Snap into a Slim Rib

By Andrew Prussack, MD
Mentor Douglas Anderson, MD
Disclosures

Nothing to disclose, but open to offers.
Patient History

APS consulted for 69 yo male to help with pain management.

CC: Numerous rib fractures in the setting of multiple injuries s/p fall.

HPI:

- Day 1 s/p 15 ft fall onto cement with LOC
  - 5 U PRBC, Prothrombin Complex Concentrate, TXA
- Transfer to Michigan Medicine
  - Left hemithorax, chest tube
  - Positive FAST → Exploratory Laparotomy
    - Splenic Laceration
Full Catalog of injuries

-Left rib fractures ribs 311

-Right rib fractures ribs 47

-Left hemothorax

-Left L1-L4 Transverse process fractures

-Left superior and inferior pubic ramus fractures

-Fractures to sacrum involving R neural foramen

-Splenic Laceration

-Left retroperitoneal hematom
Notable Medical History

PMH - Tetralogy of Fallot s/p repair, TAA s/p total arch replacement, AAA s/p endovascular repair, Atrial fibrillation, ICD placement, HTN, Stroke w/o residual deficit, CKD stage III, Gout

Medications - Apixaban, Aspirin, Carvedilol, Torsemide, Allopurinol, Colchicine, Acetaminophen, Tramadol

Social History - 60 pack year, quit in 2012
Labs, Imaging and Vitals

- Hgb 6.9, HCT 20.2, PLT 72, INR 1.2
- Cr 2.8, EGFR 22
- Intubated
- Following Commands
- Hemodynamically Stable
- Wide ranging pain scores
Imaging cont.
Prevalence of Rib Fractures and Associated Intrathoracic Injury

- **Rib fractures:**
  - 10% of all trauma patients
  - 30% of patients with Severe chest trauma

- **Flail chest:**
  - estimated to occur in 5-13% of patients with chest wall injury

- **Pneumothorax:**
  - approximately 25% of patients with multiple rib fractures

- **Hemothorax and Pulmonary Contusions**
  - commonly associated with blunt force trauma
Rib Fracture Complications

- Pneumonia:
  - ~ 6% of all patients admitted with one or more rib fractures

- Empyema
  - increased risk in patients with retained hemothorax

- Respiratory Failure

- Chronic Pain/Disability
  - 6 months: 22% chronic pain, 53% disability
Risk Factors

- Age
- Number of Fractures
- Comorbid Conditions
Increased Age

**FIG 1.** Pulmonary complication rates: comparison of the pulmonary complication rates between the elderly and young patients with rib fractures. Significant differences in pneumonia and late pulmonary effusion were noted.
Number of Fractures
Number of Fractures and Age

**FIG 2.** Relationship between pneumonia and number of rib fractures. Increasing pneumonia rates as the number of rib fractures increased were most notable for the elderly group.

**FIG 5.** Relationship between time on the ventilator and number of rib fractures increase in the elderly group.

**FIG 4.** Relationship between mortality and number of rib fractures. Increasing number of rib fractures was associated with increased mortality in both groups with a nearly linear increase in the elderly group.
# Comorbid Conditions

<table>
<thead>
<tr>
<th>Comorbidity</th>
<th>Adjusted Odds Ratio for Mortality (95% CI)</th>
<th>Adjusted Odds Ratio for Pneumonia (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congestive heart failure</td>
<td>2.62 (1.93–3.55)*</td>
<td>2.32 (1.80–2.99)*</td>
</tr>
<tr>
<td>Arrhythmia</td>
<td>1.64 (1.25–2.15)*</td>
<td>1.21 (0.97–1.51)*</td>
</tr>
<tr>
<td>Valvular disease</td>
<td>0.67 (0.34–1.30)</td>
<td>0.92 (0.60–1.40)</td>
</tr>
<tr>
<td>Disorders of pulmonary circulation</td>
<td>1.50 (0.36–6.28)</td>
<td>0.61 (0.17–2.14)</td>
</tr>
<tr>
<td>Peripheral vascular disease</td>
<td>1.16 (0.61–2.21)</td>
<td>0.49 (0.22–1.07)</td>
</tr>
<tr>
<td>Paralysis</td>
<td>0.75 (0.25–2.22)</td>
<td>2.30 (1.16–4.59)*</td>
</tr>
<tr>
<td>Other neurologic disease</td>
<td>2.59 (1.67–4.02)*</td>
<td>0.85 (0.53–1.36)</td>
</tr>
<tr>
<td>Chronic pulmonary disease</td>
<td>1.30 (1.00–1.68)</td>
<td>1.97 (1.62–2.40)*</td>
</tr>
<tr>
<td>Uncomplicated diabetes</td>
<td>0.82 (0.56–1.20)</td>
<td>0.95 (0.72–1.26)</td>
</tr>
<tr>
<td>Complicated diabetes</td>
<td>1.14 (0.53–2.44)</td>
<td>0.63 (0.29–1.38)</td>
</tr>
<tr>
<td>Hypothyroid</td>
<td>0.63 (0.37–1.09)*</td>
<td>0.58 (0.37–0.91)*</td>
</tr>
<tr>
<td>Renal failure</td>
<td>2.52 (1.29–4.09)*</td>
<td>1.29 (0.75–2.22)</td>
</tr>
<tr>
<td>Liver disease</td>
<td>5.26 (2.78–9.95)*</td>
<td>1.08 (0.52–2.22)</td>
</tr>
<tr>
<td>Peptic ulcer</td>
<td>0.29 (0.03–2.45)</td>
<td>0.24 (0.06–0.99)*</td>
</tr>
<tr>
<td>HIV/AIDS</td>
<td>2.30 (0.25–20.96)</td>
<td>1.41 (0.23–8.66)</td>
</tr>
<tr>
<td>Lymphoma</td>
<td>1.88 (0.57–6.14)</td>
<td>1.75 (0.72–4.26)</td>
</tr>
<tr>
<td>Metastatic cancer</td>
<td>6.57 (3.28–13.13)*</td>
<td>2.06 (0.89–4.78)</td>
</tr>
<tr>
<td>Solid tumor</td>
<td>0.81 (0.48–1.34)</td>
<td>0.73 (0.49–1.10)</td>
</tr>
<tr>
<td>Rheumatoid arthritis</td>
<td>0.83 (0.28–2.42)</td>
<td>0.82 (0.40–1.70)</td>
</tr>
<tr>
<td>Obesity</td>
<td>0.43 (0.11–1.75)</td>
<td>2.15 (1.37–3.37)*</td>
</tr>
<tr>
<td>Weight loss</td>
<td>1.26 (0.66–2.39)</td>
<td>3.60 (2.35–5.51)*</td>
</tr>
<tr>
<td>Deficiency anemias</td>
<td>0.42 (0.24–0.73)*</td>
<td>1.02 (0.75–1.37)</td>
</tr>
<tr>
<td>Alcohol abuse</td>
<td>0.52 (0.33–0.80)*</td>
<td>1.25 (0.98–1.59)</td>
</tr>
<tr>
<td>Drug abuse</td>
<td>1.73 (0.92–3.28)</td>
<td>0.94 (0.54–1.62)</td>
</tr>
<tr>
<td>Psychosis</td>
<td>0.10 (0.02–0.68)*</td>
<td>0.98 (0.56–1.74)</td>
</tr>
<tr>
<td>Depression</td>
<td>0.74 (0.36–1.51)</td>
<td>1.17 (0.78–1.74)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>0.55 (0.40–0.74)*</td>
<td>0.67 (0.55–0.81)*</td>
</tr>
</tbody>
</table>

CI, confidence interval.
*Variables significantly associated with mortality or pneumonia.
What is Our Role?

- Patients with rib fractures attempt to limit chest wall motion due to pain
- Reducing tidal volume and avoiding coughing
- Leading to chest wall splinting, alveolar collapse and inability to clear secretions
- Which may result in pulmonary complications

| TABLE 3. OR Estimates of VC on Outcomes
<table>
<thead>
<tr>
<th>Outcome</th>
<th>OR</th>
<th>95% Confidence Interval</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discharge to ECF</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VC (each 10% increase)</td>
<td>0.74</td>
<td>0.65–0.84</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>30–40% vs. &lt;30%</td>
<td>0.54</td>
<td>0.30–0.96</td>
<td>0.04</td>
</tr>
<tr>
<td>40–50% vs. &lt;30%</td>
<td>0.26</td>
<td>0.14–0.48</td>
<td>&lt;0.0001</td>
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<td>&gt;50% vs. &lt;30%</td>
<td>0.29</td>
<td>0.17–0.51</td>
<td>&lt;0.0001</td>
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<td>Pulmonary complication</td>
<td></td>
<td></td>
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</tr>
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<td>0.30–1.05</td>
<td>0.44</td>
</tr>
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<td>40–50% vs. &lt;30%</td>
<td>0.40</td>
<td>0.19–0.84</td>
<td>0.57</td>
</tr>
<tr>
<td>&gt;50% vs. &lt;30%</td>
<td>0.21</td>
<td>0.08–0.52</td>
<td>0.02</td>
</tr>
</tbody>
</table>
Medical Care Recommendations

- **Outpatient Care Considered**
  - <3 fractures
  - No associated injuries
  - Effectively managed by oral analgesics and incentive spirometer

- **Likely Inpatient**
  - >/= 3 fractures
  - Associated injuries
  - Age >65 year old
  - Comorbid Conditions
  - Require more extensive pain management and pulmonary therapy
Pain Management Options for Rib Fractures

- Medication (NSAIDS, multimodal analgesia)
- Opioids
- Transdermal
- Epidural
- Paravertebral
- Erector Spinae
- Intercostal
- Intrapleural
Ketorolac

- Associated with
  - Decrease in ventilator requirement
  - Decrease in ICU stay
  - Decrease in likelihood of pneumonia within 30 days
  - Not found to cause any increase in side effects

<table>
<thead>
<tr>
<th>Adverse outcome</th>
<th>Control (N=417)</th>
<th>Ketorolac (N=202)</th>
<th>Odds ratio* (95% confidence interval)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute kidney injury, n (%)</td>
<td>19 (3)</td>
<td>6 (3)</td>
<td>0.3 (0.1–0.9)</td>
</tr>
<tr>
<td>Myocardial infarction, n (%)</td>
<td>1 (0.2)</td>
<td>0 (0)</td>
<td>—</td>
</tr>
<tr>
<td>Stroke, n (%)</td>
<td>1 (0.2)</td>
<td>0 (0)</td>
<td>—</td>
</tr>
<tr>
<td>Gastrointestinal hemorrhage, n (%)</td>
<td>2 (0.5)</td>
<td>1 (0.5)</td>
<td>1.5 (0.1–22.3)</td>
</tr>
<tr>
<td>Fracture non-union, n (%)</td>
<td>3 (0.7)</td>
<td>2 (1)</td>
<td>2.3 (0.3–15.6)</td>
</tr>
<tr>
<td>Death, n (%)</td>
<td>7 (2)</td>
<td>0 (0)</td>
<td>6.2 (0.5–76.4)</td>
</tr>
</tbody>
</table>

*Adjusted for the number of rib fractures, Abbreviated Injury Scale chest and extremity scores, and the presence of chronic obstructive pulmonary disease
Opioids

- Most common analgesic used for patient with rib fractures

- IV PCA:
  - Advantages
  - Disadvantages
  - Has been shown to improve vital capacity in a few studies
Epidural Advantages

- Improved pain scores
- Improved respiratory function
- Decreased Sedation
Efficacy of Epidural Block

Frequency of Pneumonia in Patients With and Without Epidural Analgesia

Survival by Number of Rib Fractures and Use of Epidural Analgesia
Epidural Efficacy Cont.

- Jensen et al
  - Overall mortality: 6.7%
    - Age >80 years old: ~ 41x mortality
    - >/= 6 ribs: ~ 6x mortality
    - Mechanical ventilation requirement: ~65x mortality
  - Despite greater injury severity there was a .5% lower mortality rate for patients receiving epidurals
Differences in Care

- Large trauma centers have greater resources
  - Dedicated Pain Services
    - Epidural placement
    - Multimodal Pain Management
  - Increased Support Staff
    - Respiratory Therapists
    - Physical Therapists
    - Occupational Therapists
Table 2. Unadjusted univariate analyses of the outcome data of the two study groups

<table>
<thead>
<tr>
<th></th>
<th>Control group (pre-pathway patients) (n = 150)</th>
<th>Study group (post-pathway patients) (n = 150)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical ventilator-dependent days</td>
<td>1.8 ± 6.0</td>
<td>2.6 ± 6.7</td>
<td>.28</td>
</tr>
<tr>
<td>Intensive care unit days</td>
<td>5.3 ± 8.1</td>
<td>3.8 ± 8.1</td>
<td>.13</td>
</tr>
<tr>
<td>Hospital days</td>
<td>14.3 ± 16.9</td>
<td>11.7 ± 10.9</td>
<td>.11</td>
</tr>
<tr>
<td>Pneumonia rate</td>
<td>27 (18%)</td>
<td>7 (5%)</td>
<td>.0003</td>
</tr>
<tr>
<td>Mortality rate</td>
<td>20 (13%)</td>
<td>6 (4%)</td>
<td>.004</td>
</tr>
</tbody>
</table>

Multidisciplinary Pathway

**Rib Fracture Clinical Pathway**
1. Pain consult by pain management optimization (pain service paper 713-608-xxxx)
2. RT consult for Volume Expansion Protocol
3. PT/OT consult (improve patient mobility)
4. Nutrition consult (assessment and improvement)
5. Nurse Practitioner assessment and evaluation of controlled trials during morning rounds
6. Low molecular weight anti-coagulants must not be administered prior to pain consult. If they have been started, they must be held 24 hours prior to epsilon
7. (Pain, and Cough will be assessed and recorded 6 days until patient passes all three criteria for three consecutive days or until discharge from SIMUSTICU

**Rib Fracture Pathway Assessment**
On morning rounds assess
1. SI volume
2. Pain Score (1-10) (dynamic)
3. Cough Score
   - Weak = 1
   - Strong = 2

* patient responsiveness defined
  - In non-intubated patients as GCS >= 13
  - In intubated patients as GCS components ey = 4 and motor = 6
Epidural Disadvantages/Complications

- Technically demanding placement
- Epidural Hematoma
- Epidural Infection
- Postdural Puncture Headache
- Spinal Cord or Nerve Root Damage
- Hypotension
- Opioid side effects
Epidural Contraindications

- Coagulation abnormalities
- Altered mental status/neurologic deficits
- Increased ICP
- Fever/Infection
### Contraindication Survey

<table>
<thead>
<tr>
<th>Contraindication</th>
<th>Support (%)</th>
<th>Corresponding Measures</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platelet count &lt; 50 k</td>
<td>93</td>
<td>LMW heparin w/in 12 h</td>
<td>69</td>
</tr>
<tr>
<td>Cellulitis at insertion site</td>
<td>92</td>
<td>Full spine precautions</td>
<td>68</td>
</tr>
<tr>
<td>Spinal cord injury</td>
<td>90</td>
<td>Platelet count &lt; 80 k</td>
<td>69</td>
</tr>
<tr>
<td>Epidural or spinal cord haematoma</td>
<td>90</td>
<td>TBI (GCS 8–13)</td>
<td>68</td>
</tr>
<tr>
<td>INR &gt; 1.5</td>
<td>90</td>
<td>Patient deeply sedated for vent</td>
<td>69</td>
</tr>
<tr>
<td>LMW heparin w/in 8 h</td>
<td>88</td>
<td>Injury to thoracic aorta</td>
<td>69</td>
</tr>
<tr>
<td>Major TBI (GCS &lt; 8)</td>
<td>83</td>
<td>Ligament disruption thoracic spine</td>
<td>69</td>
</tr>
<tr>
<td>Intracranial haemorrhage</td>
<td>81</td>
<td>Ligament disruption cervical spine</td>
<td>69</td>
</tr>
<tr>
<td>Penetrating head injury</td>
<td>77</td>
<td>Ligament disruption lumbar spine</td>
<td>69</td>
</tr>
<tr>
<td>Haemodynamic instability</td>
<td>74</td>
<td>Unstable pelvic fracture</td>
<td>69</td>
</tr>
<tr>
<td>Unable to obtain consent</td>
<td>69</td>
<td>Normal thoracic spine films, unable to examine</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Transverse process fracture, thoracic spine</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spineous process fracture, thoracic spine</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Normal lumbar spine films, unable to examine</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Transverse process fracture, cervical spine</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spineous process fracture, cervical spine</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Normal cervical spine films, unable to examine</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Respiratory failure w/o impaired mechanics</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spineous process fracture, lumbar spine</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Transverse process fracture, lumbar spine</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.0 &lt; INR &lt; 1.5</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;3 rib fractures</td>
<td>18</td>
</tr>
</tbody>
</table>
Paravertebral Catheter
Paravertebral Efficacy
Paravertebral vs Epidural

**Table 3  Morphine Requirement and Length of Stay**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group TEA (n = 15)</th>
<th>Group TPVB (n = 15)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morphine requirement (mg)</td>
<td>9.2 ± 5.1</td>
<td>11.2 ± 9.5</td>
<td>0.477</td>
</tr>
<tr>
<td>Length of ICU stay (d)</td>
<td>6.3 ± 1.6</td>
<td>6.8 ± 4.2</td>
<td>0.650</td>
</tr>
<tr>
<td>Length of hospital stay (d)</td>
<td>10.1 ± 3.5</td>
<td>11.7 ± 5.5</td>
<td>0.350</td>
</tr>
</tbody>
</table>

**Table 5  Complications of Techniques (No. [%])**

<table>
<thead>
<tr>
<th>Complications</th>
<th>Group TEA (n = 15)</th>
<th>Group TPVB (n = 15)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypotension</td>
<td>6 (40.0)</td>
<td>1 (6.7)</td>
<td>0.04*</td>
</tr>
<tr>
<td>Multiple attempts</td>
<td>2 (13.3)</td>
<td>0 (0)</td>
<td>0.24</td>
</tr>
<tr>
<td>Difficult insertion of catheter</td>
<td>1 (6.7)</td>
<td>0 (0)</td>
<td>0.50</td>
</tr>
<tr>
<td>Convulsions</td>
<td>0 (0)</td>
<td>1 (6.7)</td>
<td>0.50</td>
</tr>
</tbody>
</table>

Fig. 1. Mean VAS scores at rest and on coughing in groups TEA and TPVB.
Paravertebral Coverage
Erector Spinae Block - What is it?

- A novel fascial plane block first described in 2016.
Erector Spinae Coverage
Erector Spinae Case Studies

- Hamilton and Manickam 2017 described the first Erector Spinae block in a patient with rib fractures
  - Patient with unilateral R sided fractures ribs-9

- Nandhakumar et al in 2018 reported on 2 patients receiving Erector Spinae Blocks to help wean off mechanical ventilation
  - 52M with R sided fractures ribs ≥8 with flail chest and R sided clavicle and scapula fractures

  - 46F with unilateral fractures in ribs ≥6 as well as forearm fracture
Erector Spinae vs Epidural/Paravertebral Catheters

- Advantages

- Limitations/Concerns
Case Result

- 4/28-5/3: Epidural placement was deferred

- 5/4: Bilateral Erector Spinae catheter with 20cc .25% ropivacaine bolus, catheters running 10cc/hr .125% bupivacaine
Case Cont.

- 5/7 Catheters removed due to DVT requiring anticoagulation
- 5/8 Reintubated 2/2 splinting and mucus plugging
- 5/10 Patient taken to OR for Rib fixation
- 5/14-5/15 Prolonged recovery, requiring continued intubation
- 6/20 Discharged
Future Option?

Fig 1. Intraoperative photograph shows the drilled holes technique in adjacent ribs during chest closure.

Diagram:
- Cold probe tip
- Ice ball
- Warm stem
- Cool gas out
- Joule-Thomson annulus
Summary

- Rib fractures
  - occur in up to 35% of severe blunt thoracic trauma
  - associated with significant morbidity and mortality
- Older patients and patients with increasing number of fractures are at notably increased risk
- Improved pain control can increase respiratory function and improve outcomes
- Epidural and Paravertebral catheters have been shown to have similar efficacy in managing rib fracture pain
  - Contraindications and limitations can prevent adequate utilization of both
  - Erector Spinae Catheters are a recent addition to our pain management arsenal which may help fill in the gap
References


Ho AM, Karmakar MK, Critchley LA. Acute pain management of patients with multiple fractured ribs: a focus on regional techniques. Curr Opin Crit Care 2011; 17:323.


