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UNIT TERMINAL OBJECTIVE

4-4 At the completion of this unit, the EMT-Intermediate student will be able to utilize 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 EMT-Intermediate student will be able to:

4-4.1 Describe the incidence, morbidity, and mortality of thoracic injuries in the trauma patient. (C-1)
4-4.2 Discuss the anatomy and physiology of the organs and structures related to thoracic injuries. (C-1)
4-4.3 Predict thoracic injuries based on mechanism of injury. (C-2)
4-4.4 Discuss the types of thoracic injuries. (C-1)
4-4.5 Discuss the pathophysiology of thoracic injuries. (C-1)
4-4.6 Discuss the assessment findings associated with thoracic injuries. (C-1)
4-4.7 Discuss the management of thoracic injuries. (C-1)
4-4.8 Identify the need for rapid intervention and transport of the patient with thoracic injuries. (C-1)
4-4.9 Discuss the epidemiology and pathophysiology of specific chest wall injuries, including: (C-1)
- a. Rib fracture
- b. Flail segment
- c. Sternal fracture

4-4.10 Discuss the assessment findings associated with chest wall injuries. (C-1)
4-4.11 Identify the need for rapid intervention and transport of the patient with chest wall injuries. (C-1)
4-4.12 Discuss the management of chest wall injuries. (C-1)
4-4.13 Discuss the pathophysiology of injury to the lung, including: (C-1)
- a. Simple pneumothorax
- b. Open pneumothorax
- c. Tension pneumothorax
- d. Hemothorax
- e. Hemopneumothorax
- f. Pulmonary contusion

4-4.14 Discuss the assessment findings associated with lung injuries. (C-1)
4-4.15 Discuss the management of lung injuries. (C-1)
4-4.16 Identify the need for rapid intervention and transport of the patient with lung injuries. (C-1)
4-4.17 Discuss the pathophysiology of myocardial injuries, including: (C-1)
- a. Pericardial tamponade
- b. Myocardial contusion

4-4.18 Discuss the assessment findings associated with myocardial injuries. (C-1)
4-4.19 Discuss the management of myocardial injuries. (C-1)
4-4.20 Identify the need for rapid intervention and transport of the patient with myocardial injuries. (C-1)
4-4.21 Discuss the pathophysiology of vascular injuries, including injuries to: (C-1)
- a. Aorta disection/rupture
- b. Vena cava
- c. Pulmonary arteries/ veins

4-4.22 Discuss the assessment findings associated with vascular injuries. (C-1)
4-4.23 Discuss the management of vascular injuries. (C-1)
4-4.24 Discuss the pathophysiology of diaphragmatic injuries. (C-1)
4-4.25 Discuss the assessment findings associated with diaphragmatic injuries. (C-1)
4-4.26 Discuss the management of diaphragmatic injuries. (C-1)
4-4.27 Discuss the pathophysiology of esophageal injuries. (C-1)

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4-4.28 Discuss the assessment findings associated with esophageal injuries. (C-1)
4-4.29 Discuss the management of esophageal injuries. (C-1)
4-4.30 Discuss the pathophysiology of tracheo-bronchial injuries. (C-1)
4-4.31 Discuss the assessment findings associated with tracheo-bronchial injuries. (C-1)
4-4.32 Discuss the management of tracheo-bronchial injuries. (C-1)
4-4.33 Discuss the pathophysiology of traumatic asphyxia. (C-1)
4-4.34 Discuss the assessment findings associated with traumatic asphyxia. (C-1)
4-4.35 Discuss the management of traumatic asphyxia. (C-1)
4-4.36 Differentiate between thoracic injuries based on the assessment and history. (C-3)
4-4.37 Formulate a field impression based on the assessment findings. (C-3)
4-4.38 Develop a patient management plan based on the field impression. (C-3)

AFFECTIVE OBJECTIVES

At the completion of this unit, the EMT-Intermediate student will be able to:

4-4.39 Advocate the use of a thorough assessment to determine a differential diagnosis and treatment plan for thoracic trauma. (A-3)
4-4.40 Advocate the use of a thorough scene survey to determine the forces involved in thoracic trauma. (A-3)
4-4.41 Value the implications of failing to properly diagnose thoracic trauma. (A-2)
4-4.42 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 EMT-Intermediate student will be able to:

4-4.43 Demonstrate a clinical assessment for a patient with suspected thoracic trauma. (P-1)
4-4.44 Demonstrate the following techniques of management for thoracic injuries: (P-1)
- a. Needle decompression
- b. Fracture stabilization
- c. ECG monitoring
- d. Oxygenation and ventilation

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DECLARATIVE

I. Introduction
- A. Epidemiology
  - 1. Incidence
  - 2. Morbidity/ mortality
  - 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
      - (2) Closed
    - 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) Latissimus dorsi
      - (4) Rhomboids
      - (5) Pectoralis major
      - (6) Diaphragm
      - (7) Sternocleidomastoid
    - d. Trachea
    - e. Bronchi

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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
      (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) Respiratory alkalosis
ii) Respiratory acidosis
iii) 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 ventilatory support
    a. Oxygen therapy
    b. Endotracheal intubation
    c. Positive pressure ventilation
    d. Occlude open wounds
    e. Stabilize chest wall
  2. Circulatory support
    a. Manage cardiac dysrhythmias
    b. Intravenous access
  3. Pharmacological interventions
    a. Analgesics
    b. Antiarrhythmics
  4. Non-pharmacological interventions
    a. Needle thoracostomy
    b. Tube thoracostomy - in hospital management
    c. Pericardiocentesis - in hospital management
  5. Transport considerations
    a. Appropriate mode
    b. Appropriate facility
  6. Psychological support/ communications strategies

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 ventilatory support
(1) Oxygen therapy
(2) Positive pressure ventilation
(3) Encourage coughing and deep breathing
b. Circulatory support
c. Pharmacological intervention
(1) Analgesics
d. Non-pharmacological intervention
(1) Splint - but avoid circumferential splinting
e. Transport considerations
(1) Appropriate mode
(2) Appropriate facility
f. 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 bellow 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 ventilatory support
      (1) Positive pressure ventilation as necessary
      (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. Circulatory support
      (1) Restrict fluids
   c. Pharmacological interventions
      (1) Analgesics
   d. Non-pharmacological interventions
      (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) Occurs 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) Intra-abdominal 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 ventilatory support
b. Circulatory support
(1) Restrict fluids if pulmonary contusion is suspected
c. Pharmacological interventions
(1) Analgesics
d. Non-pharmacological interventions
(1) Allow chest wall self-splinting
e. Transport considerations
(1) Appropriate mode
(2) Appropriate facility
f. Psychological support/ communication strategies

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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; if supine, air accumulates in the anterior chest
    - h. Trachea may tug towards the affected 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 ventilatory support
      - (1) Positive pressure ventilation as necessary
      - (2) Monitor for development of tension pneumothorax
    - b. Circulatory support
    - c. Pharmacological interventions
    - d. Non-pharmacological interventions
      - (1) Needle thorocostomy
    - e. Transport considerations
      - (1) Appropriate mode
      - (2) Appropriate facility
    - f. 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

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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. Decreased breath sounds on affected side
4. Management
    a. Airway and ventilatory support
        (1) Positive pressure ventilation as necessary
        (2) Monitor for development of tension pneumothorax
    b. Circulatory support
    c. Pharmacological interventions
    d. Non-pharmacological interventions
        (1) Occlude open wound
        (2) Tube thoracostomy - in hospital management
    e. Transport considerations
        (1) Appropriate mode
        (2) Appropriate facility
    f. 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 ventilatory support
      (1) Positive pressure ventilation as necessary
   b. Circulatory support
      (1) Relieve tension pneumothorax to improve cardiac output
   c. Pharmacological interventions
   d. Non-pharmacological interventions
      (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
   e. Transport considerations
      (1) Appropriate mode
      (2) Appropriate facility
   f. Psychological support/ communication strategies

D. Hemothorax

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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% will 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 1,000 to 1,500 ml 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. An intercostal artery can easily bleed 50 ml's per minute
    m. 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 ventilatory support
        (1) Positive pressure ventilation as necessary
    b. Circulatory support
        (1) Re-expand the affected lung to reduce bleeding

c. Pharmacological interventions
d. Non-pharmacological interventions
(1) Needle chest decompression
(2) Tube thoracostomy - in hospital management
e. Transport considerations
(1) Appropriate mode
(2) Appropriate facility
f. Psychological support/ communication strategies

E. Hemopneumothorax
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 (e.g., 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

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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 ventilatory support
(1) Positive pressure ventilation as necessary
b. Circulatory support
(1) Restrict intravenous fluids (use caution restricting fluids in hypovolemic patients)
c. Pharmacological interventions
d. Non-pharmacological interventions
e. Transport considerations
(1) Appropriate mode
(2) Appropriate facility
f. 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) Purpose
(a) Anchors heart
(b) Restricts excess movement
(c) Prevents kinking of great vessels

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(6) Parietal layer is acutely nondispensable but can slowly 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. Kussmual's sign
h. ECG changes

5. Management
a. Airway and ventilatory support
b. Circulatory support
(1) Fluid challenge
c. Pharmacological interventions
d. Non-pharmacological interventions
(1) Pericardiocentesis - in hospital management
e. Transport considerations
(1) Appropriate mode
(2) Appropriate facility
f. 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 ventilatory support
(1) Oxygen therapy
b. Circulatory support
(1) Intravenous fluid volume
c. Pharmacological interventions
(1) Antiarrhythmics
(2) Vasopressors
d. Non-pharmacological interventions
e. Transport considerations
(1) Appropriate mode
(2) Appropriate facility
f. Psychological support/ communication strategies

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

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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 arteriosom)
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 ventilatory support
b. Circulatory support
(1) Do not over hydrate
c. Pharmacological interventions
d. Non-pharmacological interventions
e. Transport considerations
(1) Appropriate mode
(2) Appropriate facility
f. 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

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e. Heart
4. Management
a. Manage hypovolemia
(1) PASG not recommended
b. Relief of tamponade if present
c. Expeditious transport

VII. Other thoracic 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 ventilatory support
(1) Positive pressure ventilation as necessary
(2) Caution - IPPB may worsen the injury
b. Circulatory support
c. Pharmacological interventions
d. Non-pharmacological interventions
(1) Do not place patient in Trendelenburg position
e. Transport considerations
(1) Appropriate mode
(2) Appropriate facility
f. Psychological support/ communication strategies
B. Esophageal injury
1. Epidemiology

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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 ventilatory support
b. Circulatory support
c. Pharmacological interventions
d. Non-pharmacological interventions
e. Transport considerations
(1) Appropriate mode
(2) Appropriate facility
f. 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

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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 don't respond to needle decompression
4. Management
   a. Airway and ventilatory support
   b. Circulatory support
   c. Pharmacological interventions
   d. Non-pharmacological interventions
   e. Transport considerations
      (1) Appropriate mode
      (2) Appropriate facility
   f. Psychological support/ communications strategies

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 ventilatory support
   b. Circulatory support
      (1) Expect hypotension once compression is released
   c. Pharmacological interventions
      (1) Sodium bicarbonate should be guided by ABG's in hospital
   d. Non-pharmacological interventions
   e. Transport considerations
      (1) Appropriate mode
      (2) Appropriate facility
   f. Psychological support/ communications strategies

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