Management of Blunt Chest Trauma

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KEYWORDS

• Chest trauma • Blunt trauma • Thoracic injury • Rib fractures

KEY POINTS

- Blunt thoracic injury commonly includes rib fractures, sternal fracture, pneumothorax, hemothorax, and pulmonary contusions. Treatment is generally supportive with multimodal analgesia with or without tube thoracostomy.
- Tube thoracostomy may be safely deferred in patients with normal hemodynamics and simple pneumothorax less than or equal to 35 mm diameter on computed tomography imaging.
- Retained hemothorax should be treated early with video-assisted thoracoscopic surgery within 4 days of injury to reduce infectious complications and hospital length of stay.
- Extracorporeal membrane oxygenation may be safely and effectively used in select patients with blunt thoracic trauma and refractory hypoxia.
- Tracheobronchial injury, esophageal injury, diaphragmatic injury, blunt cardiac injury, and blunt aortic injury are less commonly seen after blunt thoracic trauma, but operative intervention is more frequently required.

INTRODUCTION

Blunt chest trauma constitutes a heterogeneous group of injuries and accounts for at least 10% of all hospital admissions for injury.[1] The most common mechanism leading to blunt chest trauma is motor vehicle collision (MVC), although ground-level falls are more common in older adults.[2] Blunt chest wall trauma carries a mortality of up to 25%,[3–5] and numerous injuries occurring in the thorax are life-threatening.[6]

Rib Fractures

Rib fractures may be categorized as simple, wedge, or complex fractures and are nondisplaced, offset, or displaced; ribs four through ten in the anterolateral region are most commonly injured.[7–9] Three or more contiguous ribs fractured in at least two locations are defined as a flail segment; paradoxical movement inward with respiration

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Surg Clin N Am 104 (2024) 343–354
https://doi.org/10.1016/j.suc.2023.09.007 **surgical.theclinics.com**

and outward with expiration is clinical flail chest.[10] Flail chest impedes thoracic expansion, decreases vital capacity, and is associated with significant underlying lung contusions. Flail segments are associated with extensive injuries and a mortality rate of 10% to 40%[11]; concomitant pulmonary contusions (PCs), pneumothorax, and hemothorax are common.[11,12] About 80% of patients with flail segments require intensive care unit (ICU) admission, with 60% requiring mechanical ventilation.[11]

Rib fractures can present with chest wall tenderness, ecchymosis, crepitus, or obvious deformity. Chest x-ray (CXR) diagnoses rib fractures with high specificity (84%–98%) but may miss almost 50% of fractures.[2,13] Computed tomography (CT) provides optimal sensitivity and specificity.[13,14]

Rib fracture treatment is primarily nonoperative, with multimodal pain management, respiratory therapy, and mobility as the mainstays of treatment. Incentive spirometry (IS) is recommended for patients ≥65 years old as a prognostic tool to determine the risk of pulmonary complications.[15] Spirometry use in a bundled protocol has been shown to reduce complications in all age groups.[16]

Multimodal analgesia is primarily used for treatment of pain associated with rib fractures.[17] Scheduled acetaminophen is well-tolerated with minimal side effects[18,19] and reaches peak effect within 1 hour.[20] non-steroidal anti-inflammatory drugs (NSAIDs) are used as an adjunct to acetaminophen.[21] Ketorolac decreases pneumonia risk and increases rate of ventilator-free and ICU-free days[22] without increasing rates of bleeding or acute kidney injury.[23] Intravenous (IV) ibuprofen and/or low-dose ketamine infusions may decrease overall narcotic use.[24,25] Opioids are effective but have unfavorable side effects: constipation, respiratory depression, somnolence, and addictive capacity. Prior opioid exposure significantly alters the treatment trajectory: opioid-naïve patients were prescribed a median of 16 days versus 36 days of treatment for those with prior opioid exposure.[26] The use of gabapentin for pain management is not strongly supported by evidence.[27]

Locoregional pain management is an important adjunct for treatment of rib fractures. Epidural catheters lead to lower subjective pain scores[28] and are conditionally recommended by the Eastern Association for the Surgery of Trauma (EAST).[29] In older patients, epidural catheters improved pain scores and are recommended.[30] Other locoregional pain management methods include serratus anterior blocks, paravertebral blocks, targeted intercostal nerve blocks, and erector spinae blocks. Paravertebral blocks can provide continuous analgesia and are non-inferior to epidural catheters.[28] Delirium in patients ≥65 years was decreased with regional analgesia in a multicenter cohort study.[31]

Consensus guidelines recommend surgical stabilization of rib fractures (SSRF) for patients with a flail segment.[30,32–34] SSRF can allow for better excursion of the chest wall, increased inspiratory volume[35] and increased lung volumes.[36] SSRF decreases mortality and is associated with improved outcomes including decreased need for tracheostomy.[30,32] Data suggest only minimal benefit in older patients.[37,38] The NON-FLAIL study showed decreased pain scores through 8 weeks of follow-up with reduced narcotic use after SSRF.[33]

Sternal Fractures

Sternal fracture (SF) occurs in 2% of patients with blunt trauma and 3.7% of patients injured in MVCs.[39,40] Only 22% to 26% of SFs are isolated; most have associated thoracic injuries.[41,42] SF can present with focal tenderness over the sternum or anterior chest wall ecchymosis.[6] CXR lacks specificity, with 81% to 93% of SFs visualized on CT only.[40,43] Bedside ultrasonography, while user-dependent, can also diagnose SFs.[43,44]

SFs are managed with multimodal analgesia, respiratory therapy, and early mobility. Despite the lack of strong supporting evidence, IS is often used as part of a bundled care set.[18,45] Operative fixation is used for unstable fractures, fracture displacement, respiratory insufficiency, and uncontrolled severe pain.[42,46] Sternal fixation improves pain scores with decreased opioid requirements, but long-term data are lacking.[46–48]

Pneumothorax

Pneumothorax, diagnosed in 40% to 50% of all patients with thoracic trauma, occurs when air accumulates between the parietal and visceral pleura.[49,50] Pneumothorax may be categorized as simple, open, tension, or occult. Simple pneumothoraces are secondary to lung parenchymal injury. Open pneumothoraces are contiguous with the atmosphere via wounds. In tension pneumothorax, air accumulates to pressures higher than atmospheric pressure with subsequent circulatory collapse from lack of venous return. Occult pneumothorax, a pneumothorax not clinically suspected or visualized on CXR but identified on CT scan, occurs in 22% of patients after blunt trauma.[2]

Signs of pneumothorax include unilateral decreased or absent breath sounds. CXR approaches 100% specificity but can miss 50% of pneumothoraces when compared with chest ultrasonography.[51] Ultrasonography is 91% to 99% sensitive; the absence of B-lines and lung sliding have a negative predictive value of 98% to 100%.[50,51] CT scan remains the gold standard for diagnosis. Large pneumothorax is defined as greater than 2 cm and greater than 3 cm by the British Thoracic Society and the American Thoracic Society, respectively.[2,52]

Pneumothorax is treated with tube thoracostomy to re-expand the lung and restore negative intrathoracic pressure.[6] Thoracostomy carries a complication rate of 19%; observation is safe for pneumothoraces $\leq$35 mm in diameter between visceral and parietal pleura on CT.[53–56] Observation of occult pneumothoraces with positive pressure ventilation is safe in hemodynamically normal patients.[57,58] Western Trauma Association (WTA) recommends tube thoracostomy for pneumothoraces greater than 35 mm on CT scan or greater than 20% on CXR in hemodynamically stable patients; thoracostomy tube is recommended regardless of size in hemodynamically unstable patients.[49] EAST and WTA recommend prophylactic antibiotics for thoracostomy to reduce the rate of empyema and pneumonia.[59,60]

Hemothorax

Hemothorax results from hemorrhage of the pulmonary parenchyma, intercostal vessels, pulmonary arteries, or pulmonary veins. Hemothorax or hemopneumothorax occurs in one-third of patients with chest trauma, with incidence increasing for each rib fractured.[5,61,62] Occult hemothorax is defined as hemothorax seen only on CT scan. Delayed hemothorax is the development or progression of hemothorax post-injury.[63,64] Retained hemothorax, an inadequately drained hemothorax, increases the risk of empyema, pneumonia, and further surgical intervention.[65]

Signs of hemothorax are nonspecific: decreased breath sounds, crepitus over ribs suggesting rib fractures, chest wall ecchymosis, and respiratory insufficiency. CXR can diagnose hemothoraces with 200 to 300 mL of blood required to visualize blunting of the costophrenic angles and almost 1000 mL is required for diagnosis on supine CXR.[2] Ultrasonography can be helpful in unstable patients, with 60% sensitivity and 98% specificity when evaluating for anechoic areas in the pleural spaces.[66] CT scan can detect small amounts of blood and is the gold standard for diagnosis.

Hemothoraces are treated with drainage, often with a thoracostomy tube. Small bore tubes (eg, 14 Fr pigtail catheters) are efficacious.[61,67–69] EAST conditionally

recommends pigtail catheter usage with clinician-guided patient selection.[61] Thoracic irrigation via the thoracostomy tube, especially with ≥1000 mL, can reduce retained hemothorax rates and improve outcomes.[70–72] Occult hemothoraces can be observed, but volumes ≥300 mL and mechanical ventilation are risk factors for failure.[56] Delayed hemothorax may develop, especially in elderly patients.[63] Retained hemothorax may be treated with tissue plasminogen activator or streptokinase.[73] Thrombolytic regimens vary widely, however, and EAST conditionally recommends video-assisted thoracoscopic surgery (VATS) over thrombolysis in operative candidates.[61] If VATS is undertaken, it should be performed within 4 days of injury to reduce empyema rates and decrease hospital and ICU length of stay, ventilator days, and mortality.[61,74]

Pulmonary Contusions

PCs result from injury to lung parenchyma leading to edema and interstitial hemorrhage, with consequent loss of gas exchange, alveolar collapse, consolidation, and atelectasis.[10,75] Subsequent hypoxia is worsened by the increased shunting of blood through unventilated alveoli and decreased compliance of the lung. PCs occur in 20% to 35% of patients with blunt chest trauma and 70% are secondary to MVCs.[2,75,76] The severity of PCs can be quantified, but it does not completely explain the poor oxygenation seen in severe PC.[77] Increased CT scan utilization has led to increased incidence of PCs.[78]

Often, signs and symptoms of PCs develop hours to days post-injury as inflammation peaks ≥24 hours post-injury.[75] CXR can show moderate–severe PCs, with 73% of PCs seen on CT scan only.[78] PC treatment is supportive: supplemental oxygen, analgesia, IS, euvolemia, and observation. Severe PCs often require intubation to maintain oxygenation.[10] In refractory cases of hypoxia due to pulmonary contusions from trauma, extracorporeal membrane oxygenation (ECMO) may be considered for treatment.[79] Although patient selection is paramount, one study has shown a 74.1% survival to hospital discharge among patients requiring ECMO after blunt thoracic trauma.[80]

Tracheobronchial Injury

Tracheobronchial injuries are seen in 0.8% to 5% of injured patients.[10] Tracheobronchial injuries can present with respiratory distress and dyspnea, hoarseness, subcutaneous emphysema, pneumothorax, or hemoptysis.[81] Persistent air leak, pneumothorax, pneumomediastinum, or subcutaneous emphysema after thoracostomy tube placement should raise clinical suspicion for this diagnosis. CXR can show a "fallen lung sign" with atelectasis of the ipsilateral lung, absent hilum, and falling away of the lung toward the diaphragm. Chest CT scans can detect obvious disruptions, but the gold standard for diagnosis is bronchoscopy.[10,82]

Tracheobronchial injuries are treated operatively, with tracheal repair performed with absorbable sutures; simple lacerations can be repaired primarily, but extensive injuries often require debridement of necrotic tissue.[10] Lateral dissection is minimized to preserve blood supply for the trachea in the 3 and 9 o'clock positions. Repairs are buttressed with vascularized flaps of strap or intercostal muscles, pericardium, or pleura. Covered metal self-expanding tracheal stents are an efficacious alternative for poor surgical candidates.[82]

Esophageal Injury

Esophageal injury (EI) is rare (≤1% in blunt chest trauma) but carries a 9.8% mortality rate.[83] Signs of EI can include subcutaneous cervical air, hemoptysis, hoarseness, or

neck hematoma. Fever, erythema, swelling, or airway distress can occur as mediastinitis develops. Contrast esophagography is the most useful diagnostic modality. CT esophagography can be used when fluoroscopy is unavailable with similar sensitivity and specificity.[84] When combined with contrast studies, diagnostic sensitivity of esophagoscopy approaches 90% to 100%.[84]

Broad spectrum antibiotics are initiated once EI is suspected.[85] Nonoperative management is indicated for hemodynamically stable patients with either a contained perforation or no contrast extravasation. Endoscopic interventions include endoscopic clipping, with 59% to 83% success, and covered esophageal stents.[85,86] Surgical management of EIs includes wide drainage with debridement of nonviable tissue and a two-layer closure with a vascularized tissue flap buttressing the repair; large esophageal perforations require esophageal diversion with end esophagostomy and distal enteral access placement.[10]

Diaphragmatic Injury

Traumatic diaphragmatic injury (TDI) incidence rate is 0.8% to 8%.[87] Most TDIs are initially asymptomatic or have nonspecific symptoms and most occur on the left. CXR has 27% to 62% sensitivity for left TDIs and 17% for right TDIs without visceral herniation.[88] CT scans are more sensitive (80%) and specific (98%) in detecting TDIs.[87] The gold standard for diagnosis is either open or minimally invasive surgical exploration.[88]

The treatment for TDIs is surgical: EAST conditionally recommends an abdominal approach for repair versus a thoracic approach, with laparoscopy considered for hemodynamically stable patients.[87,88]

Blunt Cardiac Injury

Blunt cardiac injury (BCI) is diagnosed in $\geq$70% of patients with high force blunt chest trauma.[89] BCI symptoms may be clinically absent and can develop over hours to days post-injury. Normal electrocardiogram (EKG) and troponin I levels rule out BCI.[89,90] A new right bundle branch block is the most common EKG abnormality.[91] High-sensitivity troponin T levels greater than 14 ng/L have been shown to correlate with worse outcomes.[92] Echocardiography is recommended in the presence of other abnormalities to provide diagnostic imaging and functional evaluation.[93] Transesophageal echocardiography may have higher specificity without obscured images from subcutaneous emphysema or hematomas.[94]

Most patients can be observed with admission and telemetry, but anatomic injuries warrant surgical evaluation to determine necessity of surgical repair. Arrhythmias may require pharmacologic intervention, and possibly, cardioversion and symptomatic heart block may require a pacemaker.[91,95]

Blunt Thoracic Aortic Injury

Blunt thoracic aortic injury (BTAI) can present with hemodynamic instability or nonspecific complaints: chest pain, interscapular pain, or difficulty breathing.[96] WTA recommends evaluating for BTAI after high-force mechanism of injury.[97] CXR findings may include widened mediastinum, left hemothorax, left apical cap, and loss of aortic knob.[15] CT angiography (CTA) is the gold standard, with a sensitivity of 95% to 100% and negative predictive value of almost 100%.[98] A standard CT scan with IV contrast will often capture BTAI, but a formal CTA is recommended if the diagnosis is uncertain.

Medical management of BTAI includes anti-impulse therapy with short-acting beta blockade with a goal of less than 100 mgHg systolic blood pressure and less than 100

BPM heart rate; calcium channel blockade can be added or used in place of beta-blockade. Grades I and II injuries can be managed medically with repeat CTA to assess stability.[96,97] Grades III and IV injuries should undergo surgical intervention, but Grade III injuries can be delayed safely for 48 to 72 hours if there are severe concomitant injuries. Endovascular repair is recommended due to its lower rates of morbidity and mortality.[98] Postoperative surveillance imaging is recommended, but ideal timing and length of surveillance are not established.[97]

CLINICS CARE POINTS

- Multimodal analgesia options for treatment of rib fractures may include acetaminophen, NSAIDs, ketamine infusion, epidural catheters, and locoregional pain management methods.
- Three or more contiguous ribs fractured in at least two locations are defined as a flail segment. Surgical stabilization of rib fractures may benefit select patient populations.
- Tube thoracostomy may be safely deferred in patients with normal hemodynamics and simple pneumothorax less than or equal to 35 mm diameter on computed tomography imaging.
- Prophylactic use of antibiotics for tube thoracostomy decreases the rate of pneumonia and empyema.
- Retained hemothorax should be treated early with video-assisted thoracoscopic surgery within 4 days of injury to reduce infectious complications and hospital length of stay.
- Extracorporeal membrane oxygenation may be safely and effectively used in select patients with blunt thoracic trauma and refractory hypoxia.
- Tracheobronchial injuries are diagnosed with bronchoscopy and treated operatively, with tracheal repair performed with absorbable sutures.
- A normal troponin I level along with a normal EKG rules out blunt cardiac injury.
- The initial management of blunt thoracic aortic injury include anti-impulse therapy with beta blockade.

AUTHORSHIP

Both authors meet authorship criteria as established by the International Committee on Medical Journal Editors' (ICMJE) Criteria.

DISCLOSURE

The authors have nothing to disclose.

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