Pulmonary Parenchymal Injuries

Charles A. Adams Jr, MD FACS FCCM

Editorial Review: Clay Cothren Burlew, MD
Eric A. Toschlog, MD
Kimberly A. Davis, MD MBA

Injury/Disease Demographics

- Blunt thoracic injuries contribute to nearly half of all trauma deaths and are directly responsible for approximately 1 in 4 trauma deaths.
- Pulmonary parenchymal injuries include: pulmonary pseudocysts (pneumatoceles), pulmonary contusions, and pulmonary lacerations.
    - A pulmonary contusion, the most common injury secondary to blunt thoracic trauma, typically results from disruption of normal lung architecture by blunt trauma with flooding of the alveolar spaces with blood.
    - A pulmonary laceration containing air typically assumes a spherical shape in the parenchyma and is termed a pneumatocele and represents a more severe injury than a pulmonary contusion.
    - A pulmonary laceration containing blood is termed a pulmonary hematoma.
    - Pulmonary lacerations may result from tearing of lung parenchyma from pleural adhesions, penetration of the lung by fractured ribs or from penetration of the thorax by weapons, impalements or ballistic fragments.
- Disruption of the visceral pleura associated with lung injury leads to a pneumothorax.
- A hemothorax results from bleeding from the lung or chest wall collecting in the pleural space.

Clinical Presentation

- The classic presentation of significant pulmonary parenchymal trauma is respiratory distress with shortness of breath and hypoxemia. Cyanosis may be present in severe injuries.
- Chest wall injuries are exceedingly painful; bony crepitus, subcutaneous emphysema, or penetrating wounds are markers that the patient may have an underlying pulmonary parenchymal injury.
- Children and adolescents may have significant pulmonary parenchymal injury in the absence of chest wall trauma due to greater elasticity of their rib cage.
- Hemoptysis is uncommon but may occur with severe pulmonary contusions and hematoceles.

Evaluation/Diagnostics/Imaging

- Diminished breath sounds may be indicative of a pneumothorax or large pulmonary contusion. Often the physical exam is non-specific.
- Diminished breath sounds with hyper-resonance on percussion with associated tachycardia and/or hypotension signifies a tension pneumothorax and warrants emergent decompression of the pleural space. Tracheal deviation and jugular venous distention may also be evident.
- Decreased breath sounds, dullness on percussion and signs of hemorrhagic shock are indicative of a large hemothorax particularly in the setting of penetrating trauma.
- Diminished breath sounds with normal resonance on percussion along with signs of hypoxemia are indicative of a pulmonary contusion.

- A chest radiograph (CXR) is valuable in diagnosing and differentiating the various types of pulmonary parenchymal injuries.
    - Diffuse haziness on a supine CXR signifies hemothorax while a localized or well circumscribed haziness is suggestive of a pulmonary contusion or pulmonary hematoma.
    - CXR may also reveal other thoracic injuries such as rib fractures and pneumothoraces although relatively large anterior pneumothoraces may not be appreciated on supine CXRs.
- CT scanning of the chest yields more information than simple CXRs and can help differentiate pulmonary contusions and hematomas from hemothoraces.
- CT scans can also detect small hemothoraces and pneumothoraces not detected on CXR. These injuries are termed "occult".

Role of Expectant Management and Associated Considerations

- Occult HTX and PTX may be managed with observation alone but serial CXR may be warranted.
- Occult lesions that subsequently are evident on CXR imply progression and may be best managed with tube thoracostomy.
- Most HTX and PTX found on the initial CXR should be managed with tube or catheter thoracostomy.
- Pulmonary contusions may "blossom" following volume resuscitation, particularly if voluminous crystalloids are given, so close observation of these patients is warranted. Clinicians should have a low threshold for mechanical ventilation if dyspnea is progressive or hypoxemia develops.
- A brisk air leak or persistent PTX on CXR despite a well-placed chest tube on suction suggests a major bronchial injury and should be evaluated with fiber optic bronchoscopy.
- Bronchoscopy may also identify the source of massive hemoptysis and facilitate the placement of a bronchial blocker as a temporizing maneuver.
- Approximately 85% of patients with thoracic trauma resulting in a HTX/PTX can be effectively treated with tube or catheter thoracostomy alone.
- Pulmonary contusions, hematomas and pneumatoceles rarely require invasive therapy. Occasionally these may lead to lung abscess which optimally are drained internally. Percutaneous drainage may lead to empyema and/or bronchopleural fistula.

Indications for Operative Intervention

- HTX that drain >1500cc of blood on initial tube placement or >250cc per hour for more than 3-4 hours require exploratory thoracotomy.
- Large HTX with signs of hypovolemic shock warrant thoracotomy.
- An undrained HTX despite a well-placed and functioning tube thoracostomy implies a clotted or retained hemothorax. This is an indication for video-assisted thoracoscopic surgery (VATS) in hemodynamically stable patients.

- Massive hemoptysis can be treated with angiography in stable patients, otherwise operative exploration is required. A bronchoscopically placed bronchial blocker can prevent the patient from life threatening respiratory compromise.
- Tracheobronchial injuries with massive air leak or persistent pneumothorax are best treated with thoracic exploration.
- Air leaks that persistent beyond 7 days warrant exploration.

Pre-operative Preparation

- Endotracheal intubation with a double lumen tube is most desirable for thoracotomies and mandatory for VATS.
- For urgent thoracotomy, a standard endotracheal tube with the addition of a bronchial blocker can provide good lung isolation.
- In truly emergent cases, no lung isolation should be attempted and the patient should be ventilated with small tidal volumes at a high frequency.
- Patients should be positioned supine to allow access to the abdomen in case a laparotomy is required. A bump placed under the operative side may make exposure of the posterior hemithorax easier.
- An anterolateral thoracotomy is the incision of choice for acute explorations. A posterolateral thoracotomy in decubitus positioning is reserved for delayed explorations after other associated injuries have been definitively identified, ruled out, or managed.

Impact of Associated Injuries

- Severe blunt chest trauma may be complicated by blunt cardiac injury leading to dysrhythmia or cardiac failure.
- Hilar penetrating injuries may result in air embolism which should be suspected if a patient acutely decompensates following the initiation of positive pressure ventilation. This is an indication for emergent thoracotomy and clamping of the hilum of the lung and attempts at evacuation of the air from the heart and coronary vessels.

Operative Techniques/Intraoperative Considerations

- The vast majority of patients with a HTX (both blunt or penetrating) requiring surgical exploration will have an intercostal artery injury. Only about 20% of patients will require a pulmonary resection.
- When resecting lung it is important to remember less is more. Pneumonectomy is associated with prohibitive mortality. The mortality of a wedge resection is less than that of a lobectomy which is less than a bi-lobectomy.
- Bleeding missile tracts through the lung, particularly if peripherally located, can be managed with tractotomy and oversewing of bleeding vessels and bronchioles. A GIA stapler is invaluable in performing the tractotomy.
- Hilar penetrating injuries may require intra-pericardial control of the pulmonary artery and vein.

- Following thoracotomy, most surgeons prefer a straight apical and right angled basilar chest tube although there is no data to support this practice. The decision to use one or two tubes is based on clinical judgment but two tubes are indicated in coagulopathic patients, those with diffuse ongoing bleeding, etc.
- Rarely, coagulopathic bleeding from the chest may require damage-control techniques with packing and a vacuum assisted closure. In these cases a plastic drape can be placed on the lung to prevent the parenchyma from adhering to the lap pads with resultant lung trauma with unpacking. VAC closure of the open chest obviates the need for chest tubes but these should be placed at the time of definitive chest closure.

Postoperative Management/Complications

- The mortality of traumatic pneumonectomy is exceedingly high secondary to acute cor pulmonale. ECMO may be useful in managing these patients and other adjuncts to reduce pulmonary artery pressures are not supported by data.
- Bronchial stump leak following lobectomy or pneumonectomy is a devastating complication. It is desirable to cover the bronchial stump with some additional tissue (pleura, pericardium, or intercostal muscle) to prevent stump leak.

Considerations for Special Populations

- While children often have severe pulmonary contusion without rib fractures, the elderly have severe rib fractures with sparing of the parenchyma.
- Rib fractures in the elderly are associated with significant morbidity and mortality. Geriatric patients with 3-4 rib fractures have a mortality approaching 20% and 33% in those with more than 6 rib fractures.

Suggested Readings

- Bulger EM, Arneson MA, Mock CN, et al. Rib fractures in elderly. J Trauma 2000;48:1040-7.

- Moore FO, Goslar PW, Coimbra R, et al. Blunt traumatic occult pneumothorax: is observation safe? Results of a prospective, AAST multicenter study. J Trauma. 2011;70(5):1019-23; discussion 1023-5.

- Caceres M, Buechter KJ, Tillou A, et al. Thoracic packing for uncontrolled bleeding in penetrating thoracic injuries. South Med J. 2004;97(7):637–641.

- Huh J, Wall Jr. MJ, Estrera, et al. Surgical management of traumatic pulmonary injury. Am J Surg. 2003;186(6):620-4.