Definitions:

- Fracture displacement:
  - Undisplaced - >90% contact between the fracture cortical surfaces
  - Offset – some cortical contact between fracture surfaces, but less than 90%
  - Displaced – no cortical contact between fracture surfaces

- Fracture type:
  - Simple – single fracture line across the rib with no fragmentation or comminution
  - Wedge – a wedge fracture has a second fracture line that does not span the whole width of the rib
  - Complex – at least two fracture lines with one or more fragments that span the width of the rib

- Series of fractures – fractures on neighboring ribs

- Anatomic locations of rib fractures:
  - Anterior – anterior to the anterior axillary line (vertical line from the intersection of the posterior border of the pectoralis major and the second rib)
  - Lateral – between anterior and posterior axillary lines
  - Posterior – posterior to the posterior axillary line (vertical line through the tip of the scapula)

- Flail segment – three of more consecutive ribs with two or more fractures in each rib without clinical paradoxical chest wall movement (i.e. radiographic flail)

- Flail chest – three or more consecutive ribs with two or more fractures in each rib with clinical paradoxical chest wall movement

- Ideal Body Weight (IBW):
  - Men: 50 kg + (2.3kg*(height in inches – 60))
  - Women: 45.5 kg + (2.3kg*(height in inches – 60))

Previously Stated Policies:

- Trauma patients being admitted to SIMU or with ≥ 2 rib fractures should be admitted to trauma service.

Indications for Admission to IMU:

- Age > 45 with a series of four or more fractures and/or flail segment or chest.(1)
- Any age with a series of fractures and/or flail segment or chest and:
  - Poor pain control, or
  - Incentive spirometer (IS) volumes ≤ 15 cc/kg IBW, or
  - Oxygen requirement ≥ 5 L/min nasal cannula
  - Volume expansion protocol (VEP) desired every 2-3 hours (every 4 hours can be done on floor; <2 hours should be done in STICU)

- When the above indications are no longer met, the patient may be transferred to floor.
Indications for Admission to ICU:
- Mechanical ventilation
- VEP < q2 hours
- *When the above indications are no longer met, the patient may be transferred to a lower level of care.*

Initial Management for All Patients Admitted with a Series of Fractures:
- Multimodal pain therapy: [https://med.uth.edu/surgery/acute-trauma-pain-multimodal-therapy/](https://med.uth.edu/surgery/acute-trauma-pain-multimodal-therapy/)
- Volume expansion protocol:
  - Order in Care4: Respiratory Therapy Consult
  - Stepwise progression of therapy employed in the VEP:
    - Incentive spirometry in alert and cooperative patients. If incentive spirometry goal is not achieved, positive expiratory pressure (PEP) is initiated
    - PEP (EzPAP®, MetaNeb®) is performed if patient is:
      - Unable to perform IS-or-
      - Not meeting incentive spirometry goal-or-
      - Has persistent or severe atelectasis-or-
      - Has poor oxygenation
    - Induced deep breathing in patients with a tracheostomy
  - Indications and frequency in the VEP – the RT will assess patient and assign them a RT Triage Score. The frequency of VEP is based on the RT Triage Score:
    | RT Triage Score | VEP Frequency     |
    |-----------------|-------------------|
    | 22-32           | q4 hours and q2 hours prn |
    | 15-21           | QID and q4 hour prn  |
    | 8-14            | TID and q4 hour prn  |
    | 0-7             | BID and q4 hour prn  |
    | Tracheotomies   | q4 hour and q2 hour prn |
  - Patients who meet incentive spirometry goals are discharged from the VEP.
  - Patients with ≥2 rib fractures, a pulmonary contusion, a chest tube, or abdominal/thoracic surgery who meet incentive spirometry goals are seen q shift if STICU/SIMU status and q 48 hours if floor status.
  - If you think patient with adequate incentive spirometry requires more frequent therapy than the VEP calls for, you may order “VEP q _ hour despite IS for ___ hours duration.”
    - VEP can be done q4 on the floor at the most frequent. A patient requiring more frequent treatments should be moved to SIMU or STICU.
- Physical activity:
  - If able, patient should be out of bed for majority of day (in chair and ambulating).
  - For patients who cannot get out of bed, the stationary hand bike may be used.
    - Bike therapy should be used q4 hours during day time.
- Repeat CXR:
  - Patients with a series of fractures and/or flail segment should have a repeat CXR performed 24 hours after admission
  - If the 72-hour CXR shows any opacity concerning for a retained hemothorax, a non-contrast CT chest should immediately be obtained.
  - Clinical judgment should guide the decision to go for video assisted thoracoscopic surgery (VATS) and evacuation of hemothorax. Ideally, the VATS would occur on hospital day 3 or 4.(2)
  - If the hemothorax is estimated to be less than 500 cc, observation may be considered.
Surgical stabilization of rib fractures (SSRF)

- Indications for SSRF at RDTI:
  - Flail segment
  - Flail chest
  - Series of five or more rib fractures
  - One or more rib displaced rib fracture
  - Unstable chest wall
  - Other non-empyema indication for VATS or thoracotomy, especially if fractures preclude stable chest closure

- Contraindications for SSRF at RDTI:
  - Spine injury which precludes the lateral decubitus position
  - Any skin, subcutaneous, or pleural infection (empyema)
  - Severe TBI with active ICP management
  - Uncorrected coagulopathy
  - Respiratory failure requiring advanced ventilator management, inverse ratio ventilation, or inhaled nitric oxide

Regional analgesia (see APPENDIX A)

- May provide superior pain control to multimodal pain regimen in patients with a series of rib fractures
- Consultation with Acute Pain Service is required
- Consider when:
  - Persistent incentive spirometer volumes < 15 cc/kg 24 hours after admission
  - Progression from spontaneous breathing to invasive mechanical ventilation or non-invasive positive pressure ventilation (NIPPV) within 48 hours of admission
  - Increasing FiO2 requirement within 48 hours of admission
  - Inability to wean from mechanical ventilation within 48 hours
  - Persistent pain score > 6 requiring continued IV opioids and/or IMU status 24 hours after admission.
APPENDIX A

Neuraxial techniques:
- **Epidural analgesia (EA)**
  - Associated with lower mortality and decreased pulmonary complications in patients older than 60 years (3)
  - Provides pain control that is superior to systemic (intravenous) opioids, enteral analgesics, and intrapleural analgesia (3-8)
  - Technically challenging
  - May be contraindicated in patients with unstable spine or pelvic fractures or those whose injuries preclude positioning for the procedure
  - Cannot be performed within 12 hours of enoxaparin administration, even at prophylactic doses
  - Complications include hypotension, spinal epidural hematoma, spinal cord injury
- **Thoracic paravertebral nerve blockade (TPVB)**
  - May provide a comparable improvement in pain control compared to EA (9)
  - Is technically easier to perform than EA
  - Can be used in patients with contraindications to EA
  - Complications include inadvertent epidural, intrathecal, or intrapleural injection, pneumothorax, hypotension, and vascular puncture

Non-neuraxial regional techniques:
- Technically easier to perform
- Not associated with hypotension
- **Intercostal nerve blockade (ICNB)**
  - Can provide improved pain control over a limited dermatome distribution (10)
  - Can be performed in patients with contraindications to EA
  - May require multiple injections for sufficient dermatomal coverage, which can increase the risk of local anesthetic toxicity
  - Complications include pneumothorax and vascular puncture
- **Serratus plane block (SPB)**
  - Newer technique, not well-studied
  - May provide improved pain control over a larger dermatome distribution than ICNB
  - Can be performed in patients with contraindications to EA
  - Complications include pneumothorax and vascular puncture
## Relevant Literature Search

### Rib Fractures/Flail Chest – Systematic Reviews

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Study Type</th>
<th>Topic</th>
<th>Study Designs Included</th>
<th>Conclusions</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swart, 2017 (11)</td>
<td>SR/MA</td>
<td>SSRF</td>
<td>All</td>
<td>ORIF decreases ICU days, mortality, pulmonary complications, and hospital days</td>
<td>Results limited by inclusion of low quality studies</td>
</tr>
<tr>
<td>Schuurmans, 2017 (12)</td>
<td>SR</td>
<td>SSRF</td>
<td>RCTs</td>
<td>ORIF decreases pneumonia, ventilator days, ICU days, hospital days, tracheostomy, and cost; no difference in mortality</td>
<td>SR identified all 3 RCTs</td>
</tr>
<tr>
<td>Coughlin, 2016 (13)</td>
<td>SR</td>
<td>Operative treatment of flail chest</td>
<td>RCTs</td>
<td></td>
<td>Same as above</td>
</tr>
<tr>
<td>Cataneo, 2015 (14)</td>
<td>SR</td>
<td>Operative treatment of flail chest</td>
<td>RCTs</td>
<td></td>
<td>Same as above</td>
</tr>
<tr>
<td>Kasotakis, 2017 (15)</td>
<td>PMG</td>
<td>Operative treatment of flail chest</td>
<td>Excluded case reports</td>
<td>Decreased mortality, ventilator days, ICU days, hospital days, pneumonia, tracheostomy</td>
<td></td>
</tr>
<tr>
<td>Slobogean, 2013 (16)</td>
<td>SR</td>
<td>Operative treatment of flail chest</td>
<td>All designs</td>
<td>ORIF decreased ventilator days, pneumonia, ICU days, mortality, and tracheostomy</td>
<td></td>
</tr>
<tr>
<td>Leinicke, 2013 (17)</td>
<td>SR/MA</td>
<td>Operative treatment of flail chest</td>
<td>RCTs and observational studies</td>
<td>ORIF decreased ventilator days, ICU days, mortality, pneumonia, and tracheostomy</td>
<td></td>
</tr>
<tr>
<td>Duch, 2015 (18)</td>
<td>SR</td>
<td>Epidural analgesia versus other analgesia in rib fractures</td>
<td>RCTs</td>
<td>Epidural analgesia decreased ventilator days and pneumonia, though not statistically significant</td>
<td>The 6 included trials were judged to be at high risk of bias</td>
</tr>
<tr>
<td>Carrier, 2009 (19)</td>
<td>SR/MA</td>
<td>Epidural analgesia versus other analgesia in rib fractures</td>
<td>RCTs</td>
<td>No effect of epidural analgesia on mortality, ICU days, hospital days, or ventilator days.</td>
<td></td>
</tr>
<tr>
<td>Simon, 2012 (20)</td>
<td>PMG</td>
<td>Flail chest and pulmonary contusion</td>
<td>No level 1 data for ORIF or regional analgesia.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Rib Fractures/Flail Chest – Randomized Clinical Trials

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Intervention</th>
<th>Control</th>
<th>Primary Outcome</th>
<th>Conclusions</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moskowitz, 2018 (21)</td>
<td>Gabapentin</td>
<td>Placebo</td>
<td>Average daily pain score</td>
<td>No difference in average daily pain score or opioid exposure</td>
<td>Small study (n=40)</td>
</tr>
<tr>
<td>Cheng, 2016 (22)</td>
<td>Lidocaine patch</td>
<td>Placebo</td>
<td>Unclear</td>
<td>Shorter hospital stay and less opioid exposure in lidocaine patch group.</td>
<td>Small study (n=44)</td>
</tr>
<tr>
<td>Ingalls, 2010 (23)</td>
<td>Lidocaine patch</td>
<td>Placebo</td>
<td>Opioid exposure</td>
<td>No difference in opioid exposure</td>
<td>Small study (n=58)</td>
</tr>
<tr>
<td>Mohta, 2009 (9)</td>
<td>Thoracic paravertebral block</td>
<td>Thoracic epidural analgesia</td>
<td>Unclear</td>
<td>No difference in pain scores or other outcomes</td>
<td>Small study (n=30)</td>
</tr>
<tr>
<td>Yeying, 2017 (24)</td>
<td>Thoracic paravertebral block</td>
<td>IV PCA</td>
<td>Pain scores</td>
<td>Decreased pain scores with thoracic paravertebral blocks</td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Intervention</td>
<td>Control</td>
<td>Outcomes</td>
<td>Study Type (n)</td>
<td></td>
</tr>
<tr>
<td>--------------------</td>
<td>--------------</td>
<td>---------</td>
<td>--------------------------------------------------------------------------</td>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td>Marasco, 2013</td>
<td>SSRF</td>
<td>Usual Care</td>
<td>Ventilator and ICU days</td>
<td>SSRF decreased ICU length of stay.</td>
<td>Small study (n=44)</td>
</tr>
<tr>
<td>Tanaka, 2002</td>
<td>SSRF</td>
<td>Usual Care</td>
<td>Unclear</td>
<td>Shorter ICU length of stay and lower cost.</td>
<td>Small study (n=37)</td>
</tr>
<tr>
<td>Granetzny, 2005</td>
<td>SSRF</td>
<td>Usual Care</td>
<td>Unclear</td>
<td>Fewer ventilator, ICU, and hospital days</td>
<td>Small study (n=40)</td>
</tr>
<tr>
<td>Bulger, 2004</td>
<td>Epidural analgesia</td>
<td>IV opioids</td>
<td>Pneumonia</td>
<td>Epidural analgesia decreased rate of pneumonia and ventilator days.</td>
<td>Small study (n=46); Study notes difficulty in providing epidural analgesia in trauma population.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Search</th>
<th>Database</th>
<th>Search Term</th>
<th>Limits</th>
<th>Total Yield: # of Articles</th>
<th># Excluded Articles</th>
<th># Included Articles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PubMed</td>
<td>“rib fractures” OR “flail chest”</td>
<td>Randomize Clinical Trial/English/Humans</td>
<td>39</td>
<td>30</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>PubMed</td>
<td>“rib fractures” OR “flail chest”</td>
<td>Systematic Review</td>
<td>62</td>
<td>52</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td># Included Papers 19 (9 RCTs, 8 SRs, 2 PMGs)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
References: