Current Management of Rib Fractures

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Disclaimer Slide

No financial affiliation with any element of this talk.

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Objectives

- Review epidemiology of rib fractures.
- Discuss definitions of chest wall injury.
- Discuss nonoperative treatment of rib fractures.
- Discuss the historical treatment of rib fractures.
- Review the literature on chest wall injury.
- Discuss case vignettes.
Background

- Injury from MVC occurs every 4 sec and death every 5 min
- Rib fractures occur in 10% of all blunt trauma
- 303,462 were treated for rib fx’s in 2000\(^1\)
- Approximately 140,000 patients require admission\(^2\)

\(^1\)www.cdc.gov/nchs
\(^2\)www.ahrq.gov/data/hcup/hcupsis.htm
Background

• Thus 850 chest wall injuries occur everyday and 50% of these have an AIS of 2 or greater\(^1\)
• Roughly 4 to 12% of patients with chest wall injury die resulting in 34 to 102 deaths per day\(^1\)
• Risk of death increases from 1.8 to 3.9 % for those without fracture to those with 3 or more\(^1\)
• 70% with rib Fx’s take narcotics at least 30 days\(^2\)
• Total mean time lost from work was 70 ± 41 days\(^2\)

<table>
<thead>
<tr>
<th>AIS</th>
<th>Severity</th>
<th>Injury Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Minor</td>
<td>Rib contusion, fracture or both Sternal contusion</td>
</tr>
<tr>
<td>2</td>
<td>Moderate</td>
<td>2-3 rib fractures, stable chest Multiple fractures of a single rib Sternal fracture</td>
</tr>
<tr>
<td>3</td>
<td>Severe, not life threatening</td>
<td>Rib fracture open, displaced or comminuted, Greater than 3 rib fractures, stable chest</td>
</tr>
<tr>
<td>4</td>
<td>Severe, life threatening</td>
<td>Flail chest (unstable chest wall), &gt;3 ribs on both sides</td>
</tr>
<tr>
<td>5</td>
<td>Critical</td>
<td>Flail chest requiring ventilatory support &lt;15 years old Bilateral flail</td>
</tr>
</tbody>
</table>
Morbidity of Rib Fractures

- PAIN, PAIN, PAIN
- Impaired pulmonary mechanics
- Poor pulmonary hygiene
- Progressive displacement
- Respiratory embarrassment/failure
- Vent dependence
- Pneumonia
- Decreased mobility
- Prolonged convalescence
- Nonunion
- Death
### Mortality Odds Ratio for Age

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>65+ years</th>
<th></th>
<th>&lt;65 years</th>
<th></th>
<th>Odds Ratio</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Events</td>
<td>Total</td>
<td>Events</td>
<td>Total</td>
<td>Weight</td>
<td>M-H, Fixed, 95% CI</td>
</tr>
<tr>
<td>Bergeron</td>
<td>22</td>
<td>113</td>
<td>27</td>
<td>292</td>
<td>0.9%</td>
<td>2.37 [1.29, 4.37]</td>
</tr>
<tr>
<td>Bulger</td>
<td>22</td>
<td>277</td>
<td>10</td>
<td>187</td>
<td>0.8%</td>
<td>1.53 [0.71, 3.30]</td>
</tr>
<tr>
<td>Lee b</td>
<td>45</td>
<td>818</td>
<td>52</td>
<td>1633</td>
<td>2.5%</td>
<td>1.77 [1.18, 2.66]</td>
</tr>
<tr>
<td>Lien</td>
<td>194</td>
<td>5079</td>
<td>251</td>
<td>13777</td>
<td>9.8%</td>
<td>2.14 [1.77, 2.58]</td>
</tr>
<tr>
<td>Sharma</td>
<td>86</td>
<td>480</td>
<td>109</td>
<td>1136</td>
<td>4.0%</td>
<td>2.06 [1.52, 2.79]</td>
</tr>
<tr>
<td>Shorr</td>
<td>17</td>
<td>46</td>
<td>66</td>
<td>469</td>
<td>0.6%</td>
<td>3.58 [1.86, 6.88]</td>
</tr>
<tr>
<td>Stawicki</td>
<td>1738</td>
<td>8648</td>
<td>2190</td>
<td>19207</td>
<td>81.5%</td>
<td>1.95 [1.82, 2.09]</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>15461</strong></td>
<td><strong>36701</strong></td>
<td><strong>100.0%</strong></td>
<td><strong>1.98 [1.86, 2.11]</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total events</td>
<td>2124</td>
<td>2705</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity: Chi² = 5.06, df = 6 (P = 0.54); I² = 0%
Test for overall effect: Z = 21.67 (P < 0.00001)

Injury, Int. J. Care Injured. 2012; 43: 8–17
Mortality Odds Ratio for >3 Rib Fractures

### Study or Subgroup

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Events</th>
<th>Total</th>
<th>&lt;3 RFs</th>
<th>Events</th>
<th>Total</th>
<th>Weight</th>
<th>Odds Ratio</th>
<th>M.H, Fixed, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flagel</td>
<td>2222</td>
<td>19969</td>
<td>1494</td>
<td>25397</td>
<td>86.4%</td>
<td>2.00</td>
<td>[1.87, 2.14]</td>
<td></td>
</tr>
<tr>
<td>Lee b</td>
<td>97</td>
<td>2477</td>
<td>1837</td>
<td>103016</td>
<td>6.1%</td>
<td>2.24</td>
<td>[1.82, 2.76]</td>
<td></td>
</tr>
<tr>
<td>Lien</td>
<td>43</td>
<td>3018</td>
<td>15</td>
<td>2691</td>
<td>1.2%</td>
<td>2.68</td>
<td>[1.43, 4.65]</td>
<td></td>
</tr>
<tr>
<td>Liman</td>
<td>12</td>
<td>214</td>
<td>1</td>
<td>259</td>
<td>0.1%</td>
<td>15.33</td>
<td>[1.98, 118.85]</td>
<td></td>
</tr>
<tr>
<td>Sharma</td>
<td>174</td>
<td>1208</td>
<td>94</td>
<td>1075</td>
<td>6.3%</td>
<td>1.76</td>
<td>[1.35, 2.29]</td>
<td></td>
</tr>
</tbody>
</table>

**Total (95% CI):**

<table>
<thead>
<tr>
<th>3+ RFs</th>
<th>Events</th>
<th>Total</th>
<th>&lt;3 RFs</th>
<th>Events</th>
<th>Total</th>
<th>Weight</th>
<th>Odds Ratio</th>
<th>M.H, Fixed, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>26886</td>
<td>132438</td>
<td>100.0%</td>
<td>2.02</td>
<td>[1.89, 2.15]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total events:**

| 2548 | 3441 |

**Heterogeneity:** Chi² = 6.53, df = 4 (P = 0.16); I² = 39%

**Test for overall effect:** Z = 21.83 (P < 0.00001)

Injury, Int. J. Care Injured. 2012; 43: 8–17
### Mortality Odds Ratio for Comorbidities

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>PEC Events</th>
<th>PEC Total</th>
<th>No PEC Events</th>
<th>No PEC Total</th>
<th>Weight</th>
<th>Odds Ratio M-H, Fixed, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alexander</td>
<td>3</td>
<td>31</td>
<td>0</td>
<td>31</td>
<td>6.6%</td>
<td>7.74 [0.38, 156.36]</td>
</tr>
<tr>
<td>Barnea</td>
<td>8</td>
<td>49</td>
<td>6</td>
<td>60</td>
<td>67.0%</td>
<td>1.76 [0.57, 5.48]</td>
</tr>
<tr>
<td>Elmistekawy</td>
<td>4</td>
<td>12</td>
<td>5</td>
<td>33</td>
<td>26.4%</td>
<td>2.80 [0.61, 12.95]</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td>92</td>
<td>124</td>
<td>100.0%</td>
<td></td>
<td>2.43</td>
<td>[1.03, 5.72]</td>
</tr>
</tbody>
</table>

Total events: 15 No PEC, 11 PEC

Heterogeneity: Chi² = 0.92, df = 2 (P = 0.63); I² = 0%

Test for overall effect: Z = 2.03 (P = 0.04)

**Injury, Int. J. Care Injured. 2012; 43: 8–17**
Mortality Odds Ratio for Pneumonia

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Pneumonia</th>
<th>No pneumonia</th>
<th>Odds Ratio M-H, Fixed, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bergeron</td>
<td>18</td>
<td>31</td>
<td>5.71 [2.87, 11.37]</td>
</tr>
<tr>
<td>Elmistekawy</td>
<td>3</td>
<td>4</td>
<td>5.25 [0.84, 32.63]</td>
</tr>
<tr>
<td>Harrington</td>
<td>6</td>
<td>27</td>
<td>4.64 [1.83, 11.76]</td>
</tr>
<tr>
<td>Svennevig</td>
<td>21</td>
<td>29</td>
<td>5.09 [2.76, 9.38]</td>
</tr>
<tr>
<td>Total</td>
<td>208</td>
<td>1996</td>
<td>5.24 [3.51, 7.82]</td>
</tr>
</tbody>
</table>

Heterogeneity: Chi² = 0.13, df = 3 (P = 0.99); I² = 0%
Test for overall effect: Z = 8.09 (P < 0.00001)

Injury, Int. J. Care Injured. 2012; 43: 8–17
Flail Chest

- Paradoxical movement of the chest wall
- Fracture of three or more ribs in two or more places
- Causes of resp. failure
  - *Pulmonary contusion*
  - *Mechanical fatigue*
Morbidity of Flail Chest

- Same as before but worse
- Pulmonary contusion
- ARDS
- Associated injury
- Mortality (7% < 65, 29% > 65)
- Permanent chest wall deformity
- Reduced pulmonary function
- Chronic pain
- Chronic dyspnea
- Long term disability
Flail Chest Video from LifeForce
# Pain Control Methods In Chest Wall Trauma

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
<th>Agent</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercostal block</td>
<td>Multiple injections intercostal nerves</td>
<td>Local anesthetic w/wo epinephrine</td>
<td>Simple and ?safe</td>
<td>Ptx, multiple injections</td>
</tr>
<tr>
<td>Intercostal catheter</td>
<td>Catheter provides continuous access to prepleural space</td>
<td>Local anesthetic w/wo epinephrine</td>
<td>Convenient, minimal side effect</td>
<td>Placement difficulty</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Variable success, Repeated success</td>
</tr>
<tr>
<td>Intrapleural catheter</td>
<td>Catheter provides continuous access to pleural space</td>
<td>Local anesthetic w/wo epinephrine</td>
<td>Can be placed w/ chest tube, minimal side effects</td>
<td>Risk of Ptx, Chest tube to seal during medication administration</td>
</tr>
<tr>
<td>Epidural catheter</td>
<td>Catheter provides continuous access to epidural space</td>
<td>Local anesthetic, narcotics or both</td>
<td>Safe, convenient, improved survival in elderly</td>
<td>Placement difficulty, Urinary retention, Pruritis, hypo BP</td>
</tr>
<tr>
<td>Patient Controlled Anesthesia (PCA)</td>
<td>IV narcotics self administered</td>
<td>Narcotics</td>
<td>Immediate dosing comfort, Max limits, Safe</td>
<td>Compliance, Respiratory &amp; bowel depression, Pruritus</td>
</tr>
<tr>
<td>Transdermal Delivery</td>
<td>Cutaneous patch</td>
<td>Fentanyl/lidocaine</td>
<td>Continuous dose</td>
<td>Slow onset, Patient satisfaction</td>
</tr>
<tr>
<td>NSAIDS</td>
<td>Oral, IM, IV</td>
<td>Ibuprofen, Ketorolac</td>
<td>Adjunct to other Tx</td>
<td>Gastritis, renal dysfunction</td>
</tr>
</tbody>
</table>
Historical Treatment of Rib Fractures

- Analgesia
- Strapping
- Sand bags
- Rib blocks
- External traction
- Acrylic paste
- Wire sutures
- Staples
- Kirschner wires
- Intramedullary plates
- Traction splint
Historical Treatment of Rib Fractures

Figure 4—Continued. C. Overhead traction. Whether the injury is a fracture of the sternum, the cartilages, or the ribs, the paradoxically moving portion of the chest may be stabilized by the use of large towel clips fixed into the ribs or other damaged structures or by wire passed underneath them. Stabilization could usually be accomplished successfully by the use of two pulleys and weights, of not more than 5 pounds. D. Wire splint, fixed on either side of flail portion of chest, supports towel clips or wires attached to the fractured ribs by means of rubberbands.
Historical Treatment of Rib Fractures

- Stamen pin stabilization of costochondral separations
- External traction
Historical Treatment of Rib Fractures

Traction-counter traction device
CRITICALLY CRUSHED CHESTS

A NEW METHOD OF TREATMENT WITH CONTINUOUS MECHANICAL HYPERVENTILATION TO PRODUCE ALKALOTIC APNEA AND INTERNAL PNEUMATIC STABILIZATION

Edward E. Avery* (by initiation), E. Trier Mörch. Ph.D., M.D.** (by invitation, and Donald W. Benson, M.D.*** (by invitation)

Chicago, Ill

- Landmark paper introducing concept of positive pressure ventilation (PPV) to “splint open” flail chest
- Promoted external traction methods
- Discussed pro and cons of cuffed vs. cuffless trachs
CRITICALLY CRUSHED CHESTS

A NEW METHOD OF TREATMENT WITH CONTINUOUS MECHANICAL HYPERVENTILATION TO PRODUCE ALKALOTIC APNEA AND INTERNAL PNEUMATIC STABILIZATION

EDWARD E. AVERY* (BY INITATION), E. TRIER MÖRCH. PH.D., M.D.** (BY INVITATION, AND DONALD W. BENSON, M.D.*** (BY INVITATION)
CHICAGO, ILL

- Discussed bronchoscopy to maintain pulmonary hygiene
- Reviewed pros and cons of different types of vents
- Discussed effects of PPV on hemodynamics
- Commented that airway pressures typically should not exceed 30 mmH2O

First report in English

Compared plating to positive pressure ventilation

Plates “curved and cut with a cold chisel”

Mortality 73% (8/11) for non-op and 28.6% (4/14) for plating patients
Operative stabilization of nonpenetrating chest injuries

Bryan P. More (by invitation), London, England
Sponsored by Hermes C. Grillo, M.D., Boston, Mass.

- 112 pts with severe or moderately severe chest injuries
- Highlighted progressive displacement of rib fractures
- Used K-wires to stabilize fractures of the chest wall
- 50 patients surgically treated had perceived reduced rates of
  - Vent dependence
  - Tracheostomy
  - Death
Maxillo-facial plates applied to rib fractures in an animal model and humans with flail chest

Animal model revealed 1° bone healing (bony trabeculae) at 2 weeks with osteosynthesis plates
Cerclage plates and no plating resulted in 2° bone healing (callus) at 4 weeks.

Eight of the twelve surviving humans with osteosynthesis plates had reported very good chest wall stabilization.

Weaning after plating occurred in 3-14 days.
MANAGEMENT OF FLAIL CHEST INJURY: INTERNAL FIXATION VERSUS ENDOTRACHEAL INTUBATION AND VENTILATION

Zahoor Ahmed, FRCS, FICS, FACA and Zahoor Mohyuddin FRCS, FACS, FICS, FICA, Abu Dhabi, United Arab Emirates

- Retrospective review of 64 patients with flail chest requiring PPV
- No explanation regarding indication for plating or continued PPV
- Fixation performed with Kirschner wire “pinned” across fracture site

Operative Chest Wall Stabilization in Flail Chest—Outcomes Of Patients With or Without Pulmonary Contusion

Gregor Voggenreiter, MD, Friedrich Neudeck, MD, Michael Aufmkolk, MD, Udo Obertacke, MD, and Klaus-Peter Schmit-Neuerburg, MD

- 20 patients with flail chest and respiratory failure undergoing chest wall stabilization
- Patients without pulmonary contusion benefitted from plating (6.5±7.0 vs. 26.7±29.0 days, p<0.02)
- Flail chest and pulmonary contusion do not appear to benefit from plating
- Flail segment developing in weaning from the vent appeared to be beneficial
- Plating flail chest at the time of thoracotomy for other causes not indicated

Operative Chest Wall Stabilization in Flail Chest—Outcomes Of Patients With or Without Pulmonary Contusion

Gregor Voggenreiter, MD, Friedrich Neudeck, MD, Michael Aufmkolk, MD, Udo Obertacke, MD, and Klaus-Peter Schmit-Neuerburg, MD

- Introduced the concept of “pillar ribs” - ribs three through seven - crucial in chest wall stabilization
- Don’t need to plate all ribs
- Don’t need to plate all fractures

Pillar ribs 3-7
Surgical Stabilization [or] Internal Pneumatic Stabilization? A Prospective Randomized Study of Management of Severe Flail Chest Patients

Hideharu Tanaka, MD, Tetsuo Yukioka, MD, Yoshihiro Yamaguti MD, Syoichiro Shimizu, MD, Hideaki Goto, MD, Hiroharu Matsuda, and Syuji Shimazaki, MD

- 37 flail chest patients requiring PPV randomized to Judet struts or cont PPV

<table>
<thead>
<tr>
<th>Group</th>
<th>Vent LOS (d)</th>
<th>ICU LOS (d)</th>
<th>VAP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strut (18)</td>
<td>10.8±3.4*</td>
<td>16.5±7.4*</td>
<td>24*</td>
</tr>
<tr>
<td>PPV (19)</td>
<td>18.3±7.4</td>
<td>26.8±13.2</td>
<td>77</td>
</tr>
</tbody>
</table>

*P < 0.05

Pulmonary function testing after operative stabilization of the chest wall for flail chest

D. Lardinois\textsuperscript{a}, T. Krueger\textsuperscript{b}, M. Dusmet\textsuperscript{b}, N. Ghisletta\textsuperscript{a}, N Gugger\textsuperscript{c}, H. –B. Ris\textsuperscript{b}\textsuperscript{*}

\textsuperscript{a}Division of Thoracic Surgery, University Hospital of Berne, Berne Switzerland
\textsuperscript{b}Department of Surgery, University Hospital of Lausanne, Lausanne, Switzerland
\textsuperscript{c}Division of Pulmonary Medicine, University Hospital of Berne, Berne Switzerland

- Plated 66 patients with $>3$ rib flail segment
- No comparison group
- 3 had chronic pain relieved by plate removal
- Return to work 8 weeks (range 3-16)
- Total lung capacity showed restrictive results in 10%

Euro J Cardio-thor Surg 2001; 20: 496-501
Surgical versus conservative treatment of flail chest. Evaluation of the pulmonary Status

Andreas Granetzny\textsuperscript{a}, Mohamad Abd El-Aal\textsuperscript{b}, ElRady Emam\textsuperscript{b}, Alaa Shalaby\textsuperscript{c} and Ahmad Boseila\textsuperscript{a,*}

Department of Thoracic Surgery, Klinikum Evangelisches Krankenhaus Duisburg-Nord, Fahrner Str. 133, Duisburg 47169, Germany
Department of Cardiothoracic Surgery, Faculty of Medicine, Zagazig University, Cairo, Egypt
Department of Chest Medicine, Faculty of Medicine, Cairo, Egypt

- 40 patients randomized to surgical stabilization (k-wire) or adhesive plaster strapping
- 50% of strapping patients and 15% of surgical patients were determined to have unstable chest walls
- 2 months following injury, FVC, TLC, FEV significantly improved in surgical patients

<table>
<thead>
<tr>
<th>Comp.</th>
<th>Grp I No. (%)</th>
<th>Grp II No. (%)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>8 (40)</td>
<td>13 (65)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Chest infection</td>
<td>10 (50)</td>
<td>2 (10)</td>
<td>P=0.014</td>
</tr>
<tr>
<td>Empyema</td>
<td>2 (10)</td>
<td>1 (5)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Pulm. Embol.</td>
<td>1 (5)</td>
<td>0</td>
<td>n.s.</td>
</tr>
<tr>
<td>Mediastinitis</td>
<td>0</td>
<td>2 (10)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Wound infection</td>
<td>0</td>
<td>2 (10)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Chest Deform.</td>
<td>9 (45)</td>
<td>1 (5)</td>
<td>P=0.008</td>
</tr>
<tr>
<td>Scoliosis</td>
<td>5 (25)</td>
<td>0</td>
<td>P=0.047</td>
</tr>
<tr>
<td>Mortality</td>
<td>3 (15)</td>
<td>2 (10)</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

RCT enrolling 46 pts with flail chest mechanically ventilated

More smokers (78 vs 43%) & more ortho/gen surg procedures (74 vs 48%) in Non-op group

No diff in # ribs fractured or pulmonary contusion

Non-op pts had 5.1 days longer ICU LOS & more trach’s

Comparing OR vs ICU costs, surgery saved $14,443/pt

**Surgical versus nonsurgical interventions for flail chest**

<table>
<thead>
<tr>
<th>Study</th>
<th>Total</th>
<th>#</th>
<th>ICU LOS (days)*</th>
<th>Pneumonia(%)*</th>
<th>Mortality(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Op</td>
<td>Non</td>
<td>Op</td>
<td>Non</td>
<td>Op</td>
</tr>
<tr>
<td>Tanaka</td>
<td>18</td>
<td>19</td>
<td>6.5±7.4</td>
<td>26.8±3.2</td>
<td>4 (22)</td>
</tr>
<tr>
<td>Granetzny</td>
<td>20</td>
<td>20</td>
<td>9.6±0.7</td>
<td>14.6±2.7</td>
<td>2 (5)</td>
</tr>
<tr>
<td>Marasco</td>
<td>23</td>
<td>23</td>
<td>13.5</td>
<td>18.7</td>
<td>11 (48)</td>
</tr>
</tbody>
</table>

- *ICU LOS  better for rib plating*
- *Odds ratio of pneumonia 0.36 less for rib plating*
- No difference in mortality
- Need 550 patients to adequately power a study
Case Study #1 - Flail Chest

- 64 year old male ATV crash
- Traveling 50+ m.p.h. according to son
- Hit bumpy area and began rolling
- Scene call via Life Force
- Vital signs stabilized after administration of 1200 ml crystalloid
Case Study #1-Flail Chest

- Noted to have left flail segment
- CT chest performed demonstrating fractures ribs 4-11, flail segment 4-8
- Left chest tube placed
- Admitted to the ICU
- Intraplueral catheter placed
- Tenuous pulmonary status but remained extubated
Case Study #1 - Flail Chest

- Patient further assessed as a rib plating candidate
- Counseled on perceived benefits and risks
- Taken to operating room on hospital day 4
Rib Fracture Plating System

- Color coded, 4.5 cm “malleable” U-plate
- 4 interlocking screws
- Detachable drill guides
- Rib micrometer

Acute Innovations at www.acuteinnovations.com
Case Study #1-Flail Chest

Three month post op chest x-rays
Case Study #2 - Progressive Fracture Subluxation

- 47 year old male motor cycle crash landed on right side
- Trauma consult after transport by local EMS
- Noted to have fractures of ribs 1-12 on the right, pulmonary contusion and grade 2 liver lac
Case Study #2 - Progressive Fracture Subluxation
Case Study #2 - Progressive Fracture Subluxation

Planned incision

Applying screws
Case Study #2 - Progressive Fracture Subluxation

Comminuted fracture fragment

Completed plates
Case Study #2 - Progressive Fracture Subluxation

Incision and pain pump

- 4 weeks post-op patient back to work
- Wound well healed
- Off narcotics

Post-op chest x-ray
Case #3

Hospital Day 0

Hospital Day 2
Right Angled Drill and Screw Driver
Subscapular Exposure and Plating
Case #3

Immediately Postop
Conclusions

- Selective management of patients with chest wall injury optimizes care.
- Non-operative treatment sufficient for most.
- Plating patients with respiratory compromise secondary to flail chest reduces morbidity and length of stay but does not impact mortality.
- Plating patients with displaced, multiple rib fractures, decreased mobility or geriatric patients areas of ongoing interest.
Conclusions

- Comparative data available shows that PFTs significantly improved after rib plating.
- Several commercially available kits now make plating relatively easy.
- Multicenter trials will be necessary to clarify beneficial effects in patients not suffering from flail chest.
# Summary of Indications

<table>
<thead>
<tr>
<th>Inclusion</th>
<th>Exclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Flail chest</td>
<td>• ARDS</td>
</tr>
<tr>
<td>• Displaced rib fractures</td>
<td>• Severe TBI</td>
</tr>
<tr>
<td>• Progressive displacement</td>
<td>• Open abdomen</td>
</tr>
<tr>
<td>• Decreased mobility</td>
<td>• Active infection</td>
</tr>
<tr>
<td>• Geriatric patients</td>
<td>• Prolonged wean</td>
</tr>
</tbody>
</table>
Other Areas of Interest

Farm to table procedure
References

Management of Flail Chest Without Mechanical Ventilation

J. Kent Trinkle, M.D., J David Richardson, M.D., Jerry L. Franz, M.D., Frederick L. Grover, M.D., Kit V. Arom, M.D., And Fritz M. G. Holstrom, M.D.

- Patients with flail chest managed with early tracheostomy and PPV or fluid restriction, methylprednisalone, lasix, albumin, vigorous pulmonary toilet and intercostal n. blocks
- Refuted the notion of *Pendelluft*
- Stressed the importance of the underlying pulmonary contusion and lung injury as the mainstay of therapy

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Early Trach</th>
<th>Conservative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complications</td>
<td>100 %</td>
<td>20 %</td>
</tr>
<tr>
<td>Mortality</td>
<td>20 %</td>
<td>0 %</td>
</tr>
<tr>
<td>Length of Stay</td>
<td>31.3 days</td>
<td>9.3 days</td>
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</tbody>
</table>

427 Prospectively identified patients with “severe” chest trauma requiring hospital admission

Managed selectively based on injury criteria

- Early example of a care pathway
- Careful resus., judicious diuretics, fluid restriction, aggressive pulmonary toilet and selective intubation (no roids)

<table>
<thead>
<tr>
<th>Outcome Variable</th>
<th>Number of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not initially intubated</td>
<td>328</td>
</tr>
<tr>
<td>Successfully treated</td>
<td>318</td>
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<tr>
<td>Failure requiring intubation</td>
<td>10</td>
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<tr>
<td>Deaths in failure group</td>
<td>1</td>
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</tbody>
</table>