

# Life in the Trauma Room: An Intro 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

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## Thoracic Trauma

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

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## 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

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## Anatomy and Physiology of the Thorax

- Trachea, Bronchi & Lungs
  - Pleura
    - Visceral Pleura
      - Cover lungs
    - Parietal Pleura
      - Lines 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

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## Anatomy and Physiology of the Thorax

- Trachea, Bronchi & Lungs
  - 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

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## Anatomy and Physiology of the Thorax

- 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 4<sup>th</sup> rib anteriorly and 6<sup>th</sup> rib posteriorly
  - Major muscle of respiration
    - Draws downward during inspiration
    - Moves upward during exhalation

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## Anatomy and Physiology of the Thorax

- Thoracic Skeleton
  - Topographical Thoracic Reference Lines
    - Midclavicular 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 1<sup>st</sup> rib with associated structures
  - Thoracic Outlet
    - Inferior opening of the thorax
    - 12<sup>th</sup> rib and associated structures & Xiphisternal joint

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## Anatomy and Physiology of the Thorax

- 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

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## Blunt Injuries

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



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## 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

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## Pathophysiology of Thoracic Trauma

- 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
    - » *Ligamentum Arteriosum* shears aorta
- Age Factors
  - Pediatric Thorax: More cartilage = Absorbs forces
  - Geriatric Thorax: Calcification & osteoporosis = More fractures

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## Pathophysiology of Thoracic Trauma *Cardiovascular Injuries*

- Traumatic Aortic Rupture
  - Aorta most commonly injured in severe blunt trauma
    - 85-95% 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

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## 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

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## Penetrating Injuries

- GSW
- Stab
- Impalements



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## 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

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## Airway Injuries

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

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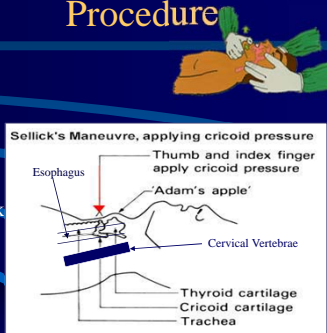
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## Airway: Resuscitative Procedure

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




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## Airway: Resuscitative Procedures - Optional

- Combitube
  - Not for use in children
- Cricothyroidotomy
  - Not recommended for child < 12 yr. Old



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## Airway: Resuscitative Procedures

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



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## Airway: Resuscitative Procedures

- Reassessment of airway
  - End tidal CO2 if tracheal intubation
  - Auscultation- Chest/Abdomen
  - Chest wall rise
  - Pulse oximeter
  - Vital signs



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## Airway Injury



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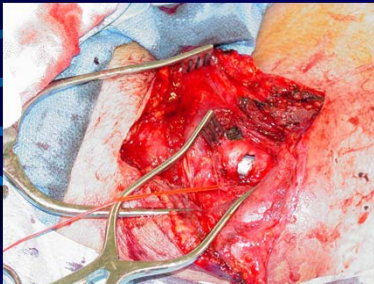
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## Exposure



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## Tracheal Repair



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## GSW



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## Bronchoscopy



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## Retrieval



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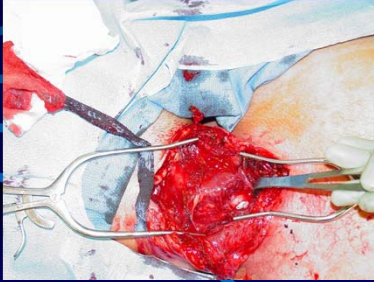
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## GSW Repair



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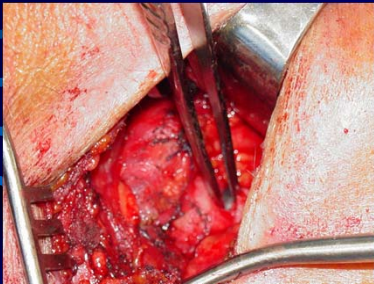
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## Exposure



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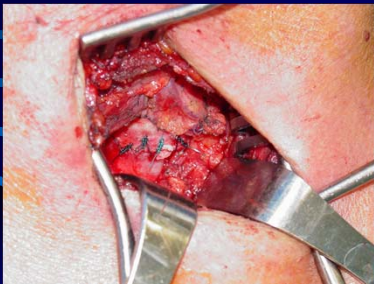
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## Repair



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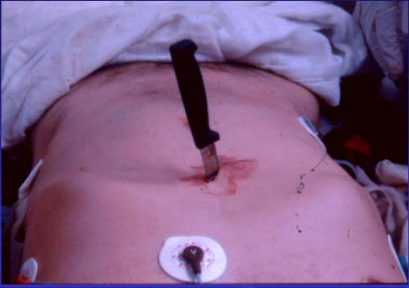
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## Thoracic Penetrating Injuries



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## Pathophysiology of Thoracic Trauma

### *Chest Wall 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 requires 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
    - If fractured, suspect liver and spleen injury
  - Hypoventilation is COMMON due to PAIN

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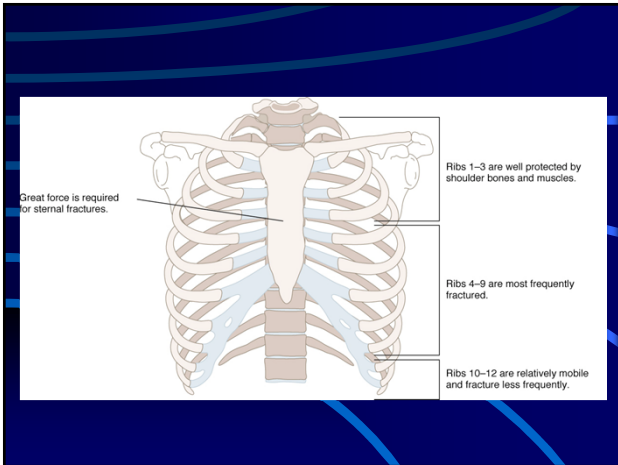
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## Pathophysiology of Thoracic Trauma

### *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- **Epecially Contusions**
    - Reduces volume of respiration/pneumonia
    - Adds to increased mortality
  - Paradoxical flail segment movement
  - Positive pressure ventilation can restore tidal volume
  - Pain control critical

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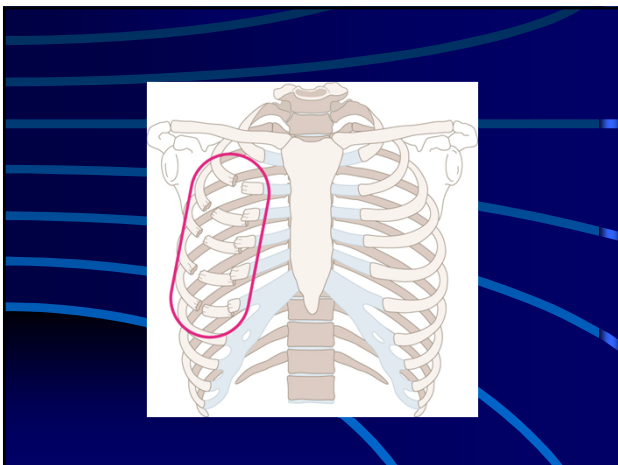
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## Pathophysiology of Thoracic Trauma *Pulmonary Injuries*

- 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

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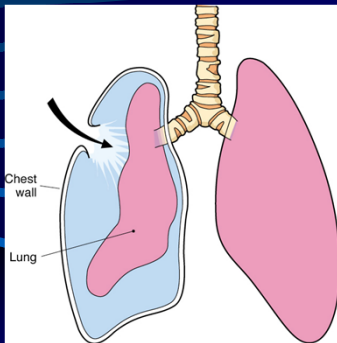
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## Pathophysiology of Thoracic Trauma *Pulmonary Injuries*

- 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

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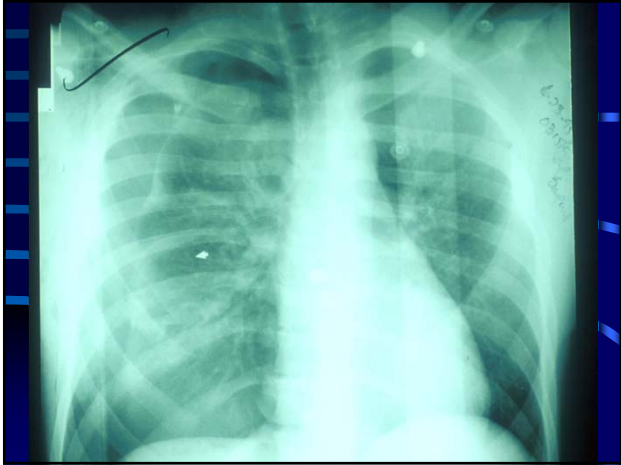
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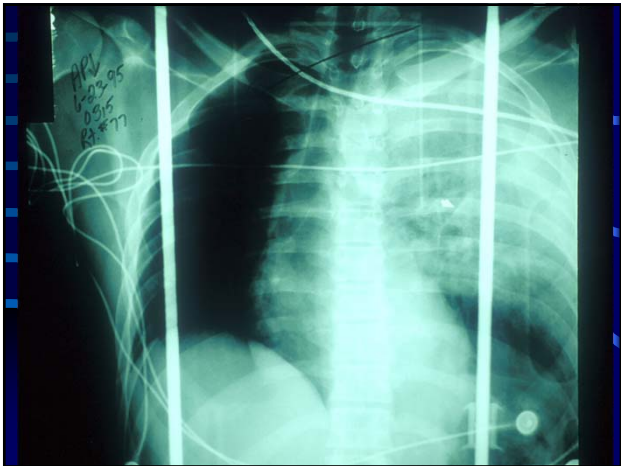
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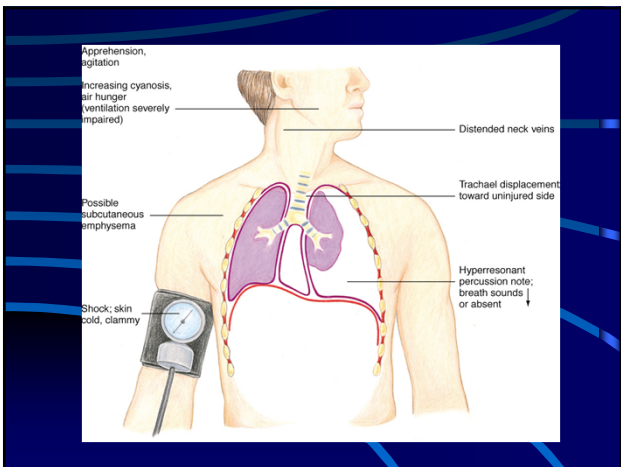
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## Pathophysiology of Thoracic Trauma *Pulmonary Injuries*

### *Tension Pneumothorax Signs & Symptoms*

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

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## Pathophysiology of Thoracic Trauma *Pulmonary Injuries*

- 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
    - Ventilation/Perfusion Mismatch & Shock
  - Typically accompanies pneumothorax
    - Hemopneumothorax

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## Pathophysiology of Thoracic Trauma *Pulmonary Injuries*

### *Hemothorax Signs & Symptoms*

- Blunt or penetrating chest trauma
- Shock
  - Dyspnea
  - Tachycardia
  - Tachypnea
  - Diaphoresis
  - Hypotension
- Dull to percussion over injured side

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## Pathophysiology of Thoracic Trauma

### *Pulmonary Injuries*

- 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

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## Pathophysiology of Thoracic Trauma

### *Chest Wall Injuries*

- Contusion
  - Most Common result of blunt injury
  - Signs & Symptoms (*often none*)
    - Erythema
    - Ecchymosis
    - DYSPNEA
    - PAIN on breathing
    - Limited breath sounds
    - HYPOVENTILATION
      - BIGGEST CONCERN = "HURTS TO BREATHE"

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## 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

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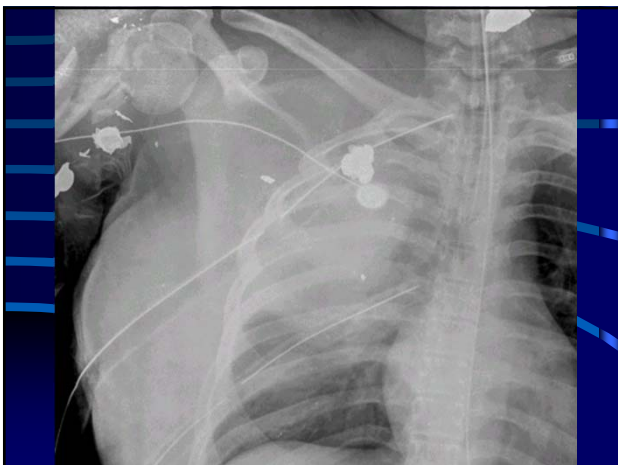
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### Pathophysiology of Thoracic Trauma Cardiovascular Injuries

- 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

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### Pathophysiology of Thoracic Trauma Cardiovascular Injuries

#### Pericardial Tamponade Signs & Symptoms

- Dyspnea
- Possible cyanosis
- Beck's Triad
  - JVD
  - Distant heart tones
  - Hypotension or narrowing pulse pressure
- Weak, thready pulse
- Shock

- Kussmaul's sign**  
Decrease or absence of JVD during inspiration
- Pulsus Paradoxus**  
Drop in SBP >10 during inspiration  
Due to increase in CO<sub>2</sub> during inspiration
- Electrical Alterans**  
P, QRS, & T amplitude changes in every other cardiac cycle
- PEA**

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## Pathophysiology of Thoracic Trauma *Cardiovascular Injuries*

- Other Vascular Injuries
  - Rupture or laceration
    - Superior Vena Cava
    - Inferior Vena Cava
    - General Thoracic Vasculature
  - Blood Localizing in Mediastinum
  - Compression of:
    - Great vessels
    - Myocardium
    - Esophagus
  - General Signs & Symptoms
    - Penetrating Trauma
    - Hypovolemia & Shock
    - Hemothorax or hemomediastinum

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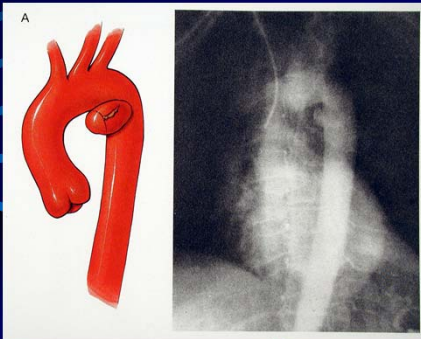
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## Aortic Injury



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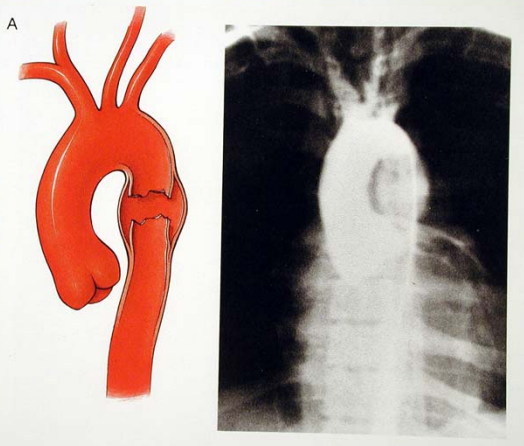
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## Pathophysiology of Thoracic Trauma

### *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

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## 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

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## PT. ASSESSMENT

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

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## 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)

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## Management of the Chest Injury Patient

### General Management

- Ensure ABCDE's
  - High flow O<sub>2</sub> 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

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## 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

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## 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 O<sub>2</sub>
    - Consider PPV or ET if decreasing respiratory status
    - Myth “ internal stenting/stabilization”
  - DO NOT USE SANDBAGS/DRESSINGS TO STABILIZE FX

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## Breathing: Resuscitative Procedures I

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



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## Breathing: Resuscitative Procedures I

- Chest Tube Insertion
- Fifth intercostal space anterior to mid-axillary line at infra-mammary crease



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## Management of the Chest Injury Patient

- Hemothorax
  - High flow O<sub>2</sub>
  - 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

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## Management of the Chest Injury Patient

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

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## 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

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## 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)

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## Prone Ventilation

- Hemodynamic instability (1.1% per prone cycle)
- Extubation (0.4%)
- Decreased O<sub>2</sub> 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)

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## Management of the Chest Injury Patient

- Traumatic Asphyxia
  - Support airway
    - Provide O<sub>2</sub>
    - 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

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## Conclusions

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

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