortality: 16%
Mortality: +TBI: 40%

(Dehghan, 2016)

**Indications for ORIF**

- EAST guidelines: Kasotakis et al, 2016
  - Flail: recommended to reduce Mortality, LOS, PNA and tracheostomy rates
  - Non-Flail: not enough data to recommend
    - i.e. no studies with only non-flail rib fractures
  - Pierraci study included multiple indications

**Other accepted indications**

1. Painful or mobile rib fractures
   - Not responding to medical treatment
   - Impending or respiratory failure
2. Significant chest wall deformity
3. Failure to wean from ventilator
   - Not due to contusion
4. Significant displaced fractures found during thoracotomy for other indication
5. Chest wall pain and deformity due to non-union

(Saarinen et al, 2017, Up-to-date 2018)

**Surgical Stabilization vs internal pneumatic**

(Tanaka, 2001)

**What about quality of life?**

- Tanaka et al in 2002:
  - Back to work in 6 months
    - ORIF: 11/18 patients
    - Standard of care: 2/18
  - Back to work in 12 months
    - ORIF: 16/18 patients
    - Standard of care: 12/18

- Landinois reported 9 year series in 2001
  - 66 patients with flail
  - All returned to work in 8 weeks
  - Mortality was 11% (Previously reported 11-30%)

**Is Cost a Factor?**

- Tanaka study
  - ORIF: $5840 vs. Non-Operative: $23,423
- Bhatnagar et al in 2012
  - Analyzed Medicare data
  - Cost effectiveness:
    - $15,269 for ORIF and $16,810 for standard of care
    - When Quality of life difference was estimated at zero
    - If QL score is 25% higher
    - $27,830
- Marasco et al, (2013) reported $14,000/patient savings
Cost of Complications

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Cost in dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>DVT</td>
<td>$3,281.29</td>
</tr>
<tr>
<td>PE</td>
<td>$5,390.61</td>
</tr>
<tr>
<td>Intubation &lt;96 hours</td>
<td>$11,279.68</td>
</tr>
<tr>
<td>Intubation &gt;96 hours</td>
<td>$26,123.17</td>
</tr>
<tr>
<td>Tracheostomy with &lt;4 days</td>
<td>$11,661.63</td>
</tr>
<tr>
<td>Tracheostomy with &gt;4 days</td>
<td>$26,505.12</td>
</tr>
<tr>
<td>VAP</td>
<td>$3,679.84</td>
</tr>
</tbody>
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[Pattnag, 2012]

Decrease complications?


<table>
<thead>
<tr>
<th></th>
<th>Odds Ratio</th>
<th>Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>0.3</td>
<td>0.18 - 0.50</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>0.24</td>
<td>0.13 - 0.46</td>
</tr>
<tr>
<td>Tracheostomy</td>
<td>0.24</td>
<td>0.12 - 0.50</td>
</tr>
</tbody>
</table>

Is timing important

- No difference in mortality between groups
- On multivariate analysis:
  - Each additional day delay until surgery
    - Increased pneumonia likelihood by 31%
    - Prolonged ventilator by 27%
  - Need for tracheostomy by 26%
- Highest numbers of patients in the ≥ 3 rib fracture criteria followed by flail.

Geriatric patients?

- All-Osman et al reported on geriatric patients
  - 64 had ORIF: Muscle sparing vs 135 non-operative

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<tr>
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<th>ORIF</th>
<th>Non-operative</th>
<th>P Value</th>
</tr>
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<tbody>
<tr>
<td>Age</td>
<td>45.0 (16 – 76)</td>
<td>72.0 (66 – 81)</td>
<td>0.004</td>
</tr>
<tr>
<td>SB</td>
<td>37.5 (9–23)</td>
<td>34.9 (9–24)</td>
<td>0.01</td>
</tr>
<tr>
<td>Mortality</td>
<td>1.0</td>
<td>0.99</td>
<td>0.35</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>0.4</td>
<td>0.97</td>
<td>0.35</td>
</tr>
<tr>
<td>Tracheostomy</td>
<td>0.11</td>
<td>0.60</td>
<td>0.35</td>
</tr>
<tr>
<td>Home oxygen</td>
<td>0.5</td>
<td>0.75</td>
<td>0.35</td>
</tr>
<tr>
<td>Long term acute care</td>
<td>0.7</td>
<td>0.66</td>
<td>0.35</td>
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Decrease complications?

Althausen et al. report of 5 years data in 2011

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<tr>
<td>All days</td>
<td>1.5</td>
<td>1.2</td>
<td>0.018</td>
</tr>
<tr>
<td>Next day</td>
<td>1.14</td>
<td>1.68</td>
<td>0.007</td>
</tr>
<tr>
<td>Injury LOS</td>
<td>11.9</td>
<td>9.07</td>
<td>0.009</td>
</tr>
<tr>
<td>Tracheostomy</td>
<td>4.55%</td>
<td>31.23%</td>
<td>0.042</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>6.55%</td>
<td>25%</td>
<td>0.067</td>
</tr>
<tr>
<td>Re-intubation</td>
<td>4.55%</td>
<td>17.86%</td>
<td>0.034</td>
</tr>
<tr>
<td>Home oxygen</td>
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ORIF

- Open source picture of Rib Plating:

ORIF of Rib Fractures

Basic Technique

- Muscle sparing technique
- Place back in anatomic position
- Clamp in reduced fashion
- Measure rib thickness
- Cut/bend plate to length
- Clamp plate in position
- Pre-drill holes
- Self Drilling screws

Answer to opioid epidemic

- deMoya et all reported in small study: n=16
  - Morphine dose decreased
    - 110mg ± 98 vs 63mg ± 57 (P=0.01)

- Uchida et al, 2017
  - N=187
  - Duration of IV narcotics: ORIF versus non-operative
    - 4.5 (3-6 days) vs 12 (9-14 days) P<0.02

Surgery changes slowly

- First description in the 1920's
- Bryan Moore, MD in Journal of Thoracic and Cardiovascular Surgery, 1975 based on 112 cases.
  ...Reduces mortality, improves respiratory function, and avoids chest wall deformity... “There is no doubt that, compared to prolonged positive-pressure ventilation as a treatment for paradoxical movement of the chest wall, operative stabilization reduces the number of days spent in the intensive care area and promotes much earlier ambulation...”

The outcome of gravity and motorcycles:

Extubated day after surgery

Minimal analgesic need

Spoke at Hampton Roads Trauma Symposium April, 2018
Conclusions

- Operative fixation of significant rib fractures can
  - Reduce mortality
  - Decrease complications
  - Decrease cost
  - Decrease LOS
  - Decrease analgesic need

- Is indicated in
  - Flail
  - Significant chest wall injuries not relieved through medical treatment
  - Non-union

Questions?

- Contact information
  - snix@saintlukeskc.org
  - Cell: 757-707-0250
  - twitter: @seannixdoc