Life in the Trauma Room: An Introduction to Thoracic Injury

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Sections

- Introduction to ThoracoAbdominal Injury
- Anatomy and Physiology of the Thorax & Abdomen
- Pathophysiology of Torso Trauma / Mechanism of Injury
- Assessment of the Torso Trauma Patient
- Management of the Torso Injury Patient

Thoracic Trauma

- Second leading cause of trauma deaths
- 85% treated with general resuscitation measures
- 15% require thoracotomy
Introduction to Thoracic Injury

- Vital Structures
  - Heart, Great Vessels, Esophagus, Tracheobronchial Tree, & Lungs
- 25% of MVC deaths are due to thoracic trauma
  - 12,000 annually in US
- Abdominal & Head injuries are common with chest trauma.

- Prevention Focus
  - Legislation
  - Improved motor vehicle restraint systems
    - Passive Restraint Systems
    - Airbags

Anatomy and Physiology of the Thorax

- Trachea, Bronchi & Lungs
  - Pleura
    - Visceral Pleura
      - Cover lungs
    - Parietal Pleura
      - Lining inside of thoracic cavity
    - Pleural Space
      - POTENTIAL SPACE
        - Air in Space = PNEUMOTHORAX
        - Blood in Space = HEMOTHORAX
      - Serous (pleural) fluid within
        - Lubricates & permits ease of expansion

- Trachea
  - Hollow & cartilage supported structure

- Bronchi
  - Right & left extend for 3 centimeters
  - Enters lungs at Pulmonary Hilum
    - Also where pulmonary arteries & veins enter
  - Further subdivide and terminate as alveoli
    - Basic unit of structure & function in the lungs
      - Single cell membrane
        - External versus Internal Respiration

- Lungs
  - Right = 3 lobes
  - Left = 2 lobes
• **Diaphragm**
  - Muscular, dome-like structure
  - Separates abdomen from the thoracic cavity
  - Affixed to the lower border of the rib cage
  - Central and superior margin extends to the level of the 4th rib anteriorly and 6th rib posteriorly
  - Major muscle of respiration
    • Draws downward during inspiration
    • Moves upward during exhalation

• **Thoracic Skeleton**
  - Topographical Thoracic Reference Lines
    • Mid-clavicular line
    • Anterior axillary line
    • Mid-axillary line
    • Posterior axillary line
  - Intercostal space
    • Artery, Vein and Nerve on inferior margin of each rib
  - Thoracic Inlet
    • Superior opening of the thorax
    • Curvature of 1st rib with associated structures
  - Thoracic Outlet
    • Inferior opening of the thorax
    • 12th rib and associated structures & Xiphisternal joint

• **Associated Musculature**
  - Shoulder girdle
  - Muscles of respiration
    • **Diaphragm**
      - Primary muscle of respiration
      - Inhalation: Contracts downward
      - Exhalation: Relaxes upward
    • Intercostal muscles
      - Contract to elevate the ribs and increase thoracic diameter
      - Increase depth of respiration
    • Sternocleidomastoid
      - Raise upper rib and sternum
Blunt Injuries

- MVC
- MCC
- Falls
- Assaults
- Contact Sports
- Pedestrian Struck
- Industrial
- Farm Mishaps

Pathophysiology of Thoracic Trauma

- Blunt Trauma
  - Results from kinetic energy forces
  - Subdivision Mechanisms
    - Blast
      - Pressure wave causes tissue disruption
      - Tear blood vessels & disrupt alveolar tissue
      - Disruption of tracheobronchial tree
      - Traumatic diaphragm rupture

(continued)

- Crush (Compression)
  - Body is compressed between an object and a hard surface
  - Direct injury of chest wall and internal structures

- Deceleration
  - Body in motion strikes a fixed object
  - Blunt trauma to chest wall
  - Internal structures continue in motion

- Age Factors
  - Pediatric Thorax: More cartilage = Absorbs forces
  - Geriatric Thorax: Calcification & osteoporosis = More fractures
Pathophysiology of Thoracic Trauma

Cardiovascular Injuries

• Traumatic Aortic Rupture
  – Aorta most commonly injured in severe blunt trauma
  – 55-65% mortality
  – Typically patients 50% will survive the initial injury insult
    • 30% mortality in 6 hrs
    • 50% mortality in 24 hrs
    • 70% mortality in 1 week
  – Injury may be confined to areas of aorta attachment
  – Signs & Symptoms
    • Rapid and deterioration of vitals
    • Pulse deficit between right and left upper or lower extremities
    • May be hemodynamically stable

Pathophysiology of Thoracic Trauma

• Penetrating Trauma
  – Low Energy
    • Arrows, knives, handguns
    • Injury caused by direct contact and cavitation
  – High Energy
    • Military, hunting rifles & high powered hand guns
    • Extensive injury due to higher kinetic energy
  – Shotgun
    • Injury severity based upon the distance between the victim and shotgun & caliber of shot
    • Type I: >7 meters from the weapon
      – Soft tissue injury
    • Type II: 3-7 meters from weapon
      – Penetration into deep fascia and some internal organs
    • Type III: <3 meters from weapon
      – Massive tissue destruction

Penetrating Injuries

• GSW
• Stab
• Impalements
Injuries Associated with Penetrating Thoraco Abdominal Trauma

- Closed pneumothorax
- Open pneumothorax (including sucking chest wound)
- Tension pneumothorax
- Pneumomediastinum
- Hemothorax
- Hemopneumothorax
- Laceration of vascular structures

Tracheobronchial tree lacerations
Esophageal lacerations
Penetrating cardiac injuries
Pericardial tamponade
Spinal cord injuries
Diaphragm trauma
Intra-abdominal penetration with associated organ injury

Airway Injuries

- Protect Airway
- Primary repair if able
  - Buttress
  - Segmental Resection
- Vent Strategy
  - Early extubation
  - Minimize Peak Pressures

Airway: Resuscitative Procedure

- DAI/RSI
  - Maintain C-spine immobilization
  - ETT size
  - Cricoid pressure (Sellick Maneuver)
    - Occlude esophagus to prevent aspiration

Sellick’s Maneuver, applying cricoid pressure
Thyroid cartilage
Cricoid cartilage
Trachea

Cervical Vertebrae
Airway: Resuscitative Procedures - Optional

• Combitube
  – Not for use in children

• Cricothyroidotomy
  – Not recommended for child < 12 yr. Old

Airway: Resuscitative Procedures

• DAI/RSI
  – Pre-oxygenate with 100% Oxygen
  – DAI Medications
    • Succinylcholine
    • IV sedation
    • Etomidate
  – Visualize vocal cords

Airway: Resuscitative Procedures

• Reassessment of airway
  – End tidal CO2 if tracheal intubation
  – Auscultation:
    Chest/Abdomen
  – Chest wall rise
  – Pulse oximeter
  – Vital signs
Airway Injury

Exposure

Tracheal Repair
GSW

Bronchoscopy

Retrieval
Thoracic Penetrating Injuries

- Rib Fractures
  - >50% of significant chest trauma cases due to blunt trauma
  - Compressional forces flex and fracture ribs at weakest point - Lateral
  - Ribs 1-3 require great force to fracture
  - Possible underlying lung injury
  - Ribs 4-9 are most commonly fractured
  - Ribs 9-12 less likely to be fractured
  - Transmit energy of trauma to internal organs
  - Hypoventilation is COMMON due to PAIN

Pathophysiology of Thoracic Trauma

Chest Wall Injuries
Pathophysiology of Thoracic Trauma

**Chest Wall Injuries**

- Flail Chest
  - Segment of the chest that becomes free to move with the pressure changes of respiration
  - Three or more adjacent rib fracture in two or more places
  - Serious chest wall injury with underlying pulmonary injury—Especially Contusions
    - Reduces volume of respiration—pneumonia
    - Adds to increased mortality
  - Paradoxical flail segment movement
  - Positive pressure ventilation can restore tidal volume
  - Pain control critical
**Pathophysiology of Thoracic Trauma**

**Pulmonary Injuries**

- **Open Pneumothorax**
  - Free passage of air between atmosphere and pleural space
  - Air replaces lung tissue
  - Mediastinum shifts to uninjured side
  - Air will be drawn through wound if wound is 2/3 diameter of the trachea or larger

- **Signs & Symptoms**
  - Penetrating chest trauma
  - Sucking chest wound
  - Frothy blood at wound site
  - Severe Dyspnea
  - Hypovolemia

- **Tension Pneumothorax** - Life Threatening
  - Buildup of air under pressure in the thorax
  - Excessive pressure reduces effectiveness of respiration
  - Air is unable to escape from inside the pleural space
  - Progression of Simple or Open Pneumothorax
  - Decreased venous return
Pathophysiology of Thoracic Trauma

**Pulmonary Injuries**

- **Dyspnea**
  - Tachypnea at first
  - Progressive ventilation/perfusion mismatch
  - Atelectasis on uninjured side
- **Hypoxemia**
- **Hyperinflation of injured side of chest**
- **Hyperresonance of injured side of chest**

**Tension Pneumothorax Signs & Symptoms**

- Diminished then absent breath sounds on injured side
- Cyanosis
- Diaphoresis
- AMS
- JVD
- Hypotension
- Hypovolemia
- Tracheal Shifting

**LATE SIGN**

- Diminished then absent breath sounds on injured side
- Cyanosis
- Diaphoresis
- AMS
- JVD
- Hypotension
- Hypovolemia
- Tracheal Shifting

**Hemothorax Signs & Symptoms**

- **Hemothorax**
  - Accumulation of blood in the pleural space
  - Serious hemorrhage may accumulate 1,500 mL of blood - Indication for Thoracotomy
    - Mortality rate of 75%
    - Each side of thorax may hold up to 3,000 mL
  - Blood loss in thorax causes a decrease in tidal volume
  - Typically accompanies pneumothorax
  - Hemopneumothorax

- **Blunt or penetrating chest trauma**
- **Shock**
  - Dyspnea
  - Tachycardia
  - Tachypnea
  - Diaphoresis
  - Hypotension
- **Dull to percussion over injured side**
Pulmonary Contusion
- Soft tissue contusion of the lung
- 30-75% of patients with significant blunt chest trauma
- Frequently associated with rib fracture
- Typical MOI
  - Deceleration
    - Chest impact on steering wheel
  - Bullet Cavitation
    - High velocity ammunition
- Microhemorrhage may account for 1-1 ½ L of blood loss in alveolar tissue
- Progressive deterioration of ventilatory status
- Hemoptysis - Not Typical

Pathophysiology of Thoracic Trauma

Chest Wall Injuries
- Contusion
  - Most Common result of blunt injury
  - Signs & Symptoms (often none)
    - Erythema
    - Ecchymosis
    - DYSPEA
    - PAIN on breathing
    - Limited breath sounds
    - HYPOVENTILATION
      - BIGGEST CONCERN - "HURTS TO BREATHE"
Pulmonary Contusion

- 70% of patients demonstrate changes 1-hour post injury
- Other patients have a 4-6 hour time lag
- Initial x-ray findings have NO correlation with severity of contusion even CCT limited due to progression
• Pericardial Tamponade
  – Restriction to cardiac filling caused by blood or other fluid within the pericardium
  – Occurs in ~2% of all serious chest trauma
    • However, very high mortality
  – Results from tear in the coronary artery or penetration of myocardium
    • Blood seeps into pericardium and is unable to escape
    • 200-300 ml of blood can restrict effectiveness of cardiac contractions
      – Removing as little as 20 ml can provide relief

Pathophysiology of Thoracic Trauma
Cardiovascular Injuries

Pericardial Tamponade Signs & Symptoms

- Kussmaul’s sign
  Decrease or absence of JVD during inspiration
- Pulsus Paradoxus
  Drop in SBP >10 during inspiration
  Due to increase in CO2 during inspiration

Electrical Alterans
P, QRS, & T amplitude changes in every other cardiac cycle

PEA
Pathophysiology of Thoracic Trauma

Other Thoracic Injuries

- Traumatic Asphyxia
  - Results from severe compressive forces applied to the thorax
  - Causes backwards flow of blood from right side of heart into superior vena cava and the upper extremities
- Signs & Symptoms
  - Head & Neck become engorged with blood
    - Skin becomes deep red, purple, or blue
    - NOT RESPIRATORY RELATED
  - JVD
  - Hypotension, Hypoxemia, Shock
  - Face and tongue swollen
  - Bulging eyes with conjunctival hemorrhage

Pathophysiology of Thoracic Trauma

Other Thoracic Injuries
Assessment of the Thoraco Abdominal Trauma Patient

- Scene Size-up
- Initial Assessment
- Rapid Trauma Assessment
  - Observe
    - JVD, SQ Emphysema, Expansion of chest
  - Question
  - Palpate
  - Auscultate
  - Percuss
  - Blunt Trauma Assessment
  - Penetrating Trauma Assessment
- Ongoing Assessment

PT. ASSESSMENT

- Difficult to assess pain (ABD vs. Ribs)
- Pain may be masked by drugs, head injury, ETOH
- Observation
  - Distention
  - Contusions
    - Cullen's sign – ecchymosis around umbilicus = splenic injury
    - Grey Turner's sign – Flank ecchymosis
    - Kehr's sign – referred pain to shoulders from ABD Injury, worse when lying flat = diaphragm and phrenic nerve

PT. ASSESSMENT (CON’D)

- Observation (con’d)
  - Penetration
  - Evisceration
  - Impaled object
  - Obvious bleeding
  - Scaphoid abdomen – Sign of herniated diaphragm
  - Encapsulating Injury – bleeding into itself without rupturing (Ex. Spleen or Liver)
Management of the Chest Injury Patient

General Management

- Ensure ABCDE’s
  - High flow O₂ via NRB
  - Intubate if indicated
  - Consider RSI
  - No role noninvasive ventilation
  - CXR/FAST exam
- Tension PTX is a CLINICAL diagnosis and can be delayed
- Shock Management
  - Fluid Bolus: 2 liters or 20 mL/kg
  - Constant Reevaluation

Management of the Chest Injury Patient

Rib Fractures

- Consider analgesics for pain and to improve chest excursion
  - Epidural
  - Rib blocks
  - Continuous infusion
- Indications for rib fixation

Management of the Chest Injury Patient

Flail Chest

- Place patient on side of injury
  - ONLY if spinal injury is NOT suspected
- Expose injury site
- Pain control
- High flow O₂:
  - Consider PPV or ET if decreasing respiratory status
  - Myth “internal stenting/stabilization”
- DO NOT USE SANDBAGS/DRESSINGS TO STABILIZE FX
Management of the Chest Injury Patient

• Open Pneumothorax
  – High flow O₂
  – Cover site with sterile occlusive dressing taped on three sides
  – Progressive airway management if indicated

• Tension Pneumothorax
  – Confirmation
    • Auscultation & Percussion
  – Pleural Decompression
    • 2nd intercostal space in mid-clavicular line TOP OF RIB
    • Consider multiple decompression sites if patient remains symptomatic
    • Create one-way valve
    • CT placement
Breathing: Resuscitative Procedures I

• Needle Decompression
  – Second Intercostal Space
  – Mid-clavicular line
  – Catheter over needle may be used

Breathing: Resuscitative Procedures I

• Chest Tube Insertion

• Fifth intercostal space anterior to mid-axillary line at infra-mammary crease

Management of the Chest Injury Patient

• Hemothorax
  – High flow O₂
  – CT placement OR for
  – 1500 cc or 300 hr x 2 hours

  – 2 large bore IV’s
    • Maintain SBP of 90-100 or MAP 55-60
    • EVALUATE BREATH SOUNDS
Management of the Chest Injury Patient

- Pulmonary contusion
- Injured lung poorly compliant
- MAP = oxygenation
  - PC inverse ratio
  - APRV
  - Bilevel
  - High frequency ventilation
- Proning?
- ECLA

Prone Ventilation

- Usually used late in the course of ARDS
- Decreased dependent atelectasis
  - Weight of the heart is removed
  - Lower weight of lung pressing down on the dependent prone lung
  - Prone positioning may shift the diaphragm down, decreasing the compressive effect of abdominal contents

Prone Ventilation

- Benefits Continued
  - Change from supine to prone with the same level of PEEP may keep the now dependent portions open while allowing the non-dependent portions to re-expand (prevents derecruitment)
  - Change in position does not completely change blood flow to the lung (good lung on the bottom may continue to receive increased flow)
Prone Ventilation

- Hemodynamic instability (1.1% per prone cycle)
- Extubation (0.4%)
- Decreased O2 sat (0.3%)
- Apical atelectasis (0.3%)
- Kinked ETT (0.1%)
- Obstructed CT (0.1%)
- Dislodged central lines (0.2%)
- Supraventricular tachycardia (0.1%)
- Possible aspiration (tube feeding rate must be decreased)

Management of the Chest Injury Patient

- Traumatic Asphyxia
  - Support airway
    - Provide O2
    - PPV with BVM to assure adequate ventilation
    - 2 large bore IV'S
    - Evaluate and treat for concomitant injuries
  - If entrapment > 20 min with chest compression
    - Consider 1mEq/kg of Sodium Bicarbonate

Conclusions

- Early Diagnosis and Interventions
- Judicious use of Fluids
- Appropriate pain control
- MAP based Ventilator Strategy
- Early mobilization and physiotherapy