Chapter 4: Thoracic Trauma

Objectives:

Upon completion of this topic, the physician will be able to identify and explain the dangers of thoracic injuries and the principles of management.

Specifically, the physician will be able to:

A. Identify and manage the following immediately life-threatening chest injuries evidenced in the primary survey:

1. Airway obstruction
2. Tension pneumothorax
3. Open pneumothorax (sucking chest wound)
4. Massive hemothorax
5. Flail chest
6. Cardiac tamponade

B. Identify and initiate treatment of the following potentially life-threatening injuries assessed during the secondary survey:

1. Pulmonary contusion
2. Myocardial contusion
3. Aortic disruption
4. Traumatic diaphragmatic hernia
5. Tracheobronchial disruption
6. Esophageal disruption

C. Explain the purpose of, define the complications of, and demonstrate the ability to perform needle thoracocentesis, chest tube insertion, and pericardiocentesis in a surgical skill practicum.
I. Introduction

A. Incidence

Chest injuries cause one out of four trauma deaths in this country. Many patients die after reaching the hospital. These deaths might be prevented by an understanding of pathophysiological factors that lead to prompt diagnosis and treatment.

Because most injuries occur at a distance from a medical center, the features of thoracic injuries that require early intervention and influence transport are very important. Less than 15% of these injuries require operation. The remaining 85% may be managed by simple procedures within the capabilities of any physician taking this course. Therefore, responsibility for the initial management of most chest-injury patients falls on the shoulders of the local physician and not on the thoracic surgeon at the major medical center.

B. Pathophysiology

Chest injury often leads to tissue hypoxia. The hypoxia may result from diminished blood volume, failure to ventilate the lungs, contusion of pulmonary tissue leading to ventilation/perfusion mismatch, or changes in the pressure relationship within the pleural space that lead to displacement of mediastinal structures and collapse of the lung. Because hypoxia is the most compelling feature of chest injury, early intervention are designed to ensure that an adequate amount of oxygen is delivered to the portions of the lung capable of normal ventilation and perfusion. The first and easiest therapy to initiate is the administration of oxygen, using a mask and bag reservoir capable of delivering an FIO$_2$ in excess of 0.85.

C. Treatment Approach

1. The physician's preconceived and prioritized plan of action is:
   a. Primary survey
   b. Resuscitation
   c. Secondary survey
   d. Definitive care.

2. Examination is guided by a high index of suspicion for specific injuries.

3. Immediately life-threatening injuries are treated as simply and quickly as possible. Only then are the potentially life-threatening injuries definitively approached for diagnosis and treatment.

4. Most life-threatening thoracic injuries are treated with an appropriately placed chest tube or needle, based on clinical skill capabilities.
II. Primary Survey of Life-Threatening Chest Trauma

A. Airway

1. Assess for airway patency and air exchange by listening for air movement at the patient's nose and mouth.

2. The patient should also be assessed for intercostal and supraclavicular retractions. The signs of chest injury or impending hypoxia, which are particularly important and often subtle, include: 1) an increased rate of breathing, and 2) a change in the breathing pattern, especially toward progressively more shallow respirations. Cyanosis appears very late during the course of hypoxia in the trauma patient because of the skin ischemia that may result from redistribution of blood volume in shock patients, because decreased hemoglobin may be present, and because an amount of unsaturated hemoglobin sufficient to produce cyanosis (5 grams/100 mL of blood) may not be present.

3. Assess the oropharynx for foreign body obstruction, particularly in the unconscious patient.

B. Breathing

Expose the patient's chest completely, and evaluate the breathing. Assess respiratory movement and quality of respiration by observing, palpating, and auscultating.

C. Circulation

1. Assess the patient's pulse for quality, rate, regularity, and presence of paradox. Remember, hypovolemic patients may not have peripheral pulses in the radial and the dorsalis pedis.

2. Assess the blood pressure for width of pulse pressure.

3. Observe and palpate the skin for color and temperature to assess the peripheral circulation.

4. Check to see if the neck veins are distended. Remember, neck veins may not be distended in hypovolemic patients with cardiac tamponade.

5. A cardiac monitor should be attached to the patient. Patients sustaining thoracic trauma - especially in the area of the sternum, or involving a rapid deceleration injury - are subject to myocardial contusion and/or coronary artery spasm, rendering them susceptible to dysrhythmias. Hypoxia and/or acidosis enhance this possibility. A common dysrhythmia is premature ventricular contraction which may require treatment with an immediate lidocaine bolus followed by a lidocaine drip. The term electromechanical dissociation (EMD) is used in this course as a manifestation of cardiac tamponade, tension pneumothorax, and/or profound hypovolemia. It may also indicate cardiac rupture.
D. Open Thoracotomy

Closed heart massage for cardiac arrest or electromechanical dissociation is ineffective for a hypovolemic patient. Assuming a surgeon is present, the procedure of a left anterior thoracotomy, cross-clamping of the descending thoracic aorta, pericardiotomy, and open chest massage in conjunction with intravascular volume restoration may be initiated. Appropriate candidates may include patients with exsanguinating penetrating injuries, and those sustaining blunt injury who arrive pulseless but with myocardial electrical activity.

III. Life-Threatening Chest Injuries Identified in the Primary Survey

A. Airway Obstruction

Airway obstruction at the alveolar level is a potentially life-threatening injury that is assessed and managed during the secondary survey and definitive-care phases. Chapter 2 deals with the management of life-threatening situations of the upper airway.

B. Tension Pneumothorax

A tension pneumothorax develops when a "one-way valve" air leak occurs either from the lung or through the chest wall. Air is forced into the thoracic cavity without any means of escape, completely collapsing the affected lung. The mediastinum and trachea are displaced to the opposite side, interfering with venous return and compressing ventilation of the other lung.

The most common causes of tension pneumothorax are mechanical ventilation with positive end-expiratory pressure, spontaneous pneumothorax in which ruptured emphysematous bullae have failed to seal, and blunt chest trauma in which the parenchymal lung injury has failed to seal. Occasionally traumatic defects in the chest wall may cause a tension pneumothorax. There is a significant incidence of pneumothorax associated with subclavian catheter insertion.

Tension pneumothorax is a clinical rather than radiologic diagnosis. A tension pneumothorax is identified by tracheal deviation, respiratory distress, unilateral absence of breath sounds, distended neck veins, and cyanosis as a late manifestation. A tension pneumothorax initially may be confused with cardiac tamponade; however, tension pneumothorax is more common. Differentiation may be made by a hypertympanic percussion note over the ipsilateral chest.

Tension pneumothorax requires immediate decompression and is managed initially by rapidly inserting a needle into the second intercostal space in the midclavicular line of the affected hemithorax. This maneuver converts the injury to a pneumothorax. Aspirating with a syringe attached to a needed is helpful. The ability to aspirate air easily confirms the diagnosis. In the event of failure to aspirate air, withdraw the syringe and needle. (Note: The possibility of subsequent pneumothorax as a result of the needle stick now exists.)

Repeated reassessment is necessary. If air is aspirated, disconnect the syringe, leaving the needle in place. Definitive treatment usually requires only the insertion of a chest tube.
into the fifth intercostal space (nipple level), anterior to the midaxillary line.

C. Open Pneumothorax

Penetrating injury to the thorax usually seals itself. However, large defects occasionally remain open, causing a "sucking chest wound." Equilibration between intrathoracic pressure and atmospheric pressure is immediate. If the opening in the chest wall is approximately two-thirds the diameter of the trachea, air passes preferentially through the chest defect with each respiratory effort, because air tends to follow the path of least resistance through the large chest-wall defect. Effective ventilation is thereby impaired, leading to hypoxia.

Manage an open pneumothorax by promptly closing the defect with a sterile occlusive dressing, large enough to overlap the wound's edges and taped securely on three sides. Taping the occlusive dressing on three sides provides a flutter-type valve effect. As the patient breathes in, the dressing is occlusively sucked over the wound, preventing air from entering. When the patient exhales, the open end of the dressing allows air to escape. Securely taping all edges of the dressing can cause air to accumulate in the thoracic cavity, resulting in a tension pneumothorax. Any occlusive dressing (plastic wrap, Vaseline gauze, etc) may be used as a stopgap so rapid assessment can continue. Place a chest tube in an area remote from the open wound. Definitive surgical closure of the defect is usually required.

D. Massive Hemothorax

Massive hemothorax, although rare, is dramatic in appearance. It occurs as a result of more than 1500 mL of blood lost into the chest cavity. It is most commonly caused by a penetrating wound that disrupts the systemic or pulmonary vessels. It may also be the result of blunt trauma. The blood loss is complicated by hypoxia. The neck veins may be flat secondary to severe hypovolemia, or may be distended because of the mechanical effects of a chest cavity full of blood. This condition is discovered when shock is associated with the absence of breath sounds and/or dullness to percussion on one side of the chest.

Massive hemothorax is initially managed by the simultaneous restoration of volume deficits and decompression of the chest cavity. Large-caliber intravenous lines and rapid crystalloid infusion are begun and type-specific blood is administered as soon as possible. If an auto-transfusion device is available, it may be used. A single chest tube (#38 French) is inserted at the nipple level, anterior to the midaxillary line, and rapid restoration of volume continues as decompression of the chest cavity is completed. Some patients require thoracotomy. This decision is based on the rate of continuing blood loss (200 mL/hour). The volume of blood that initially drains from the chest tube is not as important as the rate of continuing blood loss, and to indicate the amount of intravenous replacement required to resuscitate the patient. Similarly, the color of the blood (arterial or venous) is a poor indicator of the necessity for thoracotomy.

Penetrating anterior chest wounds medial to the nipple line and posterior wounds medial to the scapula should alert the physician to the possible need for thoracotomy, because of possible damage to the great vessels, hilar structures, and the heart, with the associated potential for cardiac tamponade. In addition, the surgeon at the definitive-care center must be
told of the presence or absence of complete pleural space evacuation and re-expansion of the lung. Open thoracotomy is not indicated unless a surgeon is present.

E. Flail Chest

A flail chest occurs when a segment of the chest wall does not have bony continuity with the rest of the thoracic cage. This condition usually results from trauma associated with multiple rib fractures. The presence of a flail chest segment results in severe disruption of normal chest wall movement. If the injury to the underlying lung is sufficient, it may produce serious hypoxia. The major difficulty in flail chest stems from the injury to the underlying lung. Although chest wall instability leads to paradoxical motion of the chest wall with inspiration and expiration, this defect alone does not cause hypoxia. Associated pain and underlying lung injury, giving rise to loss of compliance, will contribute to the respiratory pattern defect and lead to hypoxia.

Flail chest may not be initially apparent because of splinting of the chest wall. The patient moves air poorly, and movement of the thorax is asymmetrical and uncoordinated. Palpation of abnormal respiratory motion and crepitus of rib or cartilage fractures aids diagnosis. A satisfactory chest roentgenogram may suggest multiple rib fractures, but may not show costochondral separation. Arterial blood gases, suggesting respiratory failure with hypoxia, may also aid in diagnosing a flail chest.

Initial therapy includes adequate ventilation, administration of humidified oxygen, and careful control of crystalloid intravenous solutions to prevent overhydration. The injured lung in a flail chest is sensitive to both under-resuscitation of shock, and fluid overload. Specific measures to optimize fluid measurement must be taken for the patient with flail chest.

The definitive treatment is to re-expand the lung and ensure oxygenation as completely as possible. Some patients can be managed without the use of a ventilator. However, prevention of hypoxia is of paramount importance for the trauma patient, and a short period of intubation and ventilation may be necessary until the diagnosis of the entire injury pattern is complete. A careful assessment of the respiratory rate, arterial oxygen tension, and an estimate of the work of breathing will indicate appropriate timing for intubation and ventilation. Not all patients with a flail chest require immediate endotracheal intubation. It is sometimes preferable to delay intubation until cervical spine roentgenograms have been obtained.

F. Cardiac Tamponade

Cardiac tamponade most commonly results from penetrating injuries. Blunt injury may also cause the pericardium to fill with blood from the heart or great vessels. The human pericardial sac is a fixed fibrous structure, and only a relatively small amount of blood is required to restrict cardiac activity and interfere with cardiac filling. Correspondingly, removal of small amounts of blood or fluid, often as little as 15 to 20 mL, by pericardiocentesis may have enormous beneficial effects for the critically ill patient.

The classic Beck's triad consists of venous pressure elevation, decline in arterial pressure, and muffled heart tones. However, muffled heart tones are difficult to assess in the
noisy emergency department. Distended neck veins, caused by the elevated central venous pressure, may be absent due to hypovolemia. Pulsus paradoxus, a decrease in systolic pressure during inspiration in excess of 10 mm Hg, may also be absent in some of the patients with cardiac tamponade. In addition, tension pneumothorax - particularly on the left side - may mimic cardiac tamponade. Kussmaul's sign (a rise in venous pressure with inspiration when breathing spontaneously) is a true paradoxical venous pressure abnormality associated with tamponade.

Pericardiocentesis is indicated for patients who do not respond to the usual measures of resuscitation for hemorrhagic shock and who have the potential for cardiac tamponade. Insertion of a central venous line by the percutaneous infraclavicular subclavian route may aid diagnosis. Life-saving pericardiocentesis should not be delayed for this diagnostic adjunct. For the patient who is unresponsive to resuscitation, a high index of suspicion is all that is necessary to initiate pericardiocentesis by the subxyphoid method.

Even though pericardiac tamponade is strongly suspected, the initial administration of intravenous fluid will raise the venous pressure and improve cardiac output transiently while preparations are made for pericardiocentesis. Cardiac tamponade is then managed by prompt pericardiocentesis via the subxyphoid route. The use of a plastic-sheathed needle is preferable, but the urgent priority is to aspirate several milliliters of blood from the pericardial sac. Because of the self-sealing qualities of the myocardium, aspiration of pericardial blood alone may temporarily relieve symptoms. However, all patients with positive pericardiocentesis due to trauma will require open thoracotomy and inspection of the heart. Pericardial aspiration may not be diagnostic or therapeutic if the blood in the pericardial sac is clotted, which might be the case after rapid bleeding. Preparations for transfer to a definitive-care center are necessary for such patients. Open pericardiotomy may be life-saving but is indicated only when a qualified surgeon is available.

Once these injuries and other immediate life-threatening injuries have been stabilized, attention may be directed to the secondary survey and definitive-care phase of potential life-threatening thoracic injuries.

IV. Potentially Lethal Chest Injuries Identified in the Secondary Survey

The secondary survey requires further in-depth physical examination, an upright chest film if the patient's condition permits, arterial blood gases, and an electrocardiogram. In addition to lung expansion and the presence of fluid, the chest film should be examined for widening of the mediastinum, a shift of the midline, or loss of anatomic detail. Multiple rib fractures of the first and/or second rib(s) are evidence of severe force delivered to the chest and underlying tissues.

Six potentially lethal injuries are considered here.
1. Pulmonary contusion
2. Myocardial contusion
3. Aortic disruption
4. Traumatic diaphragmatic hernia
5. Tracheobronchial disruption
Unlike life-threatening conditions, these injuries are not obvious on initial physical examination. Diagnosis requires a high index of suspicion. All are more often missed than diagnosed during the initial posttraumatic period. However, if these injuries are overlooked, mortality increases.

**A. Pulmonary Contusion With or Without Flail Chest**

Pulmonary contusion, almost indistinguishable from Adult Respiratory Distress Syndrome (ARDS), is the most common potentially lethal chest injury seen in North America. It is potentially lethal because the resulting respiratory failure develops over time rather than occurring instantaneously. The definitive management also proceeds with time and requires close monitoring.

Evidence now shows that some patients may be managed selectively without endotracheal intubation or the use of the adjunctive ventilator. Patients are intubated and ventilated in the first hour after injury, if they are hypoxic, as previously defined, or if they are to be transferred to another center, or cared for in a hospital where monitoring facilities are limited. Appropriate local specialists should agree on the method of treatment and at what facility the patient will receive optimal care. Some associated medical conditions that predispose to the need for early intubation include:

1. Pre-existing chronic pulmonary disease.
2. Impaired level of consciousness.
3. Abdominal injury resulting in ileus or the need for exploratory celiotomy.
4. Skeletal injuries requiring immobilization.
5. Renal failure.

If the patient cannot maintain satisfactory oxygenation or has any of the above complicating features, intubation and mechanical ventilation should be considered.

**B. Myocardial Contusion**

Myocardial contusion, although difficult to diagnose, is another potentially lethal injury from blunt chest trauma. The patient's reported complaints of discomfort are often bypassed as being associated with chest wall contusion or fractures of the sternum and/or ribs. The diagnosis of myocardial contusion is established by abnormalities on the electrocardiogram, serial enzyme determinations, two-dimensional echocardiography, and associated history of injury. The electrocardiographic changes are variable, and may even indicate frank myocardial infarction. Multiple, premature ventricular contractions, unexplained sinus tachycardia, atrial fibrillation, bundle branch block (usually right), and ST segment changes are the most common electrocardiographic findings.

Patients with myocardial contusion are at risk for sudden dysrhythmias. They should be admitted to the critical care unit for close observation and cardiac monitoring.
C. Traumatic Aortic Rupture

Traumatic aortic rupture is the most common cause of sudden death after an automobile accident or a fall from a great height. Tears of the aorta and major pulmonary arteries, most of which result from blunt trauma, are fatal at the accident scene 90% of the time. For survivors, salvage is frequently possible, if aortic rupture is identified early.

Aortic rupture tends to occur at the ligamentum arteriosum of the aorta. Continuity maintained by an intact adventitial layer prevents immediate death. One-half of the surviving patients will die each day in the hospital if left untreated. Some blood may escape into the mediastinum, but one characteristic shared by all survivors is that this is a contained hematoma. Other than the initial pressure drop associated with the loss of 500 mL to 1000 mL of blood, hypotension responds to intravascular infusion. Persistent or recurrent hypotension is usually due to an unidentified bleeding site. Although free rupture of a transected aorta into the left chest does occur and causes hypotension, it is usually fatal unless the patient is operated on within a few minutes.

A high index of suspicion triggered by the radiologic findings, followed by arteriography, are the means of making the diagnosis. Angiography should be performed liberally because the findings of the chest roentgenogram, especially the supine view, are undependable. Approximately 10% of the aortograms will be positive for aortic rupture if liberal indications for using angiography are employed for all patients with widened mediastinum. Adjunctive radiologic signs, which may or may not be present, indicate the likelihood of major vascular injury in the chest. They include:

1. Widened mediastinum.
2. Fractures of the first and second ribs.
3. Obliteration of the aortic knob.
4. Deviation of the trachea to the right.
5. Presence of a pleural cap.
6. Elevation and rightward shift of the right mainstem bronchus.
7. Depression of the left mainstem bronchus.
8. Obliteration of space between the pulmonary artery and the aorta.
9. Deviation of the esophagus (nasogastric tube) to the right.

False positives and false negatives occur with each radiographic sign. Therefore, no single finding reliably predicts or excludes significant injury. A widened mediastinum is the most consistent finding. Arteriography is considered the gold standard. A computer tomography scan may be less reliable, and even if it is positive, it does not always provide the surgeon with adequate preoperative information. It cannot be stressed too strongly that the
The slightest suspicion of aortic injury should be confirmed angiographically.

The usual treatment is either direct repair of the aorta or resection of the injured area and grafting. A qualified surgeon should treat such a patient.

D. Traumatic Diaphragmatic Hernia

A traumatic diaphragmatic hernia is more commonly diagnosed on the left side because of the appearance of the bowel or nasogastric tube in the chest. Blunt trauma produces large radial tears that led to herniation. Penetrating trauma produces small perforations that often take some time, even years, to develop into diaphragmatic hernia.

These injuries are missed initially if the chest film is misinterpreted as showing an elevated left diaphragm, acute gastric dilatation, a loculated pneumohemothorax, or a subpulmonary hematoma. Thus, the diagnosis is not clearly identified on the initial roentgenogram or after the chest tube evacuation of the left hemothorax or pneumothorax. The diagnosis should be confirmed by contrast radiography. Occasionally, the sight of a nasogastric tube curled up in the left lower chest will eliminate the need for these special studies. The appearance of peritoneal lavage fluid in the chest tube drainage confirms the diagnosis.

E. Tracheobronchial Tree Injuries

1. Larynx

Fractures of the larynx are a rare injury and are indicated by the following triad:

a. Hoarseness
b. Subcutaneous emphysema
c. Palpable fracture crepitus.

If the patient's airway is totally obstructed or the patient is in severe respiratory distress, an attempt at intubation is warranted. If intubation is unsuccessful, a tracheostomy (not surgical cricothyroidotomy) is indicated, followed by operative repair.

2. Trachea

Direct trauma to the trachea, including the larynx, can be either penetrating or blunt. Blunt injuries may be subtle, and history is all-important. Penetrating trauma is overt and requires immediate surgical repair. Penetrating injuries are often associated with esophageal, carotid artery, and jugular vein trauma. Penetrating injuries caused by missiles are often associated with extensive tissue destruction surrounding the area of penetration because of the blast effect.

Noisy breathing indicates partial airway obstruction that suddenly may become complete. Absence of breathing suggests that complete obstruction already exists. When the
level of consciousness is depressed, detection of significant airway obstruction is more subtle. Observations of labored respiratory effort may be the only clue to airway obstruction and tracheobronchial injury. Endoscopic procedures aid diagnosis.

3. Bronchus

Injury to a major bronchus is an unusual and fatal injury that is frequently overlooked. The majority of such injuries result from blunt trauma and occur within one inch of the carina. Although the majority of patients with this injury die at the scene, those who reach the hospital alive have a 30% mortality, often due to associated injuries.

If suspicion of a bronchial injury exists, immediate surgical consultation is warranted. A patient with a bronchial injury frequently presents with hemoptysis, subcutaneous emphysema, or tension pneumothorax with a mediastinal shift. A pneumothorax associated with a persistent large air leak after tube thoracotomy suggests a bronchial injury. A second chest tube may be necessary to overcome a very large leak. Bronchoscopy confirms the diagnosis of the injury.

Treatment of tracheobronchial injuries may require only airway maintenance until the acute inflammatory and edema processes resolve. Major deviation or compression of the trachea by extrinsic masses, ie, hematomas, must be treated. Intubation frequently may be unsuccessful because of the anatomic distortion from paratracheal hematoma, major laryngotracheal injury, and associated injuries. For such patients, operative intervention is indicated. Patients surviving with bronchial injuries may require direct surgical intervention by thoracotomy.

F. Esophageal Trauma

Esophageal trauma is most commonly caused by penetrating trauma. Blunt esophageal trauma, although very rare, is lethal if unrecognized. Blunt injury of the esophagus is caused by a forceful injection of gastric contents into the esophagus from a severe blow to the upper abdomen. This forceful ejection produces a linear tear in the lower esophagus, allowing leakage into the mediastinum. The resulting mediastinitis and immediate or delayed rupture into the pleural space causes empyema. Other associated causes of esophageal trauma are primarily instrumentation.

The clinical picture is identical to that of postemetic esophageal rupture, so that diagnosis should be considered for any patient who has a left pneumothorax or hemothorax without a rib fracture; has received a severe blow to the lower sternum or epigastrium and is in pain or shock out of proportion to the apparent injury; or if particulate matter appears in the chest tube drainage after the blood begins to clear. The presence of mediastinal air, usually on the left side, is basis for diagnosis. The diagnosis can often be readily confirmed by gastrograaffin swallow and/or esophagoscopy.

Wide drainage of the pleural space and mediastinum with direct repair of the injury via thoracotomy is the treatment, if feasible. If the repair is tenuous or not feasible, esophageal diversion in the neck and gastrostomy of the lower and upper gastric segments usually is carried out, thereby avoiding continued soiling of the mediastinum and pleura by
gastric and esophageal contents.

V. Other Manifestations of Chest Injuries

A. Subcutaneous Emphysema

Subcutaneous emphysema may result from airway injury; lung injury; or rarely, blast injury. It does not require treatment.

B. Crushing Injury to the Chest

Findings associated with a crush injury to the chest include subcutaneous emphysema; and upper torso, facial, and arm plethora with petechiae secondary to superior vena cava compression.

C. Simple Pneumothorax

Pneumothorax results from air entering the potential space between the visceral and parietal pleura. Both penetrating and nonpenetrating trauma may cause this injury. Lung laceration with air leakage is the most common cause of pneumothorax resulting from blunt trauma.

The thorax is normally completely filled by the lung, held to the chest wall by surface tension between the pleural surfaces. Air in the pleural space collapses lung tissue. This collapsed lung does not participate in oxygen exchange. A ventilation perfusion defect occurs because the blood circulated to the nonventilated area is not oxygenated.

When a pneumothorax is present, percussion of the chest shows hyperresonance. Breath sounds are usually decreased or absent. An expiratory roentgenogram of the chest may aid the diagnosis. If the injuries are so critical that obtaining a chest roentgenogram would jeopardize the patient's status, needle aspiration as described for a tension pneumothorax may establish the diagnosis.

A pneumothorax associated with other injuries is best treated with a chest tube in the fourth or fifth intercostal space, anterior to the midaxillary line. Observation and/or aspiration of any pneumothorax is risky. Once a chest tube has been inserted and connected to an underwater seal apparatus with 20 to 30 of water suction, a roentgenogram of the chest is necessary to confirm re-expansion of the lung. General anesthesia should never be administered for definitive care of injuries in patients who have sustained traumatic pneumothorax, or who are at risk for unexpected intraoperative pneumothorax, until a chest tube has been inserted. The chest should also be decompressed before transporting the patient with a pneumothorax via air ambulance.

D. Hemothorax

The primary cause of hemothorax is lung laceration, or laceration of an intercostal vessel or internal mammary artery due to either penetrating or blunt trauma. In the vast majority of cases this bleeding is self-limiting and does not require operative intervention.
Hemothorax, sufficient to appear on chest roentgenogram, is usually treated with a large-caliber chest tube. Intubation of the pleural space allows evacuation of blood and reduces the risk of clotted hemothorax, which may lead to pulmonary restriction, and subsequent thoracotomy and decortication. Intubation also provides a monitoring method. While many factors are involved in the decision to operate on a patient with a hemothorax, the amount of blood drainage from the chest tube is a major factor. If a liter of blood is obtained through the chest tube, surgical consultation is warranted. Persistent drainage of more than 200 mL per hour for four hours may indicate the need for thoracotomy.

**E. Rib Fractures**

The ribs are the most commonly injured component of the thoracic cage. Injuries to the ribs are often significant. Pain on motion results in splinting of the thorax, which impairs ventilation. Tracheobronchial secretions cannot be easily eliminated. The incidence of atelectasis and pneumonia rises strongly with pre-existing lung disease.

The upper ribs (1-3) are protected by the bony framework of the upper limb. The scapula, humerus, and clavicle, along with their muscular attachments, provide a barrier to injury in this area. Fractures of the first or second rib often indicate major injury to the head, neck, spinal cord, lungs, and the great vessels. Because of the severity of the associated injuries, mortality can be as high as 50%.

The middle ribs (4-9) sustain the majority of blunt trauma. Anteroposterior compression of the thoracic cage will blow the ribs outward with a fracture in the midshaft. Direct force applied to the ribs tends to fracture them and drive the ends of the bones into the thorax with more potential for intrathoracic injury, such as a pneumothorax. As a general rule, a young patient with a more flexible chest wall is less likely to sustain rib fractures. Therefore, the presence of multiple rib fractures in young patients implies a more sizable force transfer than in older patients.

Localized pain, tenderness on palpation, and crepitus are present in rib injury patients. A palpable or visible deformity suggests rib fractures. A roentgenogram of the chest should be obtained primarily to exclude other intrathoracic injuries and not just to identify rib fractures. Fractures of anterior cartilages or separation of costochondral junctions have the same implications as rib fractures but will not be seen on the roentgenographic examinations. Special rib technique roentgenograms are expensive, and may not detect all rib injuries, add nothing to treatment, require painful positioning of the patient, and are not useful. Taping, rib belts, and external splints are contraindicated.

**F. Other Indications for Chest Tube Insertion**

1. In selected cases with suspected severe lung injury, especially those being transferred by air or ground vehicle.

2. Individuals undergoing general anesthesia for treatment of other injuries (eg, cranial or extremity), and individuals requiring positive pressure ventilation.
VI. Summary

Thoracic trauma is quite common in the multiply injured patient and can be associated with life-threatening problems. These problems can usually be relieved with simple measures such as tube thoracostomy or needle pericardiocentesis. The physician must possess the cognitive knowledge to diagnose these life-threatening thoracic injuries, and must develop the manipulative skills to perform the associated life-saving techniques. The specific details of tube thoracostomy and needle pericardiocentesis are presented in the skill station section. The high incidence of thoracic trauma also necessitates routine ECG monitoring of all multiply injured patients. This monitoring can be at times forgotten in the busy trauma room. A thorough understanding of thoracic injuries and their proper treatment can be rewarding for the physician and may save the patient's life.