

Trauma Services BC  
Specialist Trauma Advisory Network

Thoraco-Abdominal Trauma  
Specialist Advisory Group

# Clinical Practice Guideline

for the management of

## MULTIPLE RIB FRACTURES AND FLAIL CHEST

in-hospital management of adults 16 years of age or older

Version 1.0  
September 2024

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### Purpose

The purpose of this clinical practice guideline (CPG) is to review best evidence and generate expert consensus on recommendations for the management of rib fractures in adult patients (age  $\geq 16$  years) in B.C.

### Key management questions

#### I. INITIAL MANAGEMENT OF MULTIPLE RIB FRACTURES AND FLAIL CHEST

1. What is the optimal approach to care of patients with multiple rib fractures with and without flail chest?
2. What is the optimal analgesic management for patients with multiple rib fractures with and without flail chest?
3. What is the indication for open reduction and internal fixation (ORIF) in the management of rib fractures?
4. What is the preferred approach to diagnostic imaging for the assessment of rib fractures?
5. What is the optimal time period within which acute rib fixation should be accomplished?

#### II. PULMONARY CONTUSION

6. What is the optimal management of severe pulmonary contusion?

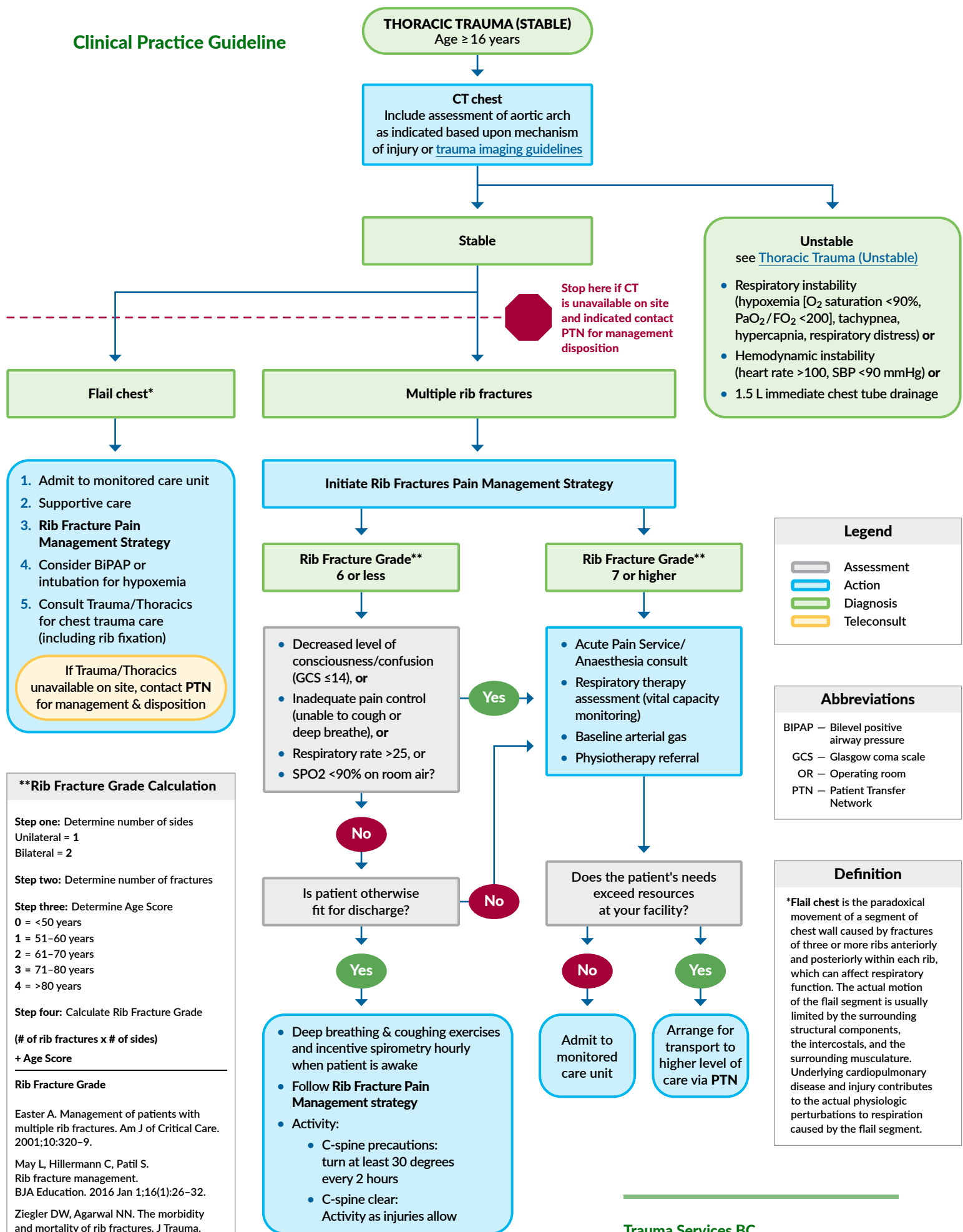
#### III. TRANSFER TO HIGHER LEVEL OF CARE

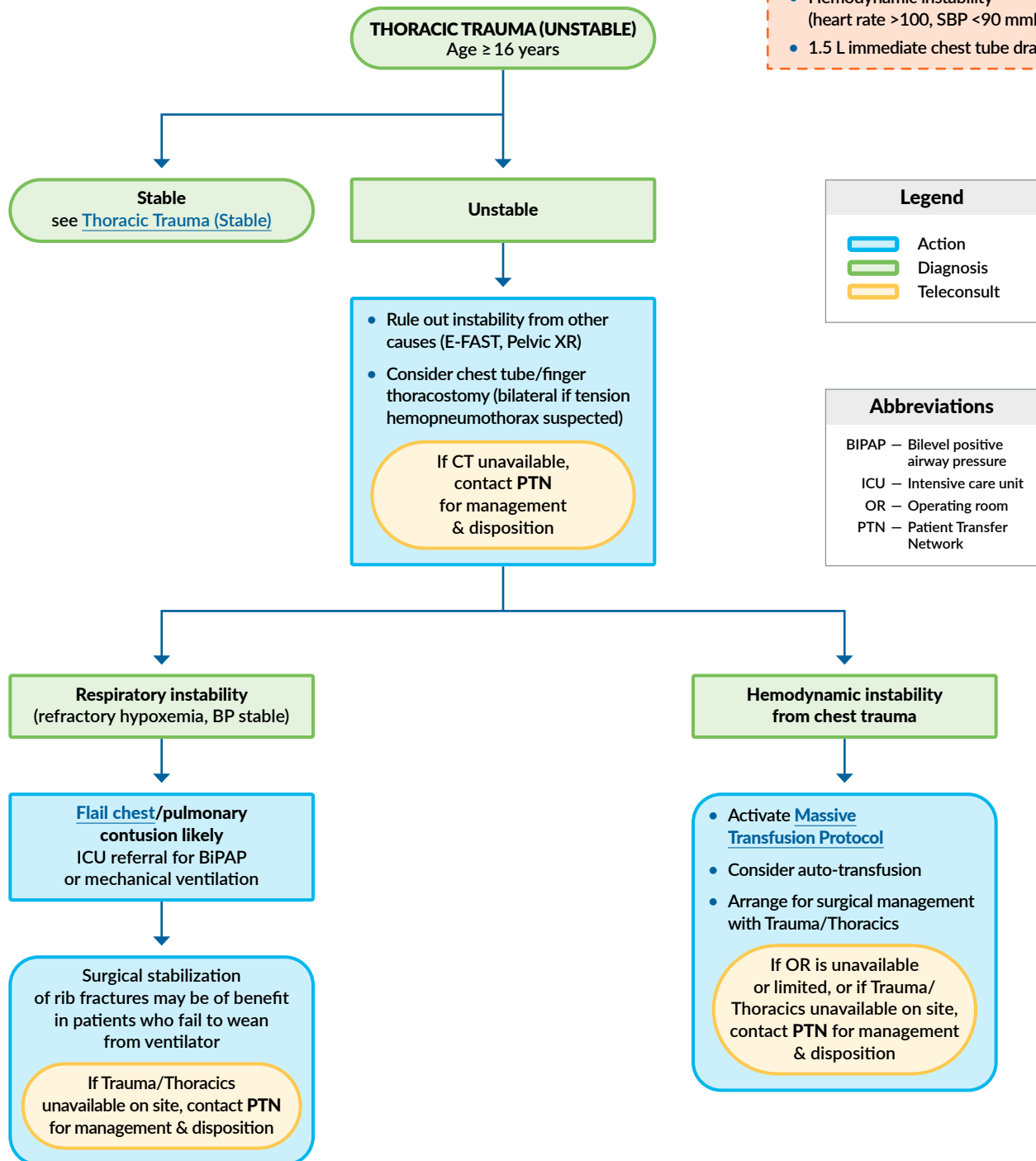
7. What are the major considerations for transfer to higher level of care for patients with multiple rib fractures or flail chest?

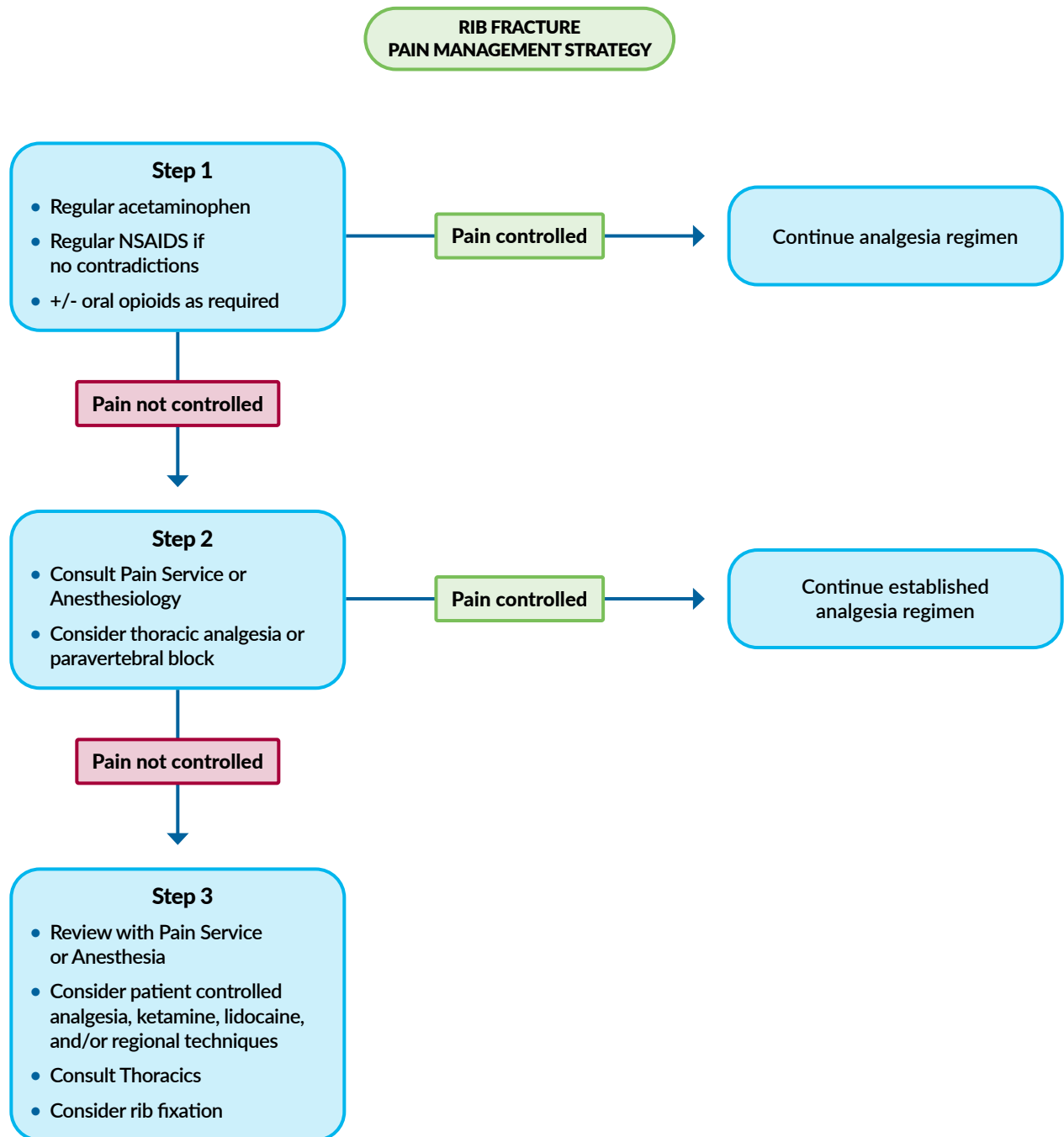
## Guidelines referenced

ORGANIZATION	TITLE, YEAR	CITATION	GRADING SYSTEM
Eastern Association for the Surgery of Trauma	Pain management for blunt thoracic trauma: A joint practice management guideline from the Eastern Association for the Surgery of Trauma and Trauma Anesthesiology Society, 2016 <sup>1</sup>	EAST/TAS 2016	GRADE Framework
American Pain Society	Management of Postoperative Pain: A Clinical Practice Guideline from the American Pain Society, the American Society of Regional Anesthesia and Pain Medicine, and the American Society of Anesthesiologists' Committee on Regional Anesthesia, Executive Committee, and Administrative Council, 2016 <sup>2</sup>	APS	Systemic review of literature and Delphi method
Eastern Association for the Surgery of Trauma	Operative fixation of rib fractures after blunt trauma: A practice management guideline from the Eastern Association for the Surgery of Trauma, 2017 <sup>3</sup>	EAST 2017	GRADE Framework
Rib Fracture Colloquium (Park City, UT, March 19–20, 2016)	Consensus statement: Surgical stabilization of rib fractures rib fracture colloquium clinical practice guidelines, 2017 <sup>4</sup>	Colloquium	GRADE and Delphi methods
Eastern Association for the Surgery of Trauma	Management of pulmonary contusion and flail chest: An Eastern Association for the Surgery of Trauma practice management guideline, 2012 <sup>2</sup>	EAST 2012	<p><b>Level 1:</b> Convincingly justifiable based on available scientific information alone. Supported by prospective randomized studies or prospective, noncomparative studies or retrospective series with controls.</p> <p><b>Level 2:</b> Reasonably justifiable by available scientific evidence and strongly supported by expert opinion. Supported by prospective, noncomparative studies or retrospective series with controls or a preponderance of retrospective analyses.</p> <p><b>Level 3:</b> Supported by available data but lacking adequate evidence. Supported by retrospective analyses.</p>

## Clinical Practice Guideline









## Summary of recommendations

Recommendations are newly drafted by the Thoraco-Abdominal Specialist Advisory Group, unless indicated otherwise.

### I. INITIAL MANAGEMENT OF MULTIPLE RIB FRACTURES AND FLAIL CHEST

#### 1. Optimal care of patients with multiple rib fractures with and without flail chest

- A. The optimal early management of patients with multiple rib fractures, including patients with flail chest not requiring mechanical ventilation, includes [adapted from EAST 2012]:
  - i. Early initiation of an effective pain management strategy according to an established institutional protocol (see below).
  - ii. The use of a standardized pain scale to quantify a patient's pain and monitor response to treatment. Pain levels should be clearly communicated to treating physicians and other providers along with the dosage and interval of administration of analgesic medication.
  - iii. For facilities managing patients with moderate or severe blunt chest trauma, easy access to the following:
    - Closed intensive care unit (ICU)
    - High acuity monitored nursing unit
    - Ability to implement regional analgesia
    - Ability to provide supportive physiotherapy at a reasonable frequency
    - Ability to intubate and mechanically ventilate in the event of precipitous decompensation
  - iv. Admission to an monitored care unit for monitoring and supportive care for any of the following criteria which are considered high-risk:
    - Rib Fracture Grading Score  $\geq 7$  (see [Appendix A](#) for calculation)
    - Decreased level of consciousness (GCS  $\leq 14$ )
    - Unable to establish effective and appropriate pain control (unable to cough or deep breathe)
    - Tachypnea (respiratory rate  $>25$ )
    - Hypoxia (SpO<sub>2</sub>  $<90\%$  on room air)
    - Hypercarbia with respiratory acidosis
  - v. Humidified oxygen to maintain SpO<sub>2</sub>  $>92\%$  in normal healthy patients, or SpO<sub>2</sub>  $>88\%$  in patients with chronic obstructive pulmonary disease (COPD).
  - vi. Early use of incentive spirometry.
  - vii. Coughing to clear secretions, assisted by nebulized saline and bronchodilators as needed.
  - viii. Early aggressive chest physiotherapy.
  - ix. Early mobilization.

- B.** Patients with blunt chest trauma experiencing respiratory distress despite the prompt initiation of the supportive care measures cited above should undergo early assessment by a critical care physician or ICU outreach team.
- C.** Obligatory mechanical ventilation in the absence of respiratory failure solely for the purpose of overcoming chest wall instability should be avoided. [Adopted from EAST 2012]

## **2. Optimal analgesic management of patients with multiple rib fractures with and without flail chest**

- A.** The use of multi-modal analgesia is recommended over opioids alone for blunt thoracic trauma. [Adapted from APS and EAST/TAS 2016].
- B.** Multi-modal analgesia should involve:
  - i.** Use of a scheduled anti-inflammatory agent, unless contra-indicated.
  - ii.** Scheduled acetaminophen, unless contraindicated.
  - iii.** A combination of oral, intravenous (IV), and/or subcutaneous opioids are recommended, with the oral route preferred over IV administration whenever possible. [Adapted from EAST/TAS 2016].
  - iv.** The total dosage of opioid analgesia should be minimized and aggressively weaned provided satisfactory analgesia is achieved.
  - v.** Additional agents targeting neuropathic pain including gabapentin, pregabalin, and/or clonidine may be added if multimodal pain therapy with acetaminophen, non-steroidal anti-inflammatory agents, and opioid agents is ineffective.
- C.** Pain specialist or acute pain service consultation is recommended for any patient meeting the criteria for admission to a monitored care unit (see 1-A-iv above). One or more of the following pain management strategies is recommended for patients requiring high doses of opioid:
  - i.** Regional anesthesia (continuous epidural analgesia) implemented early (within 4 hours of initial presentation) is strongly recommended for all suitable patients without contraindication, notably those with more than four rib fractures, frailty, advanced age (>70 years), or pain that is poorly controlled by standard multi-modal analgesia.
  - ii.** Patient-controlled analgesia (PCA) if IV opioids are effective and regularly required.
  - iii.** Ketamine infusions may be added on an individual basis.
  - iv.** Lidocaine infusions may be added on an individual basis at sites with protocols in place.
  - v.** If none of the above are available, intercostal nerve blocks can be considered for uncontrolled pain as a second line alternative to epidural analgesia or PCA when a dedicated clinical service or physician is available to monitor and manage effectiveness.

- D. Consultation should be made to chronic pain or addiction services or an appropriate specialist for patients with a known or suspected history of drug abuse or excessive chronic opioid use and for patients taking suboxone or methadone. The use of  $\geq 100$  mg per day of morphine (or equivalent) or IV opioid use generally defines excessive opioid use. For the patients with chronic pain and addiction, there should be a lower threshold for using a regional anesthetic technique and/or for ketamine infusion.
- E. Epidural catheter is the preferred mode of analgesia delivery in severe flail chest injury. [Adopted from EAST 2012]
- F. For patients who exceed the capabilities of the receiving site to provide adequate monitoring, analgesia, and supportive care, transfer to higher level of care is appropriate. (See **TRANSFER TO HIGHER LEVEL OF CARE**)

### 3. Indication for open reduction and internal fixation (ORIF) of rib fractures

- A. Patients with flail chest or multiple severely displaced rib fractures should be assessed for surgical stabilization of the chest wall. [Adopted from Colloquium]
- B. Patients who are likely to fail to wean from mechanical ventilation should be assessed for early surgical stabilization of rib fractures.
- C. Consider referral for rib fixation in the following situations:
  - Impending respiratory failure
  - Inability to wean off of ventilator
  - Refractory pain
  - Chest wall deformity

### 4. Preferred approach to diagnostic imaging for the assessment of rib fractures

- A. Chest computerized tomography (CT) is required for the assessment of all patients with suspected moderate or severe blunt chest trauma. Chest CT is required to evaluate criteria for open reduction and internal stabilization of rib fractures. Volume rendered 3D reconstructions may be helpful for surgical planning when there are multiple rib fractures or flail chest. [BC Guidelines for Diagnostic Imaging of Polytrauma]

### 5. Optimal time period within which acute rib fixation should be accomplished

- A. The recommended target for accomplishing rib fixation is 72 hours post injury.

## II. PULMONARY CONTUSION

- A. Patients with pulmonary contusion/flail chest requiring mechanical ventilation should be supported in a manner based on institutional and physician preference. [Adopted from EAST 2012 with modification] These patients may require transfer to higher level of care. (See **III. TRANSFER TO HIGHER LEVEL OF CARE** below)
- B. A trial of mask CPAP/BIPAP may be of benefit in alert, compliant patients with marginal respiratory status in combination with optimal regional anesthesia. [Adopted from EAST 2012] (See **I. INITIAL MANAGEMENT – 1. Optimal analgesic management** above)
- C. Steroids should not be used in the therapy of pulmonary contusion. [Adopted from EAST 2012]

## III. TRANSFER TO HIGHER LEVEL OF CARE

- A. Clinicians outside of trauma hospitals should initiate tele-conferencing through Patient Transfer Network (PTN) to discuss optimal management of the patient with multiple rib fractures or flail chest and indications for transfer to higher level of care (HLOC). The conference call should include the receiving Trauma Team Leader (TTL) at the HLOC trauma referral centre. Indications for transfer include:
  - i. Need for admission to ICU or an intermediate care unit.
  - ii. Indication for surgical chest wall stabilization by open reduction and internal fixation. The appropriateness of HLOC transfer for rib fixation should be ascertained at the sending facility prior to transfer. The MRP at the sending facility should initiate the transfer request through PTN after pushing CT images to the picture archiving and communication system (PACS) grid. If the receiving surgeon feels that the patient meets eligibility criteria for rib fixation, and is otherwise suitable to undergo surgery, transfer should be accomplished to enable the accomplishment of surgical stabilization within the target interval of 72 hours.

## Scientific review

### I. MANAGEMENT OF MULTIPLE RIB FRACTURES AND FLAIL CHEST

Flail chest is the paradoxical movement of a segment of chest wall caused by fractures anteriorly and posteriorly within three or more adjacent ribs, which can derange respiratory function. The paradoxical motion of the flail segment is usually limited by surrounding structural components, and principally the intercostal musculature. Underlying cardiopulmonary disease and injury contributes to the physiologic perturbations to respiration caused by the flail segment.

#### KMQ-1. What is the optimal analgesic management in multiple rib fractures and flail chest?

##### Epidural Analgesia

- Recent studies show epidural analgesia is associated with significantly lower mortality compared to non-epidural analgesia in patients with chest trauma.<sup>6,7</sup>
- Findings in the literature are mixed with regard to the benefits of epidural analgesia on morbidity, length of stay ICU and hospital, and duration on mechanical ventilation in patients with chest trauma:
  - A randomized trial found a 6-fold increased risk of pneumonia and two-fold increase in ventilator days in patients with  $\geq 3$  rib fractures receiving IV opioids compared to those receiving epidural analgesia.<sup>8</sup>
  - Meta-analyses found epidural analgesia does not significantly affect mortality, length of stay in ICU and hospital, or duration of mechanical ventilation.<sup>1,9,10</sup> One of these studies found that combining epidural analgesia with local anaesthetics resulted in decrease in days on mechanical ventilation.
  - Recently, a large registry study comparing epidural analgesia and paravertebral block showed no difference in length of stay in ICU or hospital, duration of mechanical ventilation, or development of pneumonia. Patients who did not receive any regional analgesia had longer length of stay and more frequent ICU admissions.<sup>11</sup>
  - A multi-centre retrospective study (n=836) found no difference in pneumonia, empyema, reintubation, or pulmonary embolism between epidural and non-epidural analgesia.<sup>7</sup>
- Meta-analysis by EAST shows epidural analgesia produced lower pain results at 24 and 48 hours but not at 72 hours in patients with chest trauma.<sup>1</sup>
- Epidural analgesia requires technical competence and monitoring to avoid and manage complications which include: dural puncture, spinal cord injury, hypotension, cardiac arrest, urinary retention, pruritus, headache, infection, hematoma, and motor block limiting mobility.<sup>12,13</sup>

**Patient-Controlled Analgesia**

- A randomized study showed the IV patient-controlled analgesia to be inferior to paravertebral block in reducing pain (at rest and during coughing) and improving pulmonary function in patients with chest trauma, as well as having a higher incidence of complications ( $p < 0.05$ ).<sup>14</sup>
- In the context of multimodal pain management, while oral opioids are preferred to intravenous administration, patient-controlled analgesia should be used if IV is required in patients with chest trauma.<sup>15</sup>
- A small, randomized study ( $n=60$ ) found improved arterial oxygenation function and accelerated recovery of pulmonary function in patients with chest trauma receiving ultrasound-guided patient-controlled paravertebral block compared to those on patient-controlled IV analgesia.<sup>15</sup>

**Intercostal Block**

- There are no randomized controlled trials or meta-analyses available on this topic.
- A single site prospective study ( $n=102$ ) found significant improvements in pain, respiratory rate ( $p < 0.05$ ) and shorter average length of stay in hospital (2.9 days vs. 5.9 in historical control) in patients receiving continuous intercostal nerve block (0.2% ropivacaine infusion), with no complications.<sup>16</sup>
- A small retrospective study ( $n=54$ ) found dramatic decrease in pain immediately following administration of the intercostal nerve block compared to controls ( $p=0.007$ ) but the pain control effects decreased over time (no significant difference observed 1 day and 7 days after procedure).<sup>17</sup> The authors suggest combining intercostal blocks with other modalities to manage pain.
- Intercostal blocks require an injection at the level of the fracture and one above and below. Multiple rib fractures thus require several injections, presenting potential risk of pneumothorax and local anesthetic toxicity.<sup>14</sup>

**Additional Analgesic Options**

- A double-blind RCT ( $n=36$ ) comparing IV lidocaine with usual analgesic and placebo showed a significant reduction in pain with movement in patients with two or more traumatic rib fractures.<sup>18</sup> A retrospective study ( $n=89$ ) over a 5-year period compared IV lidocaine with epidural analgesia for traumatic rib fractures and found similar reductions in pain scores, with potential opioid-sparing effect for IV lidocaine compared.<sup>19</sup> These findings suggest that IV lidocaine may be considered as an analgesic modality.

## EXTERNAL RECOMMENDATIONS

RECOMMENDATIONS	COMMENTS
1. The panel recommends that clinicians offer multimodal analgesia, or the use of a variety of analgesic medications and techniques combined with nonpharmacological interventions, for the treatment of postoperative pain in adults. [APS – Strong recommendation, high-quality evidence]	Adopted and combined with EAST/TAS statement (#2 below) to create Recommendation A.
2. In patients with blunt thoracic trauma, we conditionally recommend the use of multimodal analgesia versus opioids alone to improve analgesia and patient outcomes [EAST/TAS 2016 – low quality evidence]	Adopted and combined with AP statement (#1 above) to create Recommendation A.
3. In patients with blunt thoracic trauma, we conditionally recommend the use of epidural analgesia versus opioids alone to improve analgesia and patient outcomes. [EAST/TAS 2016 – very low quality evidence]	Implicit in Recommendation A.
4. There is insufficient evidence to prove the effectiveness of paravertebral analgesia in the trauma population. However, this modality may be equivalent to epidural analgesia and may be considered in certain situations when epidural is contraindicated. [EAST 2012 – Level 3]	Incorporated as optional regional anesthesia (Recommendation E).

**KMQ-2. What is the optimal non-analgesic management of multiple rib fractures and flail chest?****Multidisciplinary Care of Multiple Rib Fractures and Flail Chest**

- Important in managing multiple rib fractures is respiratory therapy involving aggressive pulmonary hygiene, as well as lung expansion (via incentive spirometry and positive expiratory pressure therapy devices) and secretion clearance (via vibratory mechanisms, coughing and airway suctioning) to prevent pneumonia and respiratory complications.<sup>15</sup> Standardizing these therapies into a multidisciplinary management protocol has been shown to improve patient outcomes.
- Case – Houston, Texas:<sup>20</sup>
  - **Protocol:** Patients age  $\geq 45$  years with  $>4$  rib fractures were admitted to a monitored bed (intermediate or intensive care unit). Patients received patient-controlled analgesia and incentive spirometry upon admission and are evaluated for pain, inspiratory volume ( $\geq 15$  mL/kg) and cough for the first 3 days. Patients who failed one or more of the above 3 criteria in the first 3 days entered into multidisciplinary clinical pathway:
    1. Pain consult (oral, IV and epidural analgesia) (Note: Do not start LMWH prior to pain consult. If they have been started, they must be withheld 24 hours prior to epidural)
    2. Respiratory therapy consult
    3. Physical/occupational therapy consult (optimize mobility)
    4. Nutrition consult
    5. Nurse Practitioner assessment
    6. Patients who entered into a multidisciplinary clinical pathway passed all 3 entrance criteria on 3 consecutive days, they were removed from the pathway.
  - **Results:** decreased ICU length of stay by 2.4 days ( $p=0.01$ ) and hospital length of stay by 3.7 days ( $p=0.02$ ), as well as decrease in pneumonia and mortality.

**EXTERNAL RECOMMENDATIONS**

RECOMMENDATIONS	COMMENTS
1. Obligatory mechanical ventilation in the absence of respiratory failure solely for the purpose of overcoming chest wall instability should be avoided [EAST 2012 – Level 2]	Adopted (Recommendation L)
2. The use of optimal analgesia and aggressive chest physiotherapy should be applied to minimize the likelihood of respiratory failure and ensuing ventilatory support. [EAST 2012 – Level 2]	Incorporated into Recommendations I and J
3. Self-activating multidisciplinary protocols for the treatment of chest wall injuries may improve outcome and should be considered where feasible. [EAST 2012 – Level 3]	Incorporated into Recommendation K



**KMQ-3. What is the indication for surgical stabilization in the setting of multiple rib fractures or flail chest?****Surgical fixation of flail chest**

- **Indications:** All possible indications are considered relative (not absolute) due to limited evidence. A large number of studies accept flail chest as an indication for surgical fixation but the quality of evidence is low.<sup>5, 15</sup> Multiple severely (bicortical) displaced fractures, significant chest wall deformity, and inadequate pain control have also been suggested as possible indications for acute surgical fixation.<sup>15, 21</sup>
- **Contraindications:** Pulmonary contusion and severe brain injury have been reported to result in poor outcomes<sup>22, 23</sup> but stronger evidence is needed.<sup>16, 23</sup> Other contraindications include respiratory failure not related to chest wall injury, spine instability, other injuries requiring prolonged intubation, and patient unable to tolerate surgery.<sup>15</sup>
- The majority of published studies involve ventilated patients and data on the management of non-intubated patients is lacking.<sup>15</sup>

**Effect of surgical fixation on survival, ICU length of stay, duration on mechanical ventilation, hospital length of stay, and chronic pain**

- Only three studies compare surgical fixation with non-operative multidisciplinary management, the latter involving multimodal analgesia, chest therapy, pulmonary toileting, and positive pressure ventilation, with opposing results.
  - Pieracci and colleagues<sup>24</sup> found the operative group had a significantly lower likelihood of both respiratory failure (76%) and tracheostomy (82%), shorter duration of ventilation (by 5 days), and higher median daily spirometry value (by 250 mL). [Note: This study included injuries beyond flail chest]
  - Farquhar and colleagues<sup>25</sup> found significantly better outcomes for non-operative multidisciplinary management for ventilator days (3.1 vs. 6.1 days,  $p=0.012$ ), length of stay in the intensive care unit (3.7 vs. 7.4 days,  $p=0.009$ ), total hospital length of stay (16.0 vs. 21.9 days,  $p=0.044$ ) and rates of pneumonia (22% vs. 63%,  $p=0.004$ ).
  - Beks and colleagues<sup>26</sup> found no significant advantage for surgical fixation of rib fractures ( $\geq 3$  rib fractures) compared to non-operative management. Rib fixation was not associated with improved intensive care length of stay for flail chest patients, nor with hospital length of stay for multiple rib fracture patients. The authors
- **Long-term benefits:** A prospective study showed patients receiving surgical fixation of rib fractures progressively improved in pain, mobility activity, quality of life, lung function, and disability during the first operative year.<sup>27</sup> Another prospective controlled trial (combining randomization and observation) comparing surgical fixation (within 72 hours) with non-operative management in patients with rib fractures ( $\geq 3$  ipsilateral, severely displaced rib fractures) but no flail chest found at 2-week follow-up significantly lower numeric pain score, improved quality of life, and lower pleural space complications, as well as a lower trend in narcotic consumption, in the surgical group.<sup>28</sup>

## EXTERNAL RECOMMENDATIONS

RECOMMENDATIONS	COMMENTS
1. Surgical stabilization of rib fracture (SSRF) should be considered in all patients with flail chest. [Colloquium – Level 2b, Grade B] SSRF should be considered in patients with multiple, severe (bicortical) displaced fractures. [Level 4, Grade C]	Combined into Recommendation A.
2. SSRF should be considered in patients who fail early, optimal non-operative management, regardless of radiographic fracture pattern. [Colloquium – Level 5, Grade D]	Modified into Recommendation B, due to evidence supporting the benefits of surgical stabilization reducing duration on mechanical ventilation and ICU stay (see Additional Literature Support below).
3. Pulmonary contusion should not be considered an absolute contra-indication to SSRF; patients with pulmonary contusion should be evaluated for SSRF on an individual case basis. [Colloquium – Level 5, Grade D, i.e., lowest quality of evidence and strength of recommendation]  Traumatic brain injury should not be considered an absolute contraindication to SSRF; patients with TBI be evaluated for SSRF on an individual case basis. [Level 5, Grade D, i.e., lowest quality of evidence and strength of recommendation]	Not included, as strong evidence is lacking (see Additional Literature Support below).  Clinicians outside lead trauma hospitals should initiate tele-conferencing through Patient Transfer Network (PTN) (see Recommendation A under <b>TRANSFER TO HIGHER LEVEL OF CARE</b> ).
4. We conditionally recommend operative rib ORIF compared to nonoperative management, to decrease mortality; shorten duration of mechanical ventilation, ICU length of stay (LOS), and hospital LOS; incidence of pneumonia, and need for tracheostomy. [EAST 2022 – low quality evidence]	See Recommendation A – the SAG recommends assessing the patient, via tele-conference consultation if needed, for the optimal management of rib fractures/flail chest.
5. Although improvement has not been definitively shown in any outcome parameter after surgical fixation of flail chest, this modality may be considered in cases of severe flail chest failing to wean from the ventilator or when thoracotomy is required for other reasons. The patient subgroup that would benefit from early “prophylactic” fracture fixation has not been identified. [EAST 2012 – Level 3]	Modified into Recommendation B.

**KMQ-4. What are the imaging requirements for surgical stabilization of rib fractures?****2D versus 3D CT for preoperative planning in flail chest**

- No study has yet compared the two CT imaging modalities in terms of their impact on preoperative planning for flail chest.<sup>4</sup>
- CT chest with 3D reconstruction has been suggested for preoperative planning to assist with fracture identification, selection of fractures for fixation, and assessment of pleural space.<sup>16</sup>

**KMQ-5. What is the optimal timing within which acute rib fixation should be accomplished?****Benefits of early surgical fixation of rib fractures**

- A prospective controlled multi-centre study suggests surgical stabilization of rib fractures within 1 day of admission. Each additional hospital day before surgical fixation was associated with increased likelihoods of pneumonia (31%), prolonged mechanical ventilation (27%), and tracheostomy (26%).<sup>29</sup>
- Most recent studies have performed surgical fixation with 72 hours of injury.<sup>26, 27, 30, 31</sup>
- Other benefits of early surgical fixation include less inflammation and callous formation, an early opportunity to evacuate the pleural space and place directed analgesia catheters, and less likelihood of further displacement.<sup>4, 16</sup>
- **Contraindications** to early fixation: Hemodynamic instability, other higher priority injuries (such as spine fractures and pulmonary contusion), and limited trial of non-operative management.<sup>4</sup>

**EXTERNAL RECOMMENDATIONS**

RECOMMENDATIONS	COMMENTS
1. Surgical stabilization of rib fractures should take place within 72 hours of injury. [Colloquium – Level 5, Grade D, i.e., lowest quality of evidence and strength of recommendation]	Adopted, see Recommendation A.

**II. PULMONARY CONTUSION**

Pulmonary contusion is often associated with chest wall trauma. It may not be noted on the initial chest X-ray. The clinician should be aware that respiratory status may decline over the first 24–48 hours post-injury.

**KMQ-6. What is the optimal management of pulmonary contusion?****EXTERNAL RECOMMENDATIONS**

RECOMMENDATIONS	COMMENTS
1. Patients with pulmonary contusion/flail chest (PC-FC) requiring mechanical ventilation should be supported in a manner based on institutional and physician preference. [EAST 2012 – Level 2]	Adopted, with added wording around transfer indications (see Recommendation A)
2. Steroids should not be used in the therapy of pulmonary contusion. [EAST 2012 – Level 2]	Adopted (Recommendation C)
3. A trial of mask CPAP/BIPAP may be of benefit in alert, compliant patients with marginal respiratory status in combination with optimal regional anesthesia. [EAST 2012 – Level 3]	Adopted, with added link to optimal analgesia management in this document (Recommendation B)
4. Independent lung ventilation may be considered in severe unilateral pulmonary contusion when shunt cannot be otherwise corrected owing to maldistribution of ventilation or when crossover bleeding is problematic. [EAST 2012 – Level 3]	Out of scope
5. High-frequency oscillatory ventilation (HFOV) should be considered for patients failing conventional ventilatory modes. [EAST 2012 – Level 3]	Out of scope
6. Diuretics may be used in the setting of hydrostatic fluid overload as evidenced by elevated pulmonary capillary wedge pressures in hemodynamically stable patients or in the setting of known concurrent congestive heart failure. [EAST 2012 – Level 3]	Out of scope

**III. TRANSFER TO HIGHER LEVEL OF CARE****KMQ-7. What are the considerations for transfer to higher level of care (HLOC) of flail chest?**

No relevant clinical scientific information identified.

## Appendix

### Appendix A: Rib Fracture Grade Calculation

#### **\*\*Rib Fracture Grade Calculation**

**Step one:** Determine number of sides

Unilateral = 1

Bilateral = 2

**Step two:** Determine number of fractures

**Step three:** Determine Age Score

0 = <50 years

1 = 51–60 years

2 = 61–70 years

3 = 71–80 years

4 = >80 years

**Step four:** Calculate Rib Fracture Grade

(# of rib fractures x # of sides)

+ Age Score

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**Rib Fracture Grade**

Easter A. Management of patients with multiple rib fractures. Am J of Critical Care. 2001;10:320–9.

May L, Hillermann C, Patil S. Rib fracture management. BJA Education. 2016 Jan 1;16(1):26–32.

Ziegler DW, Agarwal NN. The morbidity and mortality of rib fractures. J Trauma. 1994;37:965–979.

## KEY PERFORMANCE INDICATORS

**Purpose:** To measure improvements in the system, including CPG compliance.

INDICATOR	RATIONALE
<b>1.</b> CPG compliance Moderate BCT (Definition: RFS $\geq 7$ , not mechanically ventilated in ICU within 12 hours of admission) <ul style="list-style-type: none"> <li>• CT chest diagnostic imaging completed</li> <li>• Intermediate care monitoring</li> <li>• Pain service/anesthesia consultation</li> <li>• Referral for rib fixation (thoracoplasty) if appropriate</li> </ul>	
<b>2.</b> Number of patients with flail chest (Defined radiologically as three or more consecutive bi-costal fractures, one of which in each rib is $\geq 100\%$ displaced) By rib fixation procedure (thoracoplasty), time to thoracoplasty	
<b>3.</b> Number of patients with multiple (four or more) rib fractures	
<b>4.</b> Moderate BCT patients with unexpected intubation and ICU admission By time to ICU admission, by RFS	
<b>5.</b> Moderate BCT patients receiving epidural analgesia	
<b>6.</b> Time to rib fixation (open reduction and internal fixation) <ul style="list-style-type: none"> <li>• Proportion of rib fixation patients receiving surgery &gt;3 days after the time of injury.</li> </ul>	
<b>7.</b> Mortality By BCT severity: <ul style="list-style-type: none"> <li>• Minor (RFS &lt; 7, not initially ventilated x 12 hours)</li> <li>• Moderate (RFS <math>\geq 7</math>, not initially ventilated x 12 hours)</li> <li>• Severe (RFS <math>\geq 7</math>, pulmonary contusions, initially ventilated)</li> </ul>	

**BCT** = blunt chest trauma

**RFS** = Rib Fracture Score (see algorithm or Appendix 1 in the guideline document for RFS calculation)

## References

1. Galvagno SM, Jr., Smith CE, Varon AJ, Hasenboehler EA, Sultan S, Shaefer G, et al. Pain management for blunt thoracic trauma: A joint practice management guideline from the Eastern Association for the Surgery of Trauma and Trauma Anesthesiology Society. *J Trauma Acute Care Surg.* 2016;81(5):936-51.
2. Chou R, Gordon DB, de Leon-Casasola OA, Rosenberg JM, Bickler S, Brennan T, et al. Management of Postoperative Pain: A Clinical Practice Guideline From the American Pain Society, the American Society of Regional Anesthesia and Pain Medicine, and the American Society of Anesthesiologists' Committee on Regional Anesthesia, Executive Committee, and Administrative Council. *J Pain.* 2016;17(2):131-57.
3. Kasotakis G, Hasenboehler EA, Streib EW, Patel N, Patel MB, Alarcon L, et al. Operative fixation of rib fractures after blunt trauma: A practice management guideline from the Eastern Association for the Surgery of Trauma. *J Trauma Acute Care Surg.* 2017;82(3):618-26.
4. Pieracci FM, Majercik S, Ali-Osman F, Ang D, Doben A, Edwards JG, et al. Consensus statement: Surgical stabilization of rib fractures rib fracture colloquium clinical practice guidelines. *Injury.* 2017;48(2):307-21.
5. Simon B, Ebert J, Bokhari F, Capella J, Emhoff T, Hayward T, 3rd, et al. Management of pulmonary contusion and flail chest: an Eastern Association for the Surgery of Trauma practice management guideline. *J Trauma Acute Care Surg.* 2012;73(5 Suppl 4):S351-61.
6. Jensen CD, Stark JT, Jacobson LL, Powers JM, Joseph MF, Kinsella-Shaw JM, et al. Improved Outcomes Associated with the Liberal Use of Thoracic Epidural Analgesia in Patients with Rib Fractures. *Pain Med.* 2017;18(9):1787-94.
7. Zaw AA, Murry J, Hoang D, Chen K, Louy C, Bloom MB, et al. Epidural Analgesia after Rib Fractures. *Am Surg.* 2015;81(10):950-4.
8. Bulger EM, Edwards T, Klotz P, Jurkovich GJ. Epidural analgesia improves outcome after multiple rib fractures. *Surgery.* 2004;136(2):426-30.
9. Carrier FM, Turgeon AF, Nicole PC, Trépanier CA, Fergusson DA, Thauvette D, et al. Effect of epidural analgesia in patients with traumatic rib fractures: a systematic review and meta-analysis of randomized controlled trials. *Can J Anaesth.* 2009;56(3):230-42.
10. Duch P, Møller MH. Epidural analgesia in patients with traumatic rib fractures: a systematic review of randomised controlled trials. *Acta Anaesthesiol Scand.* 2015;59(6):698-709.
11. Malekpour M, Hashmi A, Dove J, Torres D, Wild J. Analgesic Choice in Management of Rib Fractures: Paravertebral Block or Epidural Analgesia? *Anesth Analg.* 2017;124(6):1906-11.
12. Majercik S, Pieracci FM. Chest Wall Trauma. *Thorac Surg Clin.* 2017;27(2):113-21.
13. Thiruvengkatarajan V, Cruz Eng H, Adhikary SD. An update on regional analgesia for rib fractures. *Curr Opin Anaesthesiol.* 2018;31(5):601-7.
14. Yeying G, Liyong Y, Yuebo C, Yu Z, Guangao Y, Weihu M, et al. Thoracic paravertebral block versus intravenous patient-controlled analgesia for pain treatment in patients with multiple rib fractures. *J Int Med Res.* 2017;45(6):2085-91.
15. Ge YY, Wang XZ, Yuan N, Yuan LY, Ma WH, Hu Y. [Effect of ultrasound guided patient-controlled paravertebral block on pulmonary function in patients with multiple fractured ribs]. *Zhonghua Wai Ke Za Zhi.* 2016;54(12):924-8.

16. Truitt MS, Murry J, Amos J, Lorenzo M, Mangram A, Dunn E, et al. Continuous intercostal nerve blockade for rib fractures: ready for primetime? *J Trauma*. 2011;71(6):1548-52; discussion 52.
17. Hwang EG, Lee Y. Effectiveness of intercostal nerve block for management of pain in rib fracture patients. *J Exerc Rehabil*. 2014;10(4):241-4.
18. Patton P, Vogt K, Priestap F, Parry N, Ball IM. Intravenous lidocaine for the management of traumatic rib fractures: A double-blind randomized controlled trial (INITIATE program of research). *J Trauma Acute Care Surg*. 2022;93(4):496-502.
19. Lii TR, Aggarwal AK. Comparison of intravenous lidocaine versus epidural anesthesia for traumatic rib fracture pain: a retrospective cohort study. *Reg Anesth Pain Med*. 2020;45(8):628-33.
20. Todd SR, McNally MM, Holcomb JB, Kozar RA, Kao LS, Gonzalez EA, et al. A multidisciplinary clinical pathway decreases rib fracture-associated infectious morbidity and mortality in high-risk trauma patients. *Am J Surg*. 2006;192(6):806-11.
21. Fowler TT, Taylor BC, Bellino MJ, Althausen PL. Surgical treatment of flail chest and rib fractures. *J Am Acad Orthop Surg*. 2014;22(12):751-60.
22. Voggenreiter G, Neudeck F, Aufmkolk M, Obertacke U, Schmit-Neuerburg KP. Operative chest wall stabilization in flail chest--outcomes of patients with or without pulmonary contusion. *J Am Coll Surg*. 1998;187(2):130-8.
23. Dehghan N, de Mestral C, McKee MD, Schemitsch EH, Nathens A. Flail chest injuries: a review of outcomes and treatment practices from the National Trauma Data Bank. *J Trauma Acute Care Surg*. 2014;76(2):462-8.
24. Pieracci FM, Lin Y, Rodil M, Synder M, Herbert B, Tran DK, et al. A prospective, controlled clinical evaluation of surgical stabilization of severe rib fractures. *J Trauma Acute Care Surg*. 2016;80(2):187-94.
25. Farquhar J, Almarhabi Y, Slobogean G, Slobogean B, Garraway N, Simons RK, et al. No benefit to surgical fixation of flail chest injuries compared with modern comprehensive management: results of a retrospective cohort study. *Can J Surg*. 2016;59(5):299-303.
26. Beks RB, Reetz D, de Jong MB, Groenwold RHH, Hietbrink F, Edwards MJR, et al. Rib fixation versus non-operative treatment for flail chest and multiple rib fractures after blunt thoracic trauma: a multicenter cohort study. *Eur J Trauma Emerg Surg*. 2019;45(4):655-63.
27. Caragounis EC, Fagevik Olsén M, Pazooki D, Granhed H. Surgical treatment of multiple rib fractures and flail chest in trauma: a one-year follow-up study. *World J Emerg Surg*. 2016;11:27.
28. Pieracci FM, Leasia K, Bauman Z, Eriksson EA, Lottenberg L, Majercik S, et al. A multicenter, prospective, controlled clinical trial of surgical stabilization of rib fractures in patients with severe, nonflail fracture patterns (Chest Wall Injury Society NONFLAIL). *J Trauma Acute Care Surg*. 2020;88(2):249-57.
29. Pieracci FM, Coleman J, Ali-Osman F, Mangram A, Majercik S, White TW, et al. A multicenter evaluation of the optimal timing of surgical stabilization of rib fractures. *J Trauma Acute Care Surg*. 2018;84(1):1-10.
30. DeFreest L, Tafen M, Bhakta A, Ata A, Martone S, Glotzer O, et al. Open reduction and internal fixation of rib fractures in polytrauma patients with flail chest. *Am J Surg*. 2016;211(4):761-7.
31. Pieracci FM, Rodil M, Stovall RT, Johnson JL, Biffl WL, Mauffrey C, et al. Surgical stabilization of severe rib fractures. *J Trauma Acute Care Surg*. 2015;78(4):883-7.