Thoracic trauma accounts for about 10% of all trauma and approximately 25% of all trauma deaths. In addition chest trauma is a major contributor in another 50% of deaths. In order to look at injuries let us first review the A & P of the thorax.

**Anatomy and Physiology of the Thorax**

The rib cage, intercostal muscles and costal cartilage form the basic structure of the chest wall. The thoracic skeleton consists of 12 pairs of C-shaped ribs (ribs 1-7 join the sternum with cartilage end points, ribs 8-10 join the sternum with combined cartilage at the 7th rib and ribs 11 – 12 have no anterior attachment) and the sternum (manubrium, body and xiphoid process).

Neurovascular bundles comprised of an intercostal nerve, artery and vein, run along the inferior margin of each rib. The inner lining of the chest wall is the parietal pleura. Visceral pleura covers the major thoracic organs. Between the two is a potential space with a small amount of lubrication fluid. The anterior chest wall also contains the pectoralis major and minor muscles as well as the clavicle at its superior border. Posteriorly, the scapula provides added protection to the superior thorax.

The trachea is a hollow and cartilage supported structure. The right and left bronchi extend from the trachea and enter the respective lungs at the pulmonary hilum where the pulmonary arteries and veins also enter. They further subdivide and terminate as alveoli. The alveoli have a single cell membrane and this is where gas exchange takes place.

The chest wall has two important functions: to assist in the mechanics of respiration and to protect the intrathoracic organs. Adequate ventilation is accomplished by creating negative intrathoracic pressure during inspiration and positive pressure during expiration. During inspiration, a combination of diaphragmatic excursion and contraction of
intercostal muscles to raise the ribs in a “bucket-handle” fashion increases intrathoracic volume and decreases intrathoracic pressure, which then pulls air passively into the lungs. In expiration, this process is reversed; all the muscles relax and intrathoracic pressure passively increases and volume decreases, forcing air out of the lungs.

The mediastinum is an anatomic division of the thorax extending from the diaphragm inferiorly to the thoracic inlet superiorly. It borders include the sternum anteriorly, the vertebral column posteriorly, and the parietal pleura laterally. Contained within the mediastinum are the heart, aorta, vena cava, trachea, and esophagus. The diaphragm constitutes the floor of the thoracic cavity. The diaphragm exhibits substantial movement with inspiration and expiration, and thus posttraumatic pain in the lower thorax may reflect intraabdominal as well as intrathoracic injury.

**Pathophysiology of Trauma**

Trauma to the chest is caused either by a blunt or penetrating force.

**Blunt trauma** results from kinetic energy forces. The mechanisms along with predicted injuries can be divided into three groups.

- Blasts, where pressure waves cause tissue disruption, tear blood vessels and disrupt alveolar tissue. It also can cause disruption of the tracheobronchial tree and cause rupture of the diaphragm.
- Crushes, where the body is compressed between an object and a hard surface. It causes direct injury to the chest wall and internal subjects.

- Decelerations, where the body in motion strikes a fixed object. Causing blunt trauma to the chest wall and the internal structures continue in motion causing shearing injuries.

*Penetrating trauma* is divided into three classes: low energy, high energy and shot gun.

- Low energy (arrows, knives, handguns). Injury is caused by direct contact and cavitation.

- High energy (military, hunting rifle, high powered hand guns). Injuries resulting in extensive injury due to increased pressure cavitation.

- Shotgun. Injury severity based upon the distance to the victim and the caliber of shot. Divided into 3 categories: Type I, > 7 meters from weapon resulting in soft tissue injury; Type II, 2 – 7 meters from weapon causing penetration into deep fascia and some internal organs; Type III, < than 3 meters from the weapon causing massive tissue destruction.
Injuries associated with penetrating chest trauma include:
- Closed pneumothorax
- Open pneumothorax (including sucking chest wound)
- Tension pneumothorax
- Pneumomediastinum
- Hemothorax
- Hemopneumothorax
- Laceration of vascular structures
- Tracheobronchial tree lacerations
- Esophageal lacerations
- Penetrating cardiac injuries
- Pericardial tamponade
- Spinal cord injuries
- Diaphragm trauma
- Intra-abdominal penetration with associated organ injury

**Specific Injuries**

**Chest Wall Injuries**
- Contusions: Contusions are most commonly a result of a blunt injury. Signs and symptoms include erythema, ecchymosis, dyspnea, pain on breathing, limited breath sounds, and hypoventilation (hurts to breathe).
- Rib Fractures: Rib fractures are the most common blunt thoracic injuries. Compressional forces flex and fracture ribs at their weakest point. Great force is required to fracture ribs 1 – 3, therefore an underlying lung injury must always be suspected. Ribs 4-9 are the most commonly fracture ribs. Ribs 9-12 are less likely to be fractured. When they are injured they transmit energy to the internal organs and liver and spleen injuries must be suspected.
- Sternal Fractures: Sternal fractures are associated with severe blunt anterior trauma. Typically a result of a direct blow (i.e. steering wheel). They do have a high mortality rate, 25–45% because of associated myocardial contusion, pericardial tamponade, cardiac rupture or pulmonary contusions.
• Flail Chest: A flail chest, by definition, involves 3 or more consecutive rib fractures in 2 or more places, resulting in a floating unstable segment of chest wall. Physical exam reveals paradoxical motion of the flail segment as it moves inward with inspiration and outward with expiration. A significant amount of force is needed to produce a flail segment. Therefore, associated underlying injuries should be suspected. There is a high incidence of associated pulmonary contusions and closed head injuries, which, in combination increase the mortality associated with flail chest.

Pulmonary Injuries
• Simple Pneumothorax (closed pneumothorax): Simple pneumothorax occurs when lung tissue is disrupted and air leaks into the pleural space. As air accumulates in the pleural space the lung collapses resulting in alveolar collapse. This in turn reduces the oxygen and carbon dioxide exchange causing ventilation/perfusion mismatch. Physical exam demonstrates decreased breath sounds and hyperresonance to percussion over the affected side.

• Open Pneumothorax: Most commonly caused by penetrating trauma which allows free passage of air between atmosphere and the pleural space. Air replaces lung tissue. Air will be drawn through the wound if the wound is 2/3 diameter of the trachea or larger. Signs and symptoms include penetrating trauma, sucking chest wound, frothy blood at the wound site, severe dyspnea and hypovolemia.
Management of the Chest Injury Patient

- Ensure ABC’s: High flow O2 via NRB, Intubate if indicated, consider DAI
- Anticipate Myocardial Compromise
- Shock Management
- Rib Fractures: Consider analgesics for pain and to improve chest excursion. Nitrous oxide is contraindicated because it can migrate into the pleural or mediastinal space and worsen the condition.
- Flail Chest: Place pt on side of injury (only if spinal injury is not suspected), expose injury site, dress with bulky bandage against the flail segment to stabilize the fracture site, high flow O2, do not use sandbags to stabilize the fracture.
- Open pneumothorax: high flow O2, cover site with sterile occlusive dressing taped on three sides, progressive airway management if indicated.
1. Neurovascular bundles comprised of an intercostal nerve, artery and vein, run along the ______ margin of the rib.

2. The right and left bronchi enter their respective lung at the ______ where the pulmonary arteries and veins also enter.

3. Explain how adequate ventilation is accomplished.

4. Blunt trauma is divided into three groups according to mechanism predicted injuries. Match the group with its mechanism and associated injuries:
   - Blast ________  A. The body is compressed between an object and a hard surface. It causes direct injury to the chest wall and internal structures.
   - Crushes ________  B. Pressure waves cause tissue disruption, tear blood vessels and disrupt alveolar tissue.
   - Deceleration __________  C. A body in motion strikes a fixed object, causing blunt trauma to the chest wall and shearing injuries.

5. Explain how injuries result from each of the three classes of penetrating trauma.
   - A. Low energy
   - B. High energy
   - C. Shotgun
   A. 
   B. 
   C. 
   D. 

7. Define flail chest.

8. Air will be drawn through a sucking chest wound if the wound is ___ the diameter of the trachea or larger.

9. Explain the management of a patient with a sucking chest wound.

10. Ribs 1-3 are the most commonly fractured ribs.  
    A. True  
    B. False