UNIT TERMINAL OBJECTIVE

4-4 At the completion of this unit, the EMT-Critical Care Technician 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, **head, spinal or abdominal** injury.

COGNITIVE OBJECTIVES

At the completion of this unit, the EMT-Critical Care Technician 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 dissection/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)
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)
4-4.39 Describe the incidence, morbidity, and mortality of head injury. (C-1)
4-4.40 Explain anatomy and relate physiology of the CNS to head injury. (C-1)
4-4.41 Predict head injuries based on mechanism of injury. (C-2)
4-4-42 Distinguish between head injury and brain injury. (C-3)
4-4.43 Explain the pathophysiology of head/brain injury. (C-1)
4-4.44 Explain the concept of increasing intracranial pressure (ICP). (C-1)
4-4.45 Explain the effect of increased and decreased carbon dioxide on ICP. (C-1)
4-4.46 Relate assessment findings associated with head/brain injuries. (C-1)
4-4.47 Identify the need for rapid intervention and transport of the patient with a head/brain injury. (C-1)
4-4.48 Describe and explain the general management of head/brain injury patient. (C-1)
4-4.49 Describe the incidence, morbidity, and mortality of spinal injuries in the trauma patient. (C-1)
4-4.50 Describe the anatomy and physiology of structures related to spinal injuries. (C-1)
- **a. Cervical**
- **b. Thoracic**
- **c. Lumbar**
- **d. Sacrum**
- **e. Coccyx**
- **f. Head**
- **g. Brain**
- **h. Spinal cord**
- **i. Nerve tract(s)**
- **j. Dermatomes**

4-4.51 Predict spinal injuries based on mechanism of injury. (C-2)
4-4.52 Describe the pathophysiology of spinal injuries. (C-1)
4-4.53 Explain traumatic and non-traumatic spinal injuries. (C-1)
4-4.54 Describe the assessment findings associated with spinal injuries. (C-1)
4-4.55 Describe the management of spinal injuries. (C-1)
4-4.56 Identify the need for rapid intervention and transport of the patient with spinal injuries. (C-1)
4-4.57 Describe the pathophysiology of traumatic spinal injury related to: (C-1)
- **a. Spinal shock**
- **b. Spinal neurogenic shock**
- **c. Quadriplegia/ paraplegia**
- **d. Incomplete cord injury/ cord syndromes:**
  - **1. Central cord syndrome**
  - **2. Anterior cord syndrome**

3. Brown-Sequard syndrome

4-4.58 Describe the management of traumatic spinal injuries. (C-1)

4-4.59 Describe the management of non-traumatic spinal injuries. (C-1)
4-4.60 Describe the epidemiology, including the morbidity/mortality and prevention strategies for a patient with abdominal trauma. (C-1)
4-4.61 Describe the anatomy and physiology of organs and structures related to abdominal injuries. (C-1)
4-4.62 Predict abdominal injuries based on blunt and penetrating mechanisms of injury. (C-2)
4-4.63 Describe open and closed abdominal injuries. (C-1)
4-4.64 Explain the pathophysiology of abdominal injuries. (C-1)
4-4.65 Describe the assessment findings associated with abdominal injuries. (C-1)
4-4.66 Identify the need for rapid intervention and transport of the patient with abdominal injuries based on assessment findings. (C-1)
4-4.67 Describe the management of abdominal injuries. (C-1)

AFFECTIVE OBJECTIVES

At the completion of this unit, the EMT-Critical Care Technician student will be able to:

4-4.71 Advocate the use of a thorough assessment to determine a differential diagnosis and treatment plan for thoracic trauma. (A-3)
4-4.72 Advocate the use of a thorough scene survey to determine the forces involved in thoracic trauma. (A-3)
4-4.73 Value the implications of failing to properly diagnose thoracic trauma. (A-2)
4-4.74 Value the implications of failing to initiate timely interventions to patients with thoracic trauma. (A-2)
4-4.75 Advocate the use of a thorough assessment when determining the proper management modality for spine injuries. (A-3)
4-4.76 Value the implications of failing to properly immobilize a spine injured patient.
4-4.77 Advocate the use of a thorough assessment to determine a differential diagnosis and treatment plan for abdominal trauma. (A-3)
4-4.78 Advocate the use of a thorough scene survey to determine the forces involved in abdominal trauma. (A-3)
4-4.79 Value the implications of failing to properly diagnose abdominal trauma and initiate timely interventions to patients with abdominal trauma.

PSYCHOMOTOR OBJECTIVES

At the completion of this unit, the EMT-Critical Care Technician student will be able to:

4-4.80 Demonstrate a clinical assessment for a patient with suspected thoracic trauma. (P-1)
4-4.81 Demonstrate the following techniques of management for thoracic injuries: (P-1)
a. Needle decompression
b. Fracture stabilization
c. ECG monitoring
d. Oxygenation and ventilation
4-4.82 Demonstrate a clinical assessment to determine the proper management modality for a patient with a suspected traumatic spinal injury. (P-1)
4-4.83 Demonstrate a clinical assessment to determine the proper management modality for a patient

with a suspected non-traumatic spinal injury. (P-1)

4-4.84 **Demonstrate immobilization of the urgent and non-urgent patient with assessment findings of spinal injury from the following presentations: (P-1)**
- **a. Supine**
- **b. Prone**
- **c. Semi-prone**
- **d. Sitting**
- **e. Standing**

4-4.85 **Demonstrate documentation of suspected spinal cord injury to include: (P-1)**
- **a. General area of spinal cord involved**
- **b Sensation**
- **c. Dermatomes**
- **d. Motor function**
- **e. Area(s) of weakness**

4-4.86 **Demonstrate preferred methods for stabilization of a helmet from a potentially spine injured patient. (P-1)**

4-4.87 **Demonstrate helmet removal techniques. (P-1)**

4-4.88 **Demonstrate alternative methods for stabilization of a helmet from a potentially spine injured patient. (P-1)**

4-4.89 **Demonstrate documentation of assessment before spinal immobilization. (P-1)**

4-4.91 **Demonstrate documentation of assessment during spinal immobilization. (P-1)**

4-4.92 **Demonstrate a clinical assessment to determine the proper treatment plan for a patient with suspected abdominal trauma. (P-1)**

4-4.93 **Demonstrate the proper use of MAST (PASG) in a patient with suspected abdominal trauma. (P-1)**

4-4.94 **Demonstrate the proper use of MAST (PASG) in a patient with suspected pelvic fracture. (P-1)**

DECLARATIVE

Thoracic Trauma

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
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

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
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
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
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
(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
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
e. Heart
4. Management
a. Manage hypovolemia
(1) MAST (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
      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
   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

Head Trauma

I. Introduction

A. Incidence - approximately 4 million people sustain head injuries in the U.S. each year

B. Morbidity and mortality - approximately 450,000 require hospitalization

1.. Most are minor injuries (GCS 13-15)

2. Major head injury (GCS <8) is the most common cause of death from trauma in trauma centers

3.. Over 50% of all trauma deaths involve head injury

4. Risk

a. Highest in males 15-24 years of age

b. Infants 6 months to 2 years

c. Young school age children

d. The elderly

II. Review of anatomy/ physiology of head/ brain

A. Scalp

1. Hair

2, Subcutaneous tissue - contains major scalp veins which bleed profusely

3. Muscle - attached just above the eyebrows and at the base of the occiput

4. Galea - freely moveable sheet of connective tissue, helps deflect blows

5. Loose connective tissue - contains emissary veins that drain intracranially (becomes important as a route for infection)

6. Skull - divided into two main groups of bones - face and cranium

a. Cranial bones

(1) Composed of double layer of solid bone which surrounds a spongy middle layer gives greater strength

(2) Frontal, occipital, temporal, parietal, and mastoid

- **b. Middle meningeal artery**
  - **(1) Lies under temporal bone, if fractured can tear artery**
  - **(2) Source of epidural hematoma**
- **c. Skull floor - many ridges**
- **d. Foramen magnum - opening at base of skull for spinal cord**

7. Brain - occupies 80% of intracranial space

- **a. Divisions**
  - **(1) Cerebrum - each lobe named after skull plates that lie immediately above**
    - **(a) Cortex controls**
      - **i) Voluntary skeletal movement - interference with will result in extremity paresthesia, weakness and/ or paralysis**
      - **ii) Level of awareness - part of consciousness**
    - **(b) Frontal lobe - personality, trauma here may result in placid reactions or seizures**
    - **(c) Parietal lobe - somatic sensory input, memory, emotions**
    - **(d) Temporal lobe - speech centers here, 85% of population has center on left, long term memory, taste and smell**
    - **(e) Occipital lobe - origin of optic nerve, trauma here may cause complaints of seeing "stars", blurred vision or other visual disturbances**
    - **(f) Hypothalamus - centers for vomiting, regulating body temperature and water**
  - **(2) Cerebellum - coordination of voluntary movement started by cerebral cortex**
  - **(3) Brain stem - connects the hemispheres of the brain, cerebellum and spinal cord responsible for vegetative functions and vital signs**
    - **(a) Parts - midbrain, pons and medulla oblongata**
    - **(b) Cranial nerves**
      - **i) CN III - oculomotor, origin from midbrain - controls pupil size - pressure on nerve paralyzes nerve, pupil unreactive**
      - **ii) CN X - vagal, origin from medulla - a bundle of nerves, primarily from parasympathetic system, that supply SA and AV node, stomach and GI tract - pressure on nerve stimulates bardycardia**
      - **iii) Reticular activating system - level of arousal and responsible for specific motor movements**
- **b. Level of consciousness**
  - **(1) Reticular activating centers - level of arousal**
  - **(2) Intact cortical function - level of awareness**
- **c. Meninges - protective layers the surround and enfold entire CNS**
  - **(1) Dura mater - outer layer, tough and fibrous; literally two layers, inner layer serves to divide and separate various brain structures, forms the tentorium that surrounds the brain stem and separates the cerebellum below from the cerebral structures above, used as a**

landmark to describe intracranial lesions or when swelling is involved

(2) **Arachnoid - middle layer, web-like with venous blood vessels that reabsorb cerebrospinal fluid**

(3) **Pia mater - inner layer, directly attached to brain tissue, provides form**

d. Cerebral spinal fluid (CSF) - clear, colorless fluid, circulates through entire brain and spinal cord

(1) **Function - cushion and protect**

(2) **Ventricles - in center of brain, secretes CSF by filtering blood, forms blood-brain barrier**

e. Metabolism and perfusion

(1) **High metabolic rate**

(2) **Nutrients**

(a) **Consumes 20% of body's oxygen**

(b) **Glucose**

(c) **Thiamine**

(d) **Other nutrients**

(e) **Nutrients cannot be stored**

(3) **Blood supply**

(a) **Vertebral arteries**

(b) **Receives 15% cardiac output**

(4) **Perfusion**

(a) **Cerebral perfusion pressure (CPP)**

(b) **Mechanism called autoregulation regulates body's blood pressure to maintain CPP**

(c) **CPP = mean arterial pressure (MAP) - ICP**

(d) **MAP of at least 60 mmHg required to perfuse brain**

(e) **Interference with CPP - edema, bleeding, hypotension**

III. Mechanisms of injury

A. Motor vehicle crashes

1. **Most common cause of head trauma**
2. **Most common cause of subdural hematoma**

B. Sports

C. Falls

1. **In elderly or in presence of alcohol abuse**
2. **Associated with chronic subdural hematomas**

D. Penetrating trauma

1. **Missiles (rifles, hand guns, shotguns) more common**
2. **Sharp projectiles (knives, ice picks, axes and screwdrivers) not as common**

IV. General categories of injury

A Coup injuries

1. **Directly below point of impact**
2. **More common when front of head struck because of irregularity of inner surface of frontal bones; occipital area is smooth**

B. Contrecoup injuries

1. **On the pole opposite the site of impact**

- 2. More common when back of head struck because of irregularity of inner surface of frontal bones
- C. Diffuse axonal injury (DAI)
  - 1. Shearing, tearing, stretching force of nerve fibers with axonal damage
  - 2. More common with vehicular occupants and pedestrians struck by vehicle
- D. Focal injury
  - 1. An identifiable site of injury limited to a particular area or region of the brain

V. Causes of brain injury
- A. Direct or primary
  - 1. Caused by the impact
  - 2. Mechanical disruption of cells
  - 3. Vascular permeability
- B. Indirect - secondary or tertiary
  - 1. Secondary - caused by edema, hemorrhage, infection and pressure inadequate perfusion (ischemia) tissue hypoxia
  - 2. Tertiary - caused by apnea, hypotension, pulmonary resistance and change in ECG

VI. Head injury - broad and inclusive
- A. Defined - a traumatic insult to the head that may result in injury to soft tissue, bony structures and/ or brain injury
- B. Categories - blunt (closed) trauma and open (penetrating trauma)
  - 1. Blunt head trauma
  - 2. More common
  - 3. Dura remains intact
  - 4. Brain tissue not exposed to the environment
  - 5. May result in fractures, focal brain injuries and/ or diffuse axonal injuries (DAI)
- C. Penetrating head trauma
  - 1. Less common, gun shot wound most frequent cause
  - 2. Dura and cranial contents penetrated
  - 3. Brain tissue exposed to the environment
  - 4. Results in fractures and focal brain injury

VII. Brain injury
- A. Defined (by National Head Injury Foundation) - "a traumatic insult to the brain capable of producing physical, intellectual, emotional, social and vocational changes"
- B. Categories - focal injury, subarachnoid hemorrhage or diffuse axonal injury
  - 1. Focal injury - specific, grossly observable brain lesions
    - a. Cerebral contusion - related to severity of amount of energy transmitted
    - b. Intracranial hemorrhage
      - (1) Penetrating
      - (2) Non-penetrating
    - c. Epidural hemorrhage
  - 2. Diffuse axonal injury (DAI) - effect of acceleration/ deceleration
    - a. Concussion - mild and classic
    - b. DAI - moderate and severe

VIII. Pathophysiology of head/ brain injury
- A. Increased intracranial pressure (ICP)
  - 1. Direct or indirect injury

a. Edema
b. Bleeding
c. Hypotension
e. Hypercarbia

B. Mechanism
1. As ICP approaches MAP the gradient for flow decreases, therefore cerebral blood flow is restricted
2. This decreases cerebral perfusion pressure (CPP)
3. As CPP decreases, cerebral vasodilation occurs which results in increased cerebral blood volume which leads to an increase in ICP which results in a decreased CPP which leads to further cerebral vasodilation and so on
4. Hypercarbia causes cerebral vasodilation which results in increased cerebral blood volume, which leads to increased ICP, etc.
5. Hypotension results in decreased CPP which leads to cerebral vasodilation, etc.

C. Assessment
1. Pressure exerted downward
   a. Cerebral cortices and/ or reticular activating system effected
      (1) Altered level of consciousness - amnesia of event, confusion, disorientation, lethargy or combativeness, focal deficit or weakness
   b. Hypothalamus - vomiting
   c. Brain stem
      (1) Blood pressure elevates to maintain MAP and thus CPP
      (2) Vagal nerve pressure - bardycardia
      (3) Respiratory centers - irregular respirations or tachypnea
      (4) Oculomotor nerve paralysis - unequal/ unreactive pupils
      (5) Posturing - flexion/ extension
   d. Seizures - depending on location of injury
2. Levels of increasing ICP
   a. Cerebral cortex and upper brain stem involved
      (1) BP rising and pulse rate begins slowing
      (2) Pupils still reactive
      (3) Cheyne-Stokes respirations
      (4) Initially try to localize and remove painful stimuli
         (a) Eventually withdraws then flexion occurs
      (5) All effects reversible at this stage
   b. Middle brain stem involved
      (1) Wide pulse pressure and bradycardia
      (2) Pupils nonreactive or sluggish
      (3) Central neurogenic hyperventilation (CNH)
      (4) Extension
      (5) Few patients function normally from this level
   c. Lower portion of brain stem involved/ medulla
      (1) Pupil blown - same side as injury
      (2) Respirations ataxic (erratic, no rhythm) or absent
      (3) Flaccid
      (4) Labile pulse rate, irregular often great pulse swings in rate

- (5) QRS, S-T and T wave changes
- (6) Decreased BP, often labile BP
- (7) Not considered survivable

3. Glasgow coma scale - method to assess level of consciousness
   - a. Three independent measurements
     - (1) Eye opening
     - (2) Verbal response
     - (3) Motor response
   - b. Numerical score - 3 to 15
   - c. Head injury classified according to score
     - (1) Mild - 13 to 15
     - (2) Moderate - 8 to 12
     - (3) Severe - < 8
4. Vital signs
5. Pupil size and reaction
6. Presence of focal deficit
7. History of unconsciousness or amnesia of event

D. Management

1. Suspect cervical spine injury
2. Airway and ventilation - oxygenate to 95% -100% saturations
   - a. Oxygenation does not always require hyperventilation
   - b. Hyperventilate with signs and symptoms of increased ICP
     - (1) Do not exceed rate of 30 - does not allow for adequate exhalation and retains carbon dioxide further contributing to hypercarbia
   - c. Avoid if possible nasal intubation - increases ICP
3. Circulation - start IV of isotonic fluid (NS or LR) and titrate to BP
   - a. Prevent hypotension to preserve CPP
   - b. If hypotension present, look for internal bleeding
   - c. Stop external bleeding
4. Disability - repeated assessment crucial to monitor presence of increased ICP, GCS and focal deficit
5. Pharmacology
   - a. Osmotic diuretics
     - (1) Mannitol and/ or furosemide
   - b. Paralytics/ sedation
   - c. Avoid glucose unless hypoglycemia confirmed
6. Non-pharmacological treatment
   - a. Position - head end of the backboard elevated 30 degrees
   - b. Decrease CNS stimulation
   - c. Transport considerations
   - e. Trauma center candidate - follow system guidelines
     - (1) Moderate to severe head injury (GCS < 12)
   - f. Use of helicopter versus ground transport
   - g. Use of lights/ sirens
7. Psychological support/ communication strategies

Spinal Trauma

I. Introduction

- **A. Spinal cord injury (SCI) impacts**
  - **1. Human physiology**
  - **2. Lifestyle**
  - **3. Financial**
  - **4. 1.25 million to care for a single victim with permanent SCI (overall life span)**

II. Incidences
- **A. 15,000 - 20,000 SCI per year**
- **B. Higher in men between ages 16 - 30 years**
- **C. Common causes**
  - **1. Motor vehicle crashes - 2.1 million per year (48%)**
  - **2. Falls (21%)**
  - **3. Penetrating injuries (15%)**
  - **4. Sports injuries (14%)**

VIII. Morbidity and mortality
- **A. 40% of trauma patients with neurological deficit will have temporary or permanent SCI**
- **B. 25% of SCI may be caused by improper handling**
- **C. Education in proper handling and transportation can decrease SCI**

IX. Traditional spinal assessments/ criteria
- **A. Based upon mechanism of injury (MOI)**
- **B. Past emphasis for spinal immobilization considerations**
  - **1. Unconscious accident victims**
  - **2. Conscious accident victims checked for SCI prior to movement**
  - **3. Any patient with a "motion" injury**
- **C. Lack of clear clinical guidelines or specific criteria to evaluate for SCI**
- **D. Signs which may indicate SCI**
  - **1. Pain**
  - **2. Tenderness**
  - **3. Painful movement**
  - **4. Deformity**
  - **5. Cuts/ bruises (over spinal area)**
  - **6. Paralysis**
  - **7. Paresthesias**
  - **8. Paresis (weakness)**
  - **9. Shock**
  - **10. Priapism**
- **E. Not always practical to immobilize every "motion" injury**
- **F. Most suspected injuries were moved to a normal anatomical position**
  - **1. Lying flat on a spine board**
  - **2. No exclusion criteria used for moving patients to an anatomical position**
- **G. Need to have clear criteria to assess for the presence of SCI**

- **X. General spinal anatomy and physiology review**
  - **A. Spinal column**
    - **1. Long bone**
    - **2. 33 vertebrae**
    - **3. Head balances at top of spine**
    - **4. Spine supported by pelvis**
    - **5. Ligaments and muscles connect head to pelvis**
      - **a. Anterior longitudinal ligament**
        - **(1) Runs on anterior portion of the body**
        - **(2) Major source of stability**
        - **(3) Protects against hyperextension**
      - **b. Posterior longitudinal ligament**
        - **(1) Runs along posterior body within the vertebral canal**
        - **(2) Prevents hyperflexion**
        - **(3) Can be a major source of injury**
      - **c. Other ligaments**
        - **(1) Cruciform ligament**
        - **(2) Accessory atlantoaxial ligament**
        - **(3) Add to strength, stability, and articulation**
    - **6. Injury to ligaments may cause excess movement of vertebrae**
  - **B. Cervical spine**
    - **1. 7 vertebrae**
    - **2. Supports head (16 - 25 lbs)**
    - **3. Considered “joint above” in splinting**
    - **4. Very flexible**
    - **5. C1 (atlas)**
    - **6. C2 (axis)**
  - **C. Thoracic spine**
    - **1. 12 vertebrae**
    - **2. Ribs connected**
    - **3. Provides rigid framework of thorax**
  - **D. Lumbar spine**
    - **1. 5 vertebrae**
    - **2. Largest vertebral body**
    - **3. Flexible**
    - **4. Carries most of body weight**
    - **5. Torso balances on sacrum**
  - **E. Sacrum**
    - **1. 5 fused vertebrae**
    - **2. Common to spine and pelvis**
    - **3. Forms “joint below” with pelvis for splinting**
  - **F. Coccyx**
    - **1. 4 fused vertebrae**
    - **2. Tailbone**
  - **G. Vertebral structure**
    - **1. Body**
      - **a. Constructed of cancellous bone**

- **b. Posterior portion forms part of the vertebral foramen**
- **c. Increase in size when moving from cervical to sacral region for support of the trunk**

H. Vertebral foramen
- **1. When all vertebrae are in place forms opening for spinal cord (vertebral canal)**
- **2. Formed by**
  - **a. Posterior portion of vertebral body**
  - **b. Pedicles**
    - **(1) Projecting posteriorly from vertebral body**
  - **c. Laminae**
    - **(1) Arise from pedicles and fuse into spinous process**
    - **(2) Failure of the laminae to unite during fetal development causes spina bifida**
      - **(a) Most commonly in the lumbosacral region**

I. Transverse process
- **1. Runs from between the pedicles and laminae in most vertebrae**
- **2. Projects laterally and posteriorly**
- **3. Attachment site for various muscles and ligaments**

J. Spinous process
- **1. Posterior aspect**
- **2. Formed by the laminae**
- **3. Attachment site for muscles and ligaments**

K. Intervertebral foramen
- **1. Formed by the lower surfaces of the vertebrae**
- **2. Creates a "notch" for spinal nerves**
  - **a. Allows nerves to connect to the spinal cord**

L. Intervertebral disk
- **1. Mass of fibrocartilage separating each vertebrae**
- **2. Connecting together by ligaments**
- **3. Acts as a shock absorber**
  - **a. Reducing bone wear**
  - **b. Compression protection**

M. Brain and spinal cord (central nervous system)
- **1. Brain**
  - **a. Largest and most complex portion of the nervous system**
  - **b. Continuous with spinal cord**
  - **c. Responsible for all sensory and motor functions**
- **2. Spinal cord**
  - **a. Located within the vertebral canal**
    - **(1) Begins at foramen magnum**
    - **(2) Ending near L-2**
  - **b. Dural sheath**
    - **(1) Sheathed, tube-like sac**
    - **(2) Filled with cerebrospinal fluid (CSF)**
- **3. Blood supplied by**
  - **a. Vertebral arteries**
  - **b. Spinal arteries**

4. Gray matter
   a. Core pattern in cord resembling butterfly with outspread wings
   b. Most neurons in gray matter are interneurons
5. White matter
   a. Anatomical spinal tracts
      (1) Longitudinal bundles of myelinated nerve fibers

XI. General assessment of spinal injuries
A. Determine mechanism of injury/ nature or injury
1. Positive MOI
   a. Always requires full spinal immobilization
      (1) High speed motor vehicle crash(es)
      (2) Falls greater than three times patient's height
      (3) Violent situations occurring near the spine
         (a) Stabbings
         (b) Gun shots
         (c) Others
      (4) Sports injuries
      (5) Other high impact situations
   b. Some medical directors may allow field personnel to not immobilize patients with MOI but without signs and/ or symptoms of a SCI
      (1) Based on assessment
         (a) Patient reliability
         (b) No distracting injuries
         (c) Lack of signs or symptoms
2. Negative MOI
   a. Forces or impact involved does not suggest a potential spinal injury
   b. Does not require spinal immobilization
      (1) Examples
         (a) Dropping a rock on foot
         (b) Twisted ankle while running
         (c) Isolated soft tissue injury
3. Uncertain MOI
   a. Unclear or uncertainty regarding the impact or forces
   b. Clinical criteria used for a basis of whether to employ spinal immobilization
      (1) Examples
         (a) Person trips over garden hose, falling to the ground and hitting their head
         (b) Fall from 2-4 feet
         (c) Low speed motor vehicle crash (fender bender)
4. Clinical criteria versus mechanism of injury
   a. Initial management
      (1) Based solely upon MOI
   b. Positive MOI
      (1) Spine immobilization
   c. Negative MOI
      (1) Without signs or symptoms

(a) No spine immobilization
d. Uncertain MOI
(1) Need for further clinical assessment and evaluation
e. In some non-traumatic spinal conditions immobilization may be necessary/ indicated
f. Altered LOC or unconsciousness requires spine stabilization

XII. Assessment of uncertain MOIs
A. Specific clinical criteria
1. Necessary to assess when electing not to immobilize a trauma patient
2. Begins with patient reliability
a. Continually reassessed during specific exam
3. If specific criteria cannot be clearly satisfied; complete spine immobilization undertaken
4. Positive MOI always equals spine immobilization
a. This specific assessment may still be used to determine level of injury
B. Specific criteria
1. Prevent motion of the spine by assistant maintaining stabilization throughout the exam
2. Reliable patients/ exam
a. In order for assessments of pain, tenderness, motor, and sensory function to be accurate the patient must be reliable
b. Patient must be
(1) Calm
(2) Cooperative
(3) Sober
(a) Alcohol
(b) Drugs
(4) Alert and oriented
c. Unreliable patient defined
(1) Acute stress reaction
(a) Sudden stress of any type
(2) Brain injury
(a) Any temporary change in consciousness or altered level of consciousness
(b) Uncooperative or belligerent behavior
(3) Intoxication
(4) Abnormal mental status
(5) Distracting injuries
(6) Communication problems
d. Unreliable indicators present
(1) Full spinal immobilization indicated
3. Assess for spinal pain
a. Patient is asked about
(1) Any related spinal pain
(2) Signs
(3) Symptoms

- **b. May be poorly localized**
- **c. Might not feel directly over the spinous process**
- **d. Pain with active movement of head and neck**
  - **(1) Patient is asked to slowly move their head and neck**
  - **(2) If any pain occurs**
    - **i) Full immobilization is indicated**
    - **ii) May not be able to splint in normal anatomical position**

4. Assess for spine tenderness

- **a. Palpate over each of the spinous processes of the vertebra**
- **b. Begin at the neck and work towards the pelvis**
- **c. May be beneficial to palpate back up from the pelvis to the neck**

5. Upper extremity neurological function assessment

- **a. Motor function**
  - **(1) Finger abduction/ adduction**
    - **(a) Test interosseous muscle function controlled by T-1 nerve roots**
    - **(b) Have patient spread fingers of both hands and keep them apart while you squeeze the 2nd and 4th fingers**
    - **(c) Normal resistance should be spring-like and equal on both sides**
  - **(2) Finger/ hand extension**
    - **(a) Test the extensors of the hand and fingers controlled by C-7 nerve roots**
    - **(b) Have patient hold wrist or fingers straight out and keep them out while you press down on their fingers**
    - **(c) Support the arm at the wrist to avoid testing arm function and other nerve roots**
    - **(d) Normal resistance should be felt to moderate pressure**
    - **(e) Both right and left sides should be checked**
    - **(f) Can still check if isolated, e.g., finger fracture, push on hand only not fingers; if wrist injury support MP joints and push on fingers only**
- **b. Sensory function**
  - **(1) Pain sensation**
    - **(a) Abnormal sensation - ask patient about weakness, numbness, paresthesia, or radicular pain**
    - **(b) Pain or pinprick controlled by spinothalamic tracts**
    - **(c) Need to separate from light touch (remember light touch carried by more than one tract)**
    - **(d) Use end of pen or broken Q-tip (avoid sharp objects which may damage or cause bleeding)**
    - **(e) Have patient close eyes and hold out hands; ask the patient to compare between sharp and dull pain**
    - **(f) Compare on both sides of the body; equal on both sides**

6. Lower extremity neurological function assessment

- **a. Motor function**

(1) Foot plantar flexion
(a) Tests plantar flexors of the foot controlled by S-1,2 nerve root
(b) Place your hands at the sole of each foot and have the patient push against your hands
(c) Both sides should feel equal and strong
(2) Foot/ great toe dorsiflexion
(a) Tests the dorsal flexors of the foot and great toe controlled by the L-5 nerve roots
(b) Hold foot with fingers on toes and instruct patient to pull foot back or towards their nose

b. Sensory function
(1) Pain sensation
(a) Abnormal sensation - ask patient about weakness, numbness, paresthesia, or radicular pain
(b) Pain or pinprick controlled by spinothalamic tracts
(c) Need to separate from light touch (remember light touch carried by more than one tract)
(d) Use end of pen or broken Q-tip (avoid sharp objects which may damage or cause bleeding)
(e) Have patient close eyes and hold out hands; ask the patient to compare between sharp and dull pain
(f) Compare on both sides of the body; equal on both sides

7. General motor function assessment
a. Tests nerve roots at both cervical and lumbar/ sacral spine levels
b. Check two sets of nerve roots at each level as well as left and right sides
c. Able to determine most clinical patterns of SCI
d. Motor exams can to be completed even if local injury exists
(1) If exam cannot be completed due to local injury entire exam is unreliable
(a) Spinal immobilization indicated

8. Sensory function assessment
a. Test (exam) sensory
(1) At cervical and lumbar/ sacral spine levels
(a) On both right and left sides
b. Sensory exam will detect clinical patterns of SCI
c. Any signs or symptoms of abnormal sensation
(1) Spinal immobilization indicated

XIII. General management of spinal injuries
A. Principles of spinal immobilization
1. Primary goal is to prevent further injury
2. Treat spine as a long bone with a joint at either end (head and pelvis)
3. 15% of secondary spinal injuries are preventable with proper immobilization
4. Always use “complete” spine immobilization
a. Impossible to isolate and splint specific injury site
5. Spine stabilization begins in the initial assessment

- a. Continues until the spine is completely immobilized on a long backboard
- 6. Head and neck should be placed in a neutral, in-line position unless contraindicated
  - a. Neutral positioning allows for the most space for the cord
    - (1) Reducing cord hypoxia
    - (2) Reducing excess pressure
  - b. Most stable position for the spinal column
    - (1) Reduces instability

B. Spinal stabilization/ immobilization

- 1. Systematic approach
  - a. Cervical immobilization
    - (1) Manual
    - (2) Rigid collar
  - d. Interim immobilization device
    - (1) When indicated (vest type mobilization device, short backboard)
    - (2) Movement of a stable patient from a seated position to a long backboard
  - c. Long backboard
  - d. Full body vacuum splints
  - e. Padding (body shims)
    - (1) Use to maintain anatomical position
    - (2) Limits movement of patient
    - (3) Fill all voids
    - (4) Pillows
    - (5) Towels
    - (6) Blankets
  - f. Straps
    - (1) Sufficient to immobilize to the long backboard
      - (a) Upper torso
      - (b) Pelvis
      - (c) Legs
      - (d) Feet
  - g. Cervical immobilization device
    - (1) Commercial
    - (2) Tape
    - (3) Blanket roll
    - (4) Pillows
  - h. Helmeted patients
    - (1) Special assessment needs for patients wearing helmets
      - (a) Airway and breathing
      - (b) Fit of helmet and movement within the helmet
      - (c) Ability to gain access to airway and breathing
    - (2) Indications for leaving the helmet in place
      - (a) Good fit with little or no head movement within helmet
      - (b) No impending airway or breathing problems
      - (c) Removal may cause further injury

- **(d) Proper spinal immobilization could be performed with helmet in place**
- **(e) No interference with ability to assess and reassess airway**

(3) Indications for helmet removal

- **(a) Inability to assess or reassess airway and breathing**
- **(b) Restriction of adequate management of the airway or breathing**
- **(c) Improperly fitted helmet with excessive head movement within helmet**
- **(d) Proper spinal immobilization cannot be performed with helmet in place**
- **(e) Cardiac arrest**

(4) Types of helmets

- **(a) Sports**
  - **i) Typically worn anteriorly**
  - **ii) Easier access to airway**
- **(b) Motorcycle**
  - **i) Full face**
  - **ii) Shield**
- **(c) Other**

(5) General guidelines for helmet removal

- **(a) Type of helmet worn by the patient will influence the technique used for removal**
- **(b) First person stabilizes the head and neck by placing hands on the side of the helmet with fingers extended under lower face piece (or chin)**
- **(c) Second person removes face shield (if present) and/or eye wear before helmet removal**
- **(d) Second person removes chin strap**
- **(e) Second person places one hand on mandible and the other posteriorly on the occipital region (posterior caudal edge of helmet)**
- **(f) First person then begins to remove the helmet by pulling the sides apart, sliding the helmet a short distance (approximately 4-6 cm) and then stops**
- **(g) First person again stabilizes the head and neck with hands holding the sides of the helmet**
- **(h) Second person slides hands cephalad (towards the top of the head) until the head is stabilized between the posterior or hand (now cupped under the inferior occiput) and the anterior hand now inserted under the lower part of the face piece - if the helmet has one (thumb and first finger now holding the unmovable maxilla)**
- **(i) First person again pulls the sides of the helmet apart and continues to withdraw the helmet - rotating the helmet as necessary so any lower face piece clears the nose and then an opposite movement so the posterior caudal end of the**

helmet is removed following the posterior curvature of the patient's head

(j) Once the helmet has been completely removed, the first person regains stabilization of the patient's head and neck by placing their hands along the sides of the patient's head with their fingers spread apart for maximum support - second person can now let go of the anterior/posterior support

(k) Second person can now continue with the assessment, measurement and application of a cervical collar, further immobilization and care of the patient

C. Use of steroids for traumatic spine injuries

II. Traumatic injuries

A. Causes

1. Direct trauma
2. Excessive movement
   a. Acceleration
   b. Deceleration
   c. Deformation
3. Directions of force
   a. Flexion or hyperflexion
      (1) Excessive forward motion of the head
      (2) May cause
         (a) Wedge fracture of anterior vertebrae
         (b) Stretching or rupturing of interspinous ligaments
         (c) Compressed injury to spinal cord
         (d) Disruption of disk with forward dislocation of vertebrae
         (e) Fracture of pedicle and disruption of interspinous ligament
      (3) Cervical area common injury site
   b. Extension or hyperextension
      (1) Excessive backward movement of the head
      (2) May cause
         (a) Disruption of the intervertebral disks
         (b) Osteophytes and compression of the spinal cord
         (c) Compression of the interspinous ligament
         (d) Fracture
      (3) Cervical area common injury site
   c. Rotational
      (1) Usually from acceleration forces
      (2) May cause
         (a) Flexion-rotation dislocation
         (b) Fracture or dislocation of vertebrae
         (c) Rupture of supporting ligaments
      (3) Cervical area common injury site
   d. Lateral bending
      (1) Often caused by direct blow to the side of the body
      (2) May cause

- (a) May cause lateral compression of the vertebral body
- (b) may cause lateral displacement of the vertebra
- (c) May stretch the ligaments

e. Vertical compression
- (1) Force applied along spinal axis
  - (a) Usually from top of cranium to vertebral body from sudden deceleration, e.g., diving accident
- (2) May cause
  - (a) Compression fracture without SCI
  - (b) Crushed vertebral body with SCI
- (3) Most common injury site(s)
  - (a) T-12 to L-2

f. Distraction
- (1) Force applied to spinal axis to distract or pull apart, e.g., hanging injury
- (2) May cause
  - (a) Stretching of spinal cord
  - (b) Stretching of supporting ligaments
- (3) Cervical area most common injury site

4. Can have "spinal column injury" (bony injury) with or without "SCI"
5. Can have "SCI" with or without "spinal injury"

B. Types of spinal cord injuries (SCI)

1. Primary injury
   a. Occurs at time of impact/ injury
   b. Causes
      - (1) Cord compression
      - (2) Direct cord injury
        - (a) Sharp or unstable bony structures
      - (3) Interruption in the cord's blood supply
2. Secondary injury
   a. Occurs after initial injury
   b. Causes
      - (1) Swelling
      - (2) Ischemia
      - (3) Movement of bony fragments
3. Cord concussion
   a. Results from temporary disruption of cord-mediated functions
4. Cord contusion
   a. Bruising of the cord's tissues
   b. Causes
      - (1) Swelling
   c. Temporary loss of cord-mediated function
5. Cord compression
   a. Pressure on the cord
   b. Causes tissue ischemia
   c. Must be decompressed to avoid permanent loss/ damage to cord
6. Laceration

- a. Tearing of the cord tissue
- b. May be reversed if only slight damage
- c. May result in permanent loss if spinal tracts are disrupted

7. Hemorrhage
   - a. Bleeding into the cord's tissue
   - b. Caused by damage to blood vessels
     - (1) Injury related to amount of hemorrhage
   - c. Damage or obstruction to spinal blood supply results in local ischemia

8. Cord transection
   - a. Complete
     - (1) All tracts of the spinal cord completely disrupted
     - (2) Cord-mediated functions below transection are permanently lost
     - (3) Accurately determined after at least 24 hours post-injury
     - (4) Results in
       - (a) Quadriplegia
         - i) Injury at the cervical level
         - ii) Loss of all function below injury site
       - (b) Paraplegia
         - i) Injury at the thoracic or lumbar level
         - ii) Loss of lower trunk only
   - b. Incomplete
     - (1) Some tracts of the spinal cord remain intact
     - (2) Some cord-mediated functions intact
     - (3) Has potential for recovery
       - (a) Function may only be temporarily lost
     - (4) Types
       - (a) Anterior cord syndrome
         - i) Caused by bony fragments or pressure on spinal arteries
         - ii) Involves loss of motor function and sensation to pain, temperature and light touch
         - iii) Sensation to light touch, motion, position, and vibration are spared
       - (b) Central cord syndrome
         - i) Usually occurs with a hyperextension of the cervical region
         - ii) Weakness or paresthesias in upper extremities but normal strength in lower extremities
         - iii) May have varying degrees of bladder dysfunction
       - (c) Brown-Sequard syndrome
         - i) Caused by penetrating injury
         - ii) Hemisection of the cord
         - iii) Involves only one side of the cord
         - iv) Complete damage to all spinal tract on involved side
         - v) Isolated loss of all types of functions, e.g., motor pain, temperature, motion, position, etc.
         - vi) Pain and temperature lost on opposite side of the

body
vii) Motor function, motion, position, vibration, and light touch on the same side as injury

9. Chemical and metabolic changes due to SCI
10. Spinal shock
    a. Refers to temporary loss of all types of spinal cord function distal to injury
    b. Flaccid paralysis distal to injury site
    c. Loss of autonomic function
        (1) Hypotension
        (2) Vasodilatation
        (3) Loss of bladder and bowel control
        (4) Priapism
        (5) Loss of thermoregulation
    d. Does not always involve permanent primary injury
        (1) Usually will resolve in a period of hours to weeks
        (2) Manage carefully to avoid secondary injury
11. Spinal neurogenic shock
    a. Also called spinal vascular shock
    b. Temporary loss of the autonomic function of the cord at the level of injury which controls cardiovascular function
    c. Presentation includes
        (1) Loss of sympathetic tone
        (2) Relative hypotension
            (a) Systolic pressure 80 - 100 mmHg
        (3) Skin pink, warm and dry
            (a) Due to cutaneous vasodilation
        (4) Relative bradycardia
    d. Rare in occurrence
    e. Shock presentation is usually the result of hidden volume loss
        (1) Chest injuries
        (2) Abdominal injuries
        (3) Other violent injuries
    f. Treatment
        (1) Focus primarily on volume replacement

III. Non-traumatic spinal conditions
  A. Low back pain (LBP)
    1. Affected area
        a. Between lower rib cage and gluteal muscles
        b. May radiate to thighs
    2. 1% of acute low back pain is sciatica
        a. Usual cause is in the lumbar nerve root
        b. Pain accompanied by motor and sensory deficits, e.g., weakness
    3. 60% - 90% of population experience some form of low back pain
        a. Affects men and women equally
        b. Women over 60 years old report low back pain symptoms more often
    4. Most cases of LBP are idiopathic
        a. Precise diagnosis difficult

5. Causes
   a. Tension from tumors
   b. Disk prolapsed
   c. Bursitis
   d. Synovitis
   e. Rising venous pressure
   f. Tissue pressure due to degenerative joint disease
   g. Abnormal bone pressure
   h. Problems with spinal mobility
   i. Inflammation caused by infection
      (1) Osteomyelitis
   j. Fractures
   k. Ligament strains
6. Risk factors
   a. Occupations requiring repetitious lifting
   b. Exposure to vibrations from vehicles or industrial machinery
   c. Osteoporosis
7. Anatomical considerations
   a. Pain from innervated structures
      (1) Varies from person-to-person
   b. Disk has no specific innervation
      (1) Compresses cord if herniated
   c. Source of pain in L-3,4,5, and S-1 may be interspinous bursae
   d. Anterior and posterior longitudinal ligaments, and other ligaments are richly supplied with pain receptors
   e. Muscles of spine vulnerable to sprains/ strains
8. Degenerative disk disease
   a. Common for patients over 50 years of age
   b. Causes
      (1) Degeneration of disk
         (a) Biomechemical alterations of intervertebral disk
   c. Narrowing of the disk
      (1) Results in variable segment stability
9. Spondylolysis
   a. Structural defect of spine
      (1) Involves the lamina or vertebral arch
   b. Usually occurs between superior and inferior articulating facets
   c. Heredity a significant factor
   d. Rotational fractures common at affected site
10. Herniated intervertebral disk
   a. Also called herniated nucleus pulposus
   b. Tear in the posterior rim of capsule enclosing the gelatinous center of the disk
   c. Causes
      (1) Trauma
      (2) Degenerative disk disease
      (3) Improper lifting

- (a) Most common cause
- d. Men ages 30 - 50 years are more prone than women
- e. Commonly affects L-5, S-1 and L-4, L-5 disks
- f. May also occur in C-5, C-6, and C-7

11. Spinal cord tumors
    - a. Causes
        - (1) Compression of the cord
        - (2) Degenerative changes in the bone/ joints
        - (3) Interrupted the blood supply
    - b. Manifestations are dependent upon
        - (1) Tumor type and location

XIII. Assessment and management of non-traumatic spinal conditions

A. Assessment - based mainly upon the patient's chief complaint and physical exam

1. Low back pain
    - a. Based mainly upon history and chief complaint
        - (1) Risk factors include
            - (a) Occupations requiring repetitive lifting
            - (b) Exposure to vibrations from vehicles or industrial machinery
            - (c) Osteoporosis
    - b. Precise diagnosis difficult
        - (1) Based primarily on physical exam and other in-hospital testing
            - (a) CT scan
            - (b) Electromyelography
            - (c) MRI
            - (d) Others
2. Herniated intervertebral disk
    - a. Tear in the posterior rim of capsule enclosing the gelatinous center of the disk
        - (1) Causes
            - (a) Trauma
            - (b) Degenerative disk disease
            - (c) Improper lifting
                - i) Most common cause
        - (2) Pain usually occurs with straining
            - (a) Coughing or sneezing
        - (3) May have limited range of motion in lumbar spine
        - (4) Tenderness upon palpation
        - (5) Alternations in sensation, pain, and temperature
        - (6) Due to nerve root pressure
        - (7) Cervical herniations may include
            - (a) Upper extremity pain or paresthesia
                - i) Increasing with neck motion
            - (b) Slight motor weakness may also occur in biceps and triceps
3. Spinal cord tumors

- a. Tumors of the spine which cause
  - (1) Compression of the cord
  - (2) Degenerative changes in the bone/ joints
  - (3) Interruption in the blood supply
- b. Manifestations are dependent upon
  - (1) Tumor type
  - (2) Location

B. Management

1. Primarily palliative to decrease any pain or discomfort from movement
2. May elect to immobilize to aid in comfort
   - a. Long back board
   - b. Vacuum type stretcher
3. Full spinal immobilization is not required unless condition is a result of trauma

Abdominal Trauma

I. Introduction

A. Epidemiology

1. Increased incidence of morbidity and mortality
   - a. Due to delay to surgical intervention
   - b. Death occurs as a result of increased hemorrhage due to delay
     - (1) Solid organ injuries
     - (2) Hollow organ injuries
     - (3) Abdominal vascular injuries
     - (4) Pelvic fractures
2. Prevention strategies

B. Anatomy review

1. Boundaries of the abdomen
   - a. Diaphragm
   - b. Anterior abdominal wall
   - c. Pelvic skeletal structures
   - d. Vertebral column
   - e. Muscles of the abdomen and flanks
4. Surface anatomy of the abdomen
   - a. Quadrants
     - (1) Upper
       - (a) Right
       - (b) Left
     - (2) Lower
       - (a) Right
       - (b) Left
   - b. Xiphoid
   - c. Symphysis pubis
   - d. Umbilicus
5. Intraperitoneal structures
   - a. Liver
   - b. Spleen
   - c. Stomach
   - d. Small bowel

- e. Colon
- f. Gallbladder
- g. Female reproductive organs

6. Retroperitoneal structures
   - a. Central structures
     - (1) Duodenum
     - (2) Pancreas
     - (3) Major vascular structures
   - b. Lateral structures
     - (1) Kidneys
     - (2) Ureters
     - (3) Posterior ascending and descending colon
   - c. Pelvic structures
     - (1) Rectum
     - (2) Ureters
     - (3) Pelvic vascular plexus
     - (4) Major vascular structures
     - (5) Pelvic skeletal structures
     - (6) Reproductive organs

7. Physiology review
   - a. Injury to abdominal structures causes morbidity and mortality primarily as a result of hemorrhage
   - b. Injury may be subtle
   - c. High index of suspicion
   - d. Solid organs
     - (1) Hemorrhage
     - (2) Shock
   - e. Hollow organs
     - (1) Spillage of contents
     - (2) Peritonitis
   - f. Vascular structures
     - (1) Hemorrhage
     - (2) Shock

C. Mechanism of injury review

1. Index of suspicion
2. Blunt mechanisms
   - a. Compression forces
   - b. Shear forces
   - c. Deceleration forces
   - d. Motor vehicle collisions
     - (1) Head-on or frontal impact
       - (a) Down and under path
       - (b) Up and over path
     - (2) Rear impact
     - (3) Lateral or side impact
     - (4) Rotational impact
     - (5) Rollover

- (6) Restrained (type of restraint) or unrestrained
- (7) Seat belt injuries
- (8) Steering wheel injuries

e. Motorcycle collisions
f. Pedestrian injuries
g. Falls
h. Assault
i. Blast injuries

3. Penetrating mechanisms
   a. Energy imparted to the body
      - (1) Low velocity
        - (a) Knife
        - (b) Ice pick
      - (2) Medium velocity
        - (a) Gunshot wounds
        - (b) Shotgun wounds
      - (3) High velocity
        - (a) High power hunting rifles
        - (b) Military weapons
        - (c) Ballistics
        - (d) Trajectory
        - (e) Distance

II. General system pathophysiology, assessment, and management
   A. Pathophysiology of abdominal injuries
      1. Hemorrhage
         a. No external signs
         b. Rapid blood loss
         c. Hypovolemic shock
         d. Blood is not chemical irritant to peritoneum (therefore, no peritonitis)
      2. Spillage of contents
         a. Enzymes
         b. Acids
         c. Bacteria
         d. Chemical irritation to peritoneum (peritonitis)
         e. Localized pain sensation via somatic nerve fibers
         f. Muscular spasm secondary to peritonitis (rigid abdomen)
   B. Assessment
      1. Focused history and physical examination
         a. General
            - (1) Head injury and/ or intoxicants (drugs/ ethanol) mask signs and symptoms
            - (2) Hemoperitoneum (solid organ or vascular injuries)
              - (a) Blood not chemical irritant to peritoneum
              - (b) Adult abdomen will accommodate 1.5 liters with no abdominal distention
              - (c) Often present even with normal abdominal exam

- (d) Unexplained shock
- (e) Shock out of proportion to known injuries

(3) Peritonitis (hollow organ injury)

- (a) Pain (subjective symptom from patient)
- (b) Tenderness (objective sign with percussion/ palpation)
- (c) Guarding/ rigidity
- (d) Distention (late finding)

(4) Abrasions
(5) Ecchymosis
(6) Visible wounds
(7) Mechanism of injury
(8) Unexplained shock

b. Critical findings

(1) Rapid assessment and transport
(2) Detailed assessment
(3) On-going assessment

c. Noncritical findings

(1) Focused history and physical examination
(2) Other interventions and transport considerations

2. Comprehensive assessment

a. Vital signs

(1) Indications of shock

b. Inspection

(1) Abrasions
(2) Ecchymosis

- (a) Seat belt sign

(3) Distention
(4) Obvious external blood loss
(5) Wounds
(6) Impaled object
(7) Evisceration

c. Auscultation - not useful out-of-hospital assessment tool
d. Percussion (tenderness)
e. Palpation

(1) Tenderness
(2) Guarding/ rigidity
(3) Pelvic stability/ tenderness

f. Absence of signs and/ or symptoms does not rule-out abdominal injuries
g. Not necessary to determine definitively if abdominal injuries are present
h. Examine the back

4. Differential diagnosis and continued management

D. Management/ treatment plan

1. Surgical intervention only effective therapy
2. No definitive therapy possible out-of-hospital
3. Rapid evaluation
4. Initiation of shock resuscitation
5. Rapid packaging and transport to nearest appropriate facility

- a. Facility must have immediate surgical capability
- b. Rapid transport
  - (1) Defeated if hospital cannot provide immediate surgical intervention

6. Crystalloid fluid replacement
   - a. En route to hospital
7. Airway support
8. Breathing support
9. Circulatory support
   - a. Control obvious hemorrhage
   - b. Tamponade bleeding
   - c. Manage hypotension
     - (1) Fluid resuscitation
10. Patient packaging
11. Transport
    - a. Indications for rapid transport
      - (1) Critical findings
      - (2) Surgical intervention required to control hemorrhage and/ or contamination
      - (3) High index of suspicion for abdominal injury
      - (4) Unexplained shock
      - (5) Physical signs of abdominal injury
      - (6) Hemorrhage continues until controlled in the operating room
      - (7) Survival determined by length of time from injury to definitive surgical control of hemorrhage
      - (8) Any delay in the field negatively impacts this time period
    - b. Indications for transport to trauma center
    - c. Indications for transport to acute care facility
    - d. Indications for no transport required