

UNIT TERMINAL OBJECTIVE

4-7 At the completion of this unit, the paramedic student will be able to integrate pathophysiological principles and the assessment findings to formulate a field impression and implement a treatment plan for a patient with a thoracic injury.

COGNITIVE OBJECTIVES

At the completion of this unit, the paramedic student will be able to:

- 4-7.1 Describe the incidence, morbidity, and mortality of thoracic injuries in the trauma patient. (C-1)
- 4-7.2 Discuss the anatomy and physiology of the organs and structures related to thoracic injuries. (C-1)
- 4-7.3 Predict thoracic injuries based on mechanism of injury. (C-2)
- 4-7.4 Discuss the types of thoracic injuries. (C-1)
- 4-7.5 Discuss the pathophysiology of thoracic injuries. (C-1)
- 4-7.6 Discuss the assessment findings associated with thoracic injuries. (C-1)
- 4-7.7 Discuss the management of thoracic injuries. (C-1)
- 4-7.8 Identify the need for rapid intervention and transport of the patient with thoracic injuries. (C-1)
- 4-7.9 Discuss the pathophysiology of specific chest wall injuries, including: (C-1)
 - a. Rib fracture
 - 2. Flail segment
 - 3. Sternal fracture
- 4-7.10 Discuss the assessment findings associated with chest wall injuries. (C-1)
- 4-7.11 Identify the need for rapid intervention and transport of the patient with chest wall injuries. (C-1)
- 4-7.12 Discuss the management of chest wall injuries. (C-1)
- 4-7.13 Discuss the pathophysiology of injury to the lung, including: (C-1)
 - 1. Simple pneumothorax
 - 2. Open pneumothorax
 - 3. Tension pneumothorax
 - 4. Hemothorax
 - 5. Hemopneumothorax
 - 6. Pulmonary contusion
- 4-7.14 Discuss the assessment findings associated with lung injuries. (C-1)
- 4-7.15 Discuss the management of lung injuries. (C-1)
- 4-7.16 Identify the need for rapid intervention and transport of the patient with lung injuries. (C-1)
- 4-7.17 Discuss the pathophysiology of myocardial injuries, including: (C-1)
 - a. Pericardial tamponade
 - 2. Myocardial contusion
 - 3. Myocardial rupture
- 4-7.18 Discuss the assessment findings associated with myocardial injuries. (C-1)
- 4-7.19 Discuss the management of myocardial injuries. (C-1)
- 4-7.20 Identify the need for rapid intervention and transport of the patient with myocardial injuries. (C-1)
- 4-7.21 Discuss the pathophysiology of vascular injuries, including injuries to: (C-1)

- a. Aorta
 2. Vena cava
 3. Pulmonary arteries/ veins
- 4-7.22 Discuss the assessment findings associated with vascular injuries. (C-1)
- 4-7.23 Discuss the management of vascular injuries. (C-1)
- 4-7.24 Identify the need for rapid intervention and transport of the patient with vascular injuries. (C-1)
- 4-7.25 Discuss the pathophysiology of diaphragmatic injuries. (C-1)
- 4-7.26 Discuss the assessment findings associated with diaphragmatic injuries. (C-1)
- 4-7.27 Discuss the management of diaphragmatic injuries. (C-1)
- 4-7.28 Identify the need for rapid intervention and transport of the patient with diaphragmatic injuries. (C-1)
- 4-7.29 Discuss the pathophysiology of esophageal injuries. (C-1)
- 4-7.30 Discuss the assessment findings associated with esophageal injuries. (C-1)
- 4-7.31 Discuss the management of esophageal injuries. (C-1)
- 4-7.32 Identify the need for rapid intervention and transport of the patient with esophageal injuries. (C-1)
- 4-7.33 Discuss the pathophysiology of tracheo-bronchial injuries. (C-1)
- 4-7.34 Discuss the assessment findings associated with tracheo-bronchial injuries. (C-1)
- 4-7.35 Discuss the management of tracheo-bronchial injuries. (C-1)
- 4-7.36 Identify the need for rapid intervention and transport of the patient with tracheo-bronchial injuries. (C-1)
- 4-7.37 Discuss the pathophysiology of traumatic asphyxia. (C-1)
- 4-7.38 Discuss the assessment findings associated with traumatic asphyxia. (C-1)
- 4-7.39 Discuss the management of traumatic asphyxia. (C-1)
- 4-7.40 Identify the need for rapid intervention and transport of the patient with traumatic asphyxia. (C-1)
- 4-7.41 Integrate the pathophysiological principles to the assessment of a patient with thoracic injury. (C-1)
- 4-7.42 Differentiate between thoracic injuries based on the assessment and history. (C-3)
- 4-7.43 Formulate a field impression based on the assessment findings. (C-3)
- 4-7.44 Develop a patient management plan based on the field impression. (C-3)

AFFECTIVE OBJECTIVES

At the completion of this unit, the paramedic student will be able to:

- 4-7.45 Advocate the use of a thorough assessment to determine a differential diagnosis and treatment plan for thoracic trauma. (A-3)
- 4-7.46 Advocate the use of a thorough scene survey to determine the forces involved in thoracic trauma. (A-3)

4-7.47 Value the implications of failing to properly diagnose thoracic trauma. (A-2)

4-7.48 Value the implications of failing to initiate timely interventions to patients with thoracic trauma.
(A-2)

PSYCHOMOTOR OBJECTIVES

At the completion of this unit, the paramedic student will be able to:

4-7.49 Demonstrate a clinical assessment for a patient with suspected thoracic trauma. (P-1)

4-7.50 Demonstrate the following techniques of management for thoracic injuries: (P-1)

- a. Needle decompression
2. Fracture stabilization
3. Elective intubation
4. ECG monitoring
5. Oxygenation and ventilation

DECLARATIVE

- I. Introduction
 - A. Epidemiology
 - 1. Incidence
 - 2. Morbidity and mortality of thoracic injuries
 - 3. Risk factors
 - 4. Prevention strategies
 - a. Gun safety education
 - b. Sports training
 - c. Seat belts
 - d. Other
 - B. Mechanism of injury
 - 1. Classification
 - a. Blunt thoracic injuries
 - (1) Deceleration
 - (2) Compression
 - b. Penetrating thoracic injuries
 - 2. Injury patterns
 - a. General Types
 - (1) Open injuries
 - (2) Closed Injuries
 - b. Thoracic cage
 - c. Cardiovascular
 - d. Pleural and pulmonary
 - e. Mediastinal
 - f. Diaphragmatic
 - g. Esophageal
 - h. Penetrating cardiac trauma
 - 3. Blast injury
 - a. Confined spaces
 - b. Shock wave
 - C. Anatomy and physiology review of the thorax
 - 1. Anatomy
 - a. Skin
 - b. Bones
 - (1) Thoracic cage
 - (2) Sternum
 - (3) Thoracic spine
 - c. Muscles
 - (1) Intercostal
 - (2) Trapezius
 - (3) Latisissimus dorsi

- (4) Rhomboids
- (5) Pectoralis major
- (6) Diaphragm
- (7) Sternocleidomastoid
- d. Trachea
- e. Bronchi
- f. Lungs
 - (1) Parenchyma
 - (2) Alveoli
 - (3) Alveolar - capillary interface
 - (4) Pleura
 - (a) Visceral
 - (b) Parietal
 - (c) Serous fluid
 - (5) Lobes
- g. Vessels
 - (1) Arteries
 - (a) Aorta
 - (b) Carotid
 - (c) Subclavian
 - (d) Intercostal arteries
 - (e) Innominate
 - (f) Internal mammary
 - (2) Veins
 - (a) Superior vena cava
 - (b) Inferior vena cava
 - (c) Subclavian
 - (d) Internal jugular
 - (3) Pulmonary
 - (a) Arteries
 - (b) Veins
- h. Heart
 - (1) Ventricles
 - (2) Atria
 - (3) Valves
 - (4) Pericardium
- i. Esophagus
 - (1) Thoracic inlet
 - (2) Course through chest
 - (3) Esophageal foramen through diaphragm
- j. Mediastinum
 - (1) Structures located in mediastinum
 - (a) Heart
 - (b) Trachea
 - (c) Vena cava
 - (d) Aorta
 - (e) Esophagus

2. Physiology

- a. Ventilation
 - (1) Expansion and contraction of thoracic cage
 - (a) Bellows system
 - (b) Musculoskeletal structure
 - (c) Intercostal muscles
 - (d) Diaphragm
 - (e) Accessory muscles
 - (f) Changes in intrathoracic pressure
- b. Respiration
 - (1) Neurochemical control
 - (2) Gas exchange
 - (a) Alveolar-capillary interface
 - (b) Capillary-cellular interface
 - (c) Pulmonary circulation
 - (d) Cardiac circulation
 - (e) Acid-base balance
 - i) Henderson-Hasselbach equation
 - ii) Respiratory alkalosis
 - iii) Respiratory acidosis
 - iv) Compensation for metabolic acidosis and alkalosis

II. General system pathophysiology, assessment and management of thoracic trauma

- A. Pathophysiology
 - 1. Impairments in cardiac output
 - a. Blood loss
 - b. Increased intrapleural pressures
 - c. Blood in pericardial sac
 - d. Myocardial valve damage
 - e. Vascular disruption
 - 2. Impairments in ventilatory efficiency
 - a. Chest bellow action compromise
 - (1) Pain restricting chest excursion
 - (2) Air entering pleural space
 - (3) Chest wall fails to move in unison
 - b. Bleeding in pleural space
 - c. Ineffective diaphragmatic contraction
 - 3. Impairments in gas exchange
 - a. Atelectasis
 - b. Contused lung tissue
 - c. Disruption of respiratory tract
- B. Assessment findings
 - 1. Pulse
 - a. Deficit
 - b. Tachycardia
 - c. Bradycardia
 - 2. Blood pressure
 - a. Narrow pulse pressure
 - b. Hypertension

- c. Hypotension
- d. Pulsus paradoxus
- 3. Respiratory rate and effort
 - a. Tachypnea
 - b. Bradypnea
 - c. Labored
 - d. Retractions
 - e. Other evidence of respiratory distress
- 4. Possible hypothermia
- 5. Skin
 - a. Diaphoresis
 - b. Pallor
 - c. Cyanosis
 - d. Open wounds
 - e. Ecchymosis
 - f. Other evidence of trauma
- 6. Hemoptysis
- 7. Neck
 - a. Position of trachea
 - b. Subcutaneous emphysema
 - c. Jugular venous distention
 - d. Penetrating wounds
- 8. Chest
 - a. Contusions
 - b. Tenderness
 - c. Asymmetry
 - d. Lung sounds
 - (1) Absent or decreased
 - (a) Unilateral
 - (b) Bilateral
 - (2) Location
 - (3) Bowel sounds in hemithorax
 - e. Abnormal percussion finding
 - (1) Hyperresonance
 - (2) Hyporesonance
 - f. Heart sounds
 - (1) Muffled
 - (2) Distant
 - (3) Regurgitant murmur
 - g. Shift of apical impulse
 - h. Open wounds
 - i. Impaled object or penetration
 - j. Crepitation
 - k. Paradoxical movement of chest wall segment
- 9. Scaphoid abdomen
- 10. Decreased level of consciousness
- 11. ECG
 - a. ST - T wave elevation or depression

- b. Conduction disturbances
- c. Rhythm disturbances
- 12. History
 - a. Dyspnea
 - b. Chest pain
 - c. Associated symptoms
 - (1) Other areas of pain or discomfort
 - (2) Symptoms prior to incident
 - d. Past history of cardiorespiratory disease
 - e. Use of restraint in motor vehicle crash
- C. Management
 - 1. Airway and ventilation
 - a. Oxygen therapy
 - b. Endotracheal intubation
 - c. Needle cricothyrotomy
 - d. Surgical cricothyrotomy
 - e. Positive pressure ventilation
 - f. Occlude open wounds
 - g. Stabilize chest wall
 - 2. Circulation
 - a. Manage cardiac dysrhythmias
 - b. Intravenous access
 - 3. Pharmacologic
 - a. Analgesics
 - b. Antiarrhythmics
 - 4. Non-pharmacologic
 - a. Needle thoracostomy
 - b. Tube thoracostomy - in hospital management
 - c. Pericardiocentesis - in hospital management
 - 5. Transport considerations
 - a. Appropriate mode
 - b. Appropriate facility
- III. Chest wall injuries
 - A. Rib fractures
 - 1. Epidemiology
 - a. Incidence
 - (1) Infrequent until adult life
 - (2) Most often elderly patients
 - (3) Significant force required
 - b. Morbidity/ mortality
 - (1) Can lead to serious consequences
 - (2) Older ribs more brittle and rigid
 - (3) Associated underlying pulmonary or cardiovascular injury
 - (4) Increases with
 - (a) Age
 - (b) Number of fractures
 - (c) Location of fractures

2. Anatomy and physiology review
3. Pathophysiology
 - a. Most often caused by blunt trauma, bowing effect with midshaft fracture
 - b. Ribs 4 to 9 are most often fractured (thin and poorly protected)
 - c. Respiratory restriction due to pain and splinting
 - (1) Atelectasis
 - (2) Ventilation/ perfusion mismatch
 - d. May be associated with underlying lung or cardiac contusion
 - e. Intercostal vessel injury
 - f. Associated complications
 - (1) First and second ribs are injured by severe trauma
 - (a) Rupture of aorta
 - (b) Tracheobronchial tree injury
 - (c) Vascular injury
 - (2) Left lower rib injury associated with splenic rupture
 - (3) Right lower rib injury associated with hepatic injury
 - (4) Multiple rib fractures
 - (a) Atelectasis
 - (b) Hypoventilation
 - (c) Inadequate cough
 - (d) Pneumonia
 - (5) Open rib fracture associated with visceral injury
 - (6) Posterior rib fracture
 - (a) Fifth through ninth ribs most frequently injured
 - (b) Lower ribs associated with spleen and kidney injury
4. Assessment findings
 - a. Localized pain
 - b. Pain that worsens
 - (1) Movement
 - (2) Deep breathing
 - (3) Coughing
 - c. Point tenderness
 - d. Crepitus or audible crunch
 - e. Splinting on respiration
 - f. Anteroposterior pressure elicits pain
5. Management
 - a. Airway and ventilation
 - (1) Oxygen therapy
 - (2) Positive pressure ventilation
 - (3) Encourage coughing and deep breathing
 - b. Pharmacological
 - (1) Analgesics
 - c. Non-pharmacological
 - (1) Splint - but avoid circumferential splinting
 - d. Transport consideration
 - (1) Appropriate mode
 - (2) Appropriate facility
 - e. Psychological support/ communication strategies

- B. Flail segment
 - 1. Epidemiology
 - a. Incidence
 - (1) Most common cause is vehicular crash
 - (2) Falls from heights
 - (3) Industrial accidents
 - (4) Assault
 - (5) Birth trauma
 - b. Morbidity/ mortality
 - (1) Significant chest trauma
 - (2) Mortality rates 20-40% due to associated injuries
 - (3) Mortality increased with
 - (a) Advanced age
 - (b) Seven or more rib fractures
 - (c) Three or more associated injuries
 - (d) Shock
 - (e) Head injuries
 - 2. Pathophysiology
 - a. Three or more ribs fractured in two or more places producing a free floating segment of chest wall
 - b. Respiratory failure due to
 - (1) Underlying pulmonary contusion
 - (2) Associated intrathoracic injury
 - (3) Inadequate bellows action of chest
 - c. Paradoxical movement of the chest
 - (1) Minimal because of muscle spasm
 - (2) Must be large to compromise ventilation
 - d. Pain
 - (1) Reduces thoracic expansion
 - (2) Decreases ventilation
 - e. Pulmonary contusion
 - (1) Decreased lung compliance
 - (2) Intra alveolar-capillary hemorrhage
 - (3) Alveolar hemorrhage
 - f. Decreased ventilation
 - g. Impaired venous return with resultant ventilation-perfusion mismatch
 - h. Hypercapnia
 - i. Hypoxia
 - 3. Assessment findings
 - a. Chest wall contusion
 - b. Respiratory distress
 - c. Paradoxical chest wall movement
 - d. Pleuritic chest pain
 - e. Crepitus
 - f. Pain and splinting of affected side
 - g. Tachypnea
 - h. Tachycardia
 - i. Possible bundle branch block on ECG

- 4. Management
 - a. Airway and ventilation
 - (1) Positive pressure ventilation may be needed
 - (2) Oxygen (high concentration)
 - (3) Evaluate the need for endotracheal intubation
 - (4) Stabilize flail segment (may be controversial locally)
 - (5) Positive end expiratory pressure (PEEP)
 - b. Circulation
 - (1) Restrict fluids
 - c. Pharmacologic
 - (1) Analgesics
 - d. Non-pharmacologic
 - (1) Positioning
 - (2) Endotracheal intubation and positive pressure ventilation for internal splinting effect
 - e. Transport considerations
 - (1) Appropriate mode
 - (2) Appropriate facility
 - f. Psychological support/ communication strategies
- C. Sternal fracture
 - 1. Epidemiology
 - a. Incidence
 - (1) 5-8% in blunt chest trauma
 - (2) Deceleration compression injury
 - (a) Steering wheel
 - (b) Dashboard
 - (3) Blow to chest
 - (4) Severe hyperflexion of thoracic cage
 - (5) Occur at or below the manubriosternal junction
 - b. Morbidity/ mortality
 - (1) 25-45% mortality
 - (2) High association with myocardial or lung injury
 - (a) Myocardial contusion
 - (b) Myocardial rupture
 - (c) Pulmonary contusion
 - 2. Pathophysiology
 - a. Associated injuries cause morbidity and mortality
 - (1) Pulmonary and myocardial contusion
 - (2) Flail chest
 - (3) Vascular disruption of thoracic vessels
 - (4) Intraabdominal injuries
 - (5) Head injuries
 - b. Rarely is fracture displaced posteriorly to directly impinge on heart or vessels
 - 3. Assessment findings
 - a. Localized pain
 - b. Tenderness over sternum
 - c. Crepitus
 - d. Tachypnea

- e. ECG changes associated with myocardial contusion
- f. History of blunt trauma
- 4. Management
 - a. Airway and ventilation
 - b. Circulation
 - (1) Restrict fluids if pulmonary contusion is suspected
- 5. Pharmacologic
 - a. Analgesics
- 6. Non-pharmacologic
 - a. Allow chest wall self-splinting
- 7. Transport considerations
 - a. Appropriate mode
 - b. Appropriate facility
- 8. Psychological support/ communication strategies

IV. Injury to the lung

- A. Simple pneumothorax
 - 1. Epidemiology
 - a. Incidence
 - (1) 10-30% in blunt chest trauma
 - (2) Almost 100% with penetrating chest trauma
 - b. Morbidity/ mortality
 - (1) Extent of atelectasis
 - (2) Associated injuries
 - 2. Pathophysiology
 - a. Lung 1-3 cm away from the chest wall
 - b. May have stable amount of accumulation of air
 - c. Pulmonary function may be good
 - d. Internal wound allows air to enter the pleural space
 - e. Small tears self-seal, larger one may progress
 - f. Paper bag syndrome
 - g. If standing air will accumulate in the apices, check there first for diminished breath sounds otherwise, if supine it accumulates in the anterior chest
 - h. Trachea may tug towards the effected side
 - i. Ventilation/ perfusion mismatch
 - 3. Assessment findings
 - a. Tachypnea
 - b. Tachycardia
 - c. Respiratory distress
 - d. Absent or decreased breath sounds on affected side
 - e. Hyperresonance
 - f. Decreased chest wall movement
 - g. Dyspnea
 - h. Chest pain referred to shoulder or arm on affected side
 - i. Slight pleuritic chest pain
 - 4. Management
 - a. Airway and ventilation
 - (1) Positive pressure ventilation if necessary

- (2) Monitor for development of tension pneumothorax
 - b. Non-pharmacologic
 - (1) Needle thorocostomy
 - c. Transport consideration
 - (1) Appropriate mode
 - (2) Appropriate facility
 - 5. Psychological support/ communication strategies
- B. Open pneumothorax
 - 1. Epidemiology
 - a. Incidence
 - (1) Penetrating trauma
 - b. Morbidity/ mortality
 - (1) Profound hypoventilation could result
 - (2) Death related to delayed management
 - 2. Pathophysiology
 - a. Open defect in the chest wall
 - (1) Allows communication between pleural space and atmosphere
 - (2) Prevents development of negative intrapleural pressure
 - (3) Produces collapse of ipsilateral lung
 - (4) Inability to ventilate affected lung
 - (5) Ventilation/ perfusion mismatch
 - (a) Shunting
 - (b) Hypoventilation
 - (c) Hypoxia
 - (d) Large functional dead space
 - b. Air will enter pleural space during inspiratory phase
 - c. Air may exit during exhalation phase
 - d. Resistance to air flow through respiratory tract may be greater than through open wound resulting in ineffective respiratory effort
 - e. One way flap valve may let air in but not out resulting in built up pressure in pleural space
 - f. Direct lung injury may be present
 - g. Vena cava kinked from swaying of mediastinum
 - h. Preload decreased from knifing of inferior vena cava
 - 3. Assessment findings
 - a. To and fro air motion out of defect
 - b. Defect in the chest wall
 - c. Penetrating injury to the chest which does not seal itself
 - d. Sucking sound on inhalation
 - e. Tachycardia
 - f. Tachypnea
 - g. Respiratory distress
 - h. Subcutaneous emphysema
 - i. Decreases breath sounds on affected side
 - 4. Management
 - a. Airway and ventilation
 - (1) Positive pressure ventilation if necessary
 - (2) Monitor for development of tension pneumothorax

- b. Non-pharmacologic
 - (1) Occlude open wound
 - (2) Tube thoracostomy - in hospital management
 - c. Transport consideration
 - (1) Appropriate mode
 - (2) Appropriate facility
 - 5. Psychological support/ communication strategies
- C. Tension pneumothorax
- 1. Epidemiology
 - a. Incidence
 - (1) Penetrating trauma
 - (2) Blunt trauma
 - b. Morbidity/ mortality
 - (1) Profound hypoventilation could result
 - (2) Death related to delayed management
 - (3) Immediate life-threatening chest injury
 - 2. Pathophysiology
 - a. Defect in airway allowing communication with pleural space
 - b. Blunt trauma
 - (1) Penetration by rib fracture
 - (2) Sudden increase in intrapulmonary pressure
 - (3) Bronchial disruption from shear forces
 - c. Air trapped in pleural space with build up of pressure
 - d. Lung collapse on affected side with mediastinal shift to contralateral side
 - e. Lung collapse leads to right-to-left intrapulmonary shunting and hypoxia
 - f. Reduction in cardiac output
 - (1) Increased intrathoracic pressure
 - (2) Deformation of vena cava reducing preload (decreased venous return to heart)
 - 3. Assessment findings
 - a. Unilateral decreased or absent breath sounds
 - b. Dyspnea
 - c. Tachypnea
 - d. Respiratory distress
 - e. Extreme anxiety
 - f. Cyanosis
 - g. Bulging of intercostal muscles
 - h. Tachycardia
 - i. Hypotension
 - j. Narrow pulse pressure
 - k. Subcutaneous emphysema
 - l. Jugular venous distention
 - m. Tracheal deviation
 - n. Hyperresonance
 - 4. Management
 - a. Airway and ventilation
 - (1) Positive pressure ventilation if necessary
 - b. Circulation

- (1) Relieve tension pneumothorax to improve cardiac output
 - c. Non-pharmacologic
 - (1) Occlude open wound
 - (2) Needle thoracentesis
 - (a) Equipment
 - (b) Technique
 - (c) Assess the need for a second or third needle insertion
 - (3) Tube thoracostomy - in hospital management
 - d. Transport consideration
 - (1) Appropriate mode
 - (2) Appropriate facility
 - e. Psychological support/ communication strategies
- D. Hemothorax
- 1. Epidemiology
 - a. Incidence
 - (1) Associated with pneumothorax
 - (2) Blunt or penetrating trauma
 - (3) Rib fractures are frequent cause
 - b. Morbidity/ mortality
 - (1) Life-threatening injury that frequently requires urgent chest tube and/ or surgery
 - (2) Hemothorax associated with great vessel or cardiac injury
 - (a) 50% will die immediately
 - (b) 25% live five to ten minutes
 - (c) 25% may live 30 minutes or longer
 - 2. Pathophysiology
 - a. Accumulation of blood in the pleural space
 - b. Bleeding from
 - (1) Penetrating or blunt lung injury
 - (2) Chest wall vessels
 - (3) Intercostal vessels
 - (4) Myocardium
 - c. Pulmonary parenchyma is low-pressure vascular system
 - d. Bleeding from pulmonary contusion generally causes 1000 to 1500 cc blood loss
 - e. Massive hemothorax indicates great vessel or cardiac injury
 - f. Collapse of ipsilateral lung
 - g. Respiratory insufficiency dependent on amount of blood
 - h. Hypoxia
 - i. Hypotension and inadequate perfusion may result from blood loss
 - j. Chest cavity can hold 2,000 to 3,000 ml of blood
 - k. Classified by amount of blood loss
 - l. Tissue pressure effects of legs, arms and abdomen versus thorax
 - (1) La Place law
 - (2) Extraluminal pressure in legs
 - (3) Extraluminal pressure in thorax
 - m. An intercostal artery can easily bleed 50 ccs per minute
 - n. Intrapulmonary hemorrhage
 - (1) Bronchus

- (2) Parenchyma
 - 3. Assessment findings
 - a. Tachypnea
 - b. Tachycardia
 - c. Dyspnea
 - d. Respiratory distress
 - e. Hypotension
 - f. Narrow pulse pressure
 - g. Pleuritic chest pain
 - h. Pale, cool, moist skin
 - i. Dullness on percussion
 - j. Decreased breath sounds
 - 4. Management
 - a. Airway and ventilation
 - (1) Positive pressure ventilation if necessary
 - b. Circulation
 - (1) Re-expand the affected lung to reduce bleeding
 - c. Non-pharmacological
 - (1) Needle chest decompression
 - (2) Tube thoracostomy - in hospital management
 - d. Transport considerations
 - (1) Appropriate mode
 - (2) Appropriate facility
 - e. Psychological support/ communication strategies
- E. Hemothorax
 - 1. Pathophysiology
 - a. Pneumothorax with bleeding in pleural space
 - 2. Assessment
 - a. Findings and management same as hemothorax
 - 3. Management
 - a. Management is the same as a hemothorax
- F. Pulmonary contusion
 - 1. Epidemiology
 - a. Incidence
 - (1) Blunt trauma to chest
 - (a) Most common injury from blunt thoracic trauma
 - (b) 30-75% with blunt trauma have pulmonary contusion
 - (2) Associated commonly with rib fracture
 - (3) High energy shock waves from explosion
 - (4) High velocity missile wounds
 - (5) Rapid deceleration
 - (6) High incidence of extrathoracic injuries
 - (7) Low velocity - ice pick
 - b. Morbidity/ mortality
 - (1) Missed due to high incidence of other associated injuries
 - (2) Mortality between 14-20%
 - 2. Pathophysiology
 - a. Three physical mechanisms

- (1) Implosion effect
 - (a) Overexpansion of air in lungs secondary to positive-pressure concussive wave
 - (b) Rapid excessive stretching and tearing of alveoli
- (2) Inertial effect
 - (a) Strips alveoli from heavier bronchial structures when accelerated at varying rates by concussive wave
- (3) Spalding effect
 - (a) Liquid-gas interface is disrupted by shock-wave
 - (b) Wave releases energy
 - (c) Differential transmission of energy causes disruption of tissue
- b. Alveolar and capillary damage with interstitial and intraalveolar extravasation of blood
- c. Interstitial edema
- d. Increased capillary membrane permeability
- e. Gas exchange disturbances
- f. Hypoxemia and carbon dioxide retention
- g. Hypoxia causes reflex thickening of mucous secretions
 - (1) Bronchiolar obstruction
 - (2) Atelectasis
- h. Blood is shunted away from unventilated alveoli leading to further hypoxemia
- 3. Assessment findings
 - a. Tachypnea
 - b. Tachycardia
 - c. Cough
 - d. Hemoptysis
 - e. Apprehension
 - f. Respiratory distress
 - g. Dyspnea
 - h. Evidence of blunt chest trauma
 - i. Cyanosis
- 4. Management
 - a. Airway and ventilation
 - (1) Positive pressure ventilation if necessary
 - b. Circulation
 - (1) Restrict intravenous fluids (use caution restricting fluids in hypovolemic patients)
 - c. Transport considerations
 - (1) Appropriate mode
 - (2) Appropriate facility
 - d. Psychological support/ communication strategies

- V. Myocardial injuries
 - A. Pericardial tamponade
 - 1. Epidemiology
 - a. Incidence
 - (1) Rare in blunt trauma
 - (2) Penetrating trauma

- (3) Occurs in less than 2% of chest trauma
- b. Morbidity/ mortality
 - (1) Gunshot wounds carry higher mortality than stab wounds
 - (2) Lower mortality rate if isolated tamponade is present
- 2. Anatomy and physiology
 - a. Pericardium
 - (1) Tough fibrous sac
 - (2) Encloses heart
 - (3) Attaches to great vessels at the base of heart
 - (4) Two layers
 - (a) Visceral forms epicardium
 - (b) Parietal regarded as sac itself
 - (5) Purposes
 - (a) Anchor heart
 - (b) Restricts excess movement
 - (c) Prevents kinking of great vessels
 - (6) Parietal layer is acutely nondispensable but can chronically distend by as much as 1,000 to 1,500 ml
 - (7) Space between visceral and parietal layer is "potential space"
 - (8) Space normally filled with 30-50 ml of straw-colored fluid secreted by visceral layer
 - (a) Lubrication
 - (b) Lymphatic drainage
 - (c) Immunologic protection for heart
- 3. Pathophysiology
 - a. Rapid accumulation of fluid over a period of minutes to hours leads to increases in intrapericardial pressure
 - b. Increased intrapericardial pressure
 - (1) Compresses heart and decreases cardiac output due to restricted diastolic expansion and filling
 - (2) Hampers venous return
 - c. Myocardial perfusion decreases due to pressure effects on walls of heart and decreased diastolic pressures
 - d. Ischemic dysfunction may result in infarction
 - e. Removal of as little as 20 ml of blood may drastically improve cardiac output
- 4. Assessment findings
 - a. Tachycardia
 - b. Respiratory distress
 - c. Narrow pulse pressure
 - d. Pulsus paradoxus
 - e. Cyanosis
 - (1) Head
 - (2) Neck
 - (3) Upper extremities
 - f. Beck's triad - advanced stage seen in only 30% of patients
 - (1) Hypotension
 - (2) Neck vein distention
 - (3) Muffled heart tones

- g. Kussmaul's sign
- h. ECG changes
- 5. Management
 - a. Airway and ventilation
 - b. Circulation
 - (1) Fluid challenge
 - c. Non-pharmacological
 - (1) Pericardiocentesis - in hospital management
 - d. Transport considerations
 - (1) Appropriate mode
 - (2) Appropriate facility
 - e. Psychological support/ communication strategies
- B. Myocardial contusion (blunt myocardial injury)
 - 1. Epidemiology
 - a. Incidence
 - (1) 16-76% of blunt trauma
 - b. Morbidity/ mortality
 - (1) Significant cause of morbidity and mortality in the blunt trauma patient
 - 2. Pathophysiology
 - a. Hemorrhage with edema and fragmented myocardial fibers
 - b. Cellular injury
 - c. Vascular damage may occur
 - d. Hemopericardium may occur from lacerated epicardium or endocardium
 - e. Fibrinous reaction at contusion site may lead to
 - (1) Delayed rupture
 - (2) Ventricular aneurysm
 - f. Areas of damage are well demarcated
 - g. Conduction defects
 - 3. Assessment findings
 - a. Associated injuries
 - (1) One to three rib fractures
 - (2) Sternal fracture
 - b. Retrosternal chest pain
 - c. ECG changes
 - (1) Persistent tachycardia
 - (2) ST elevation, T wave inversion
 - (3) Right bundle branch block
 - (4) Atrial flutter, fibrillation
 - (5) Premature ventricular contractions
 - (6) Premature atrial contractions
 - d. New cardiac murmur
 - e. Pericardial friction rub (late)
 - 4. Management
 - a. Airway and ventilation
 - (1) Oxygen therapy
 - b. Circulation
 - (1) Intravenous fluid volume
 - c. Pharmacological

- (1) Antiarrhythmics
 - (2) Vasopressors
 - d. Transport considerations
 - (1) Appropriate mode
 - (2) Appropriate facility
 - e. Psychological support/ communication strategies
 - C. Myocardial rupture
 - 1. Associated with immediate trauma or delayed for 2-3 weeks
 - 2. Associates with blunt trauma
 - a. Compression between sternum and vertebrae
 - 3. Penetrating trauma
 - a. Rib
 - b. Missile
 - c. Sternal bone
 - 4. History of trauma with a presentation of
 - a. Congestive heart failure
 - b. Cardiac tamponade
 - 5. Immediate onset of congestive heart failure following trauma
 - a. Rupture of cardiac valves
 - b. Intraventricular septal rupture
 - 6. Management is supportive
- VI. Vascular injuries
 - A. Aortic dissection/ rupture
 - 1. Epidemiology
 - a. Incidence
 - (1) Blunt trauma
 - (a) Motor vehicle crash
 - (b) Falls
 - (2) 15% of all blunt trauma deaths
 - 2. Morbidity/ mortality
 - a. 85-95% die instantaneously
 - b. 10-15% survive to arrive at hospital
 - (1) 33% of survivors die within six hours
 - (2) 33% of survivors die within twenty-four hours
 - (3) 33% survive three days or longer
 - 3. Pathophysiology
 - a. Shear injury
 - b. Separation of the aortic intima and media
 - c. Blood enters media through a small intima tear
 - d. Tear due to effect of high speed deceleration on portions of the aorta at points of relative fixation
 - e. Increased intraluminal pressure results from impact
 - f. Thinned out layer may rupture
 - g. Descending aorta at the isthmus just distal to left subclavian artery is most common site of rupture (ligamentum arteriosum)
 - h. Ruptures of ascending aorta much less common
 - 4. Assessment findings
 - a. Retrosternal or interscapular pain

- b. Dyspnea
- c. Dysphagia
- d. Ischemic pain of the extremities
- e. Upper extremity hypertension with absent or decreased amplitude of femoral pulses
- f. Harsh systolic murmur over precordium or interscapular region
- 5. Management
 - a. Airway and ventilation
 - b. Circulation
 - (1) Do not over hydrate
 - c. Transport considerations
 - (1) Appropriate mode
 - (2) Appropriate facility
 - d. Psychological support/ communication strategies
- B. Penetrating wounds of the great vessels
 - 1. Usually involve
 - a. Chest
 - b. Abdomen
 - c. Neck
 - 2. Wounds are accompanied by
 - a. Massive hemothorax
 - b. Hypovolemic shock
 - c. Cardiac tamponade
 - d. Enlarging hematomas
 - 3. Hematomas may cause compression of any structure
 - a. Vena cava
 - b. Trachea
 - c. Esophagus
 - d. Great vessels
 - e. Heart
 - 4. Management
 - a. Manage hypovolemia
 - (1) PASG not recommended
 - b. Relief of tamponade if present
 - c. Expeditious transport
- VII. Other thorax injuries
 - A. Diaphragmatic injury
 - 1. Epidemiology
 - a. Incidence
 - (1) Blunt trauma
 - (2) Penetrating trauma
 - (3) Frequently encountered injury
 - b. Morbidity/ mortality
 - (1) Could be life-threatening
 - 2. Pathophysiology
 - a. High-pressure compression to abdomen with resultant intra-abdominal pressure increase

- b. Can produce very subtle signs and symptoms
- c. Bowel obstruction and strangulation
- d. Restriction of lung expansion
 - (1) Hypoventilation
 - (2) Hypoxia
- e. Mediastinal shift
 - (1) Cardiac compromise
 - (2) Respiratory compromise
- 3. Assessment findings
 - a. Tachypnea
 - b. Tachycardia
 - c. Respiratory distress
 - d. Dullness to percussion
 - e. Scaphoid abdomen
 - f. Bowel sounds in affected hemithorax
 - g. Decreased breath sounds
- 4. Management
 - a. Airway and ventilation
 - (1) Positive pressure ventilation if necessary
 - (2) Caution IPPB may worsen the injury
 - b. Non-pharmacologic
 - (1) Do not place patient in Trendelenburg position
 - c. Transport consideration
 - (1) Appropriate mode
 - (2) Appropriate facility
 - d. Psychological support/ communication strategies
- B. Esophageal injury
 - 1. Epidemiology
 - a. Incidence
 - (1) Penetrating trauma most frequent cause
 - (2) Rare in blunt trauma
 - b. Morbidity/ mortality
 - (1) Could be life-threatening if missed
 - 2. Pathophysiology
 - a. Missile and knife wounds penetrate esophagus
 - b. Can perforate spontaneously
 - (1) Violent emesis
 - (2) Carcinoma
 - (3) Anatomic distortions produced by diverticulae or gastric reflux
 - 3. Assessment findings
 - a. Pain
 - b. Fever
 - c. Hoarseness
 - d. Dysphagia
 - e. Respiratory distress
 - f. Cervical esophageal perforation
 - (1) Local tenderness
 - (2) Subcutaneous emphysema

- (3) Resistance of neck on passive motion
 - g. Intrathoracic esophageal perforation
 - (1) Mediastinal emphysema
 - (2) Mediastinitis
 - (3) Subcutaneous emphysema
 - (4) Mediastinal crunch
 - (5) Splinting of chest wall
 - h. Respiratory distress
 - i. Shock
 - 4. Management
 - a. Airway and ventilation
 - b. Transport consideration
 - (1) Appropriate mode
 - (2) Appropriate facility
 - c. Psychological support/ communication strategies
- C. Tracheo-bronchial injuries
 - 1. Epidemiology
 - a. Incidence
 - (1) Rare injury - less than 3% of chest trauma
 - (2) Penetrating trauma
 - (3) Blunt trauma
 - b. Morbidity/ mortality
 - (1) High mortality rate - greater than 30%
 - 2. Pathophysiology
 - a. Majority occur within 3 cm of carina
 - b. Tear can occur anywhere along tracheal/ bronchial tree
 - c. Rapid movement of air into pleural space
 - d. Tension pneumothorax refractory to needle decompression
 - e. Continuous flow of air from needle of decompressed chest
 - f. Severe hypoxia
 - 3. Assessment
 - a. Tachypnea
 - b. Tachycardia
 - c. Massive subcutaneous emphysema
 - d. Dyspnea
 - e. Respiratory distress
 - f. Hemoptysis
 - g. Signs of tension pneumothorax that doesn't respond to needle decompression
 - 4. Management
 - a. Airway and ventilation
 - b. Circulation
 - c. Transport consideration
 - (1) Appropriate mode
 - (2) Appropriate facility
- D. Traumatic asphyxia
 - 1. Epidemiology
 - a. Incidence
 - b. Morbidity/ mortality

2. Pathophysiology
 - a. Sudden compressional force squeezes the chest
 - b. Blood backs up into the head and neck
 - c. Jugular veins engorge, capillaries rupture
3. Assessment
 - a. Cyanosis to the face and upper neck
 - b. Jugular venous distention
 - c. Swelling or hemorrhage of the conjunctiva
 - d. Skin below area remains pink
 - e. Hypotension when pressure released
4. Management
 - a. Airway and ventilation
 - b. Circulation
 - (1) Expect hypotension once compression is released
 - c. Pharmacological
 - (1) Sodium bicarbonate should be guided by ABGs in hospital
 - d. Transport considerations
 - (1) Appropriate mode
 - (2) Appropriate facility

VIII. Integration