Thoracic Trauma
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Outline
- Emergency Department Thoracotomy
- REBOA
- Lung
- Trachea
- Esophagus
- Heart
- Thoracic Vascular Injuries

ED Thoracotomy

EAST Practice Management Guidelines
- EDT Survival Predictors
  - 1. Injury mechanism
  - 2. Anatomic injury location
  - 3. Presence of life on presentation

EAST Scenarios
- Patient 1: Pulseless to ED with signs of life after penetrating thoracic injury?
  - Yes
- Patient 2: Pulseless to ED without signs of life after penetrating thoracic injury?
  - Yes, conditionally
- Patient 3: Pulseless to the ED with signs of life after penetrating extrathoracic injury?
  - Yes, conditionally
- Patient 4: Pulseless to the ED without signs of life after penetrating extrathoracic injury?
  - Yes, conditionally
- Patient 5: Pulseless to the ED with signs of life after blunt injury?
  - Yes, conditionally
- Patient 6: Pulseless to the ED without signs of life after blunt injury?
  - No
    - Some voting "conditionally"
    - Low quality of evidence

EAST Scenarios
- Patient 5: Pulseless to the ED with signs of life after blunt injury?
  - Yes, conditionally
- Patient 6: Pulseless to the ED without signs of life after blunt injury?
  - No
    - Some voting "conditionally"
    - Low quality of evidence
Resuscitative Endovascular Balloon Occlusion of the Aorta\textsuperscript{2-12}

- **Benefits:**
  - Maximizes cerebral and coronary perfusion
  - Limits infradiaphragmatic hemorrhage
  - Avoids thoracotomy

- **Limitations/complications:**
  - Vascular injury
  - Time consumptive?
  - Learning curve
  - Appropriate setting/provider

- [YouTube Video](https://youtu.be/L3z5utZvnQ4)

Upcoming studies

- **EPR-CAT (Emergency Preservation and Resuscitation for Cardiac Arrest From Trauma):**
  - Compares pulseless penetrating trauma victims with scene signs of life who undergo standard resuscitative efforts including EDI compared to arterial cath placement to induce hypothermia followed by resuscitative surgery then cardiopulmonary bypass.

Lung Trauma

- **Intro**
  - **Mechanism**
    - Blunt thoracic trauma
      - 8% of all thoracic trauma admits in US\textsuperscript{1}
    - Penetrating thoracic trauma
      - 7% of all thoracic trauma admits and 16% of penetrating trauma admissions overall\textsuperscript{2}
  - **Management**
    - 18-40% managed with chest tube alone
      - 3-12% require thoracotomy
    - 30% will require pulmonary resection

- **Lung Trauma**
  - Injury to the bony thorax?
    - Suspect possible pulmonary injury
  - Opposite in children due to greater chest wall elasticity
  - Alveoli rupture - pneumothorax
  - Lung parenchyma damage
    - Bleeding
    - Bruising
  - Chest wall bleeding
    - Intercostal arteries
    - Mammary arteries

**Lung Trauma**

- **Pneumothorax**
  - Large - tension physiology
  - Increased intrathoracic pressure
  - Decreased venous return
  - Decreased cardiac output
  - Cardiac arrest

- **Hemothorax**
  - Large
  - Hypovolemia
  - Eventually tension physiology

**Presentation/Evaluation**

- Distended neck veins
- Tracheal deviation
- Subcutaneous emphysema
- Muffled heart sounds

**Monitor vitals**

- Work of breathing, sats
- No time for radiographs

**Penetrating trauma in hemodynamically unstable patient**

- Generally go to OR

**Workup:**

- ABG
  - Oxygenation, ventilation, shock
- E-FAST
- CXR
  - Though some question in the stable patient
  - E-FAST as sensitive
- CT
  - If indicated
  - Thoracic-us, esophagoscopy, bronchoscopy, echocardiogram

**CT imaging**

- Three dimensional recon
  - Aorta, great vessels
- Pneumothorax on CT?
  - Small and asymptomatic - observation
  - Maybe 15.9 mm - not found to be an independent predictor for failure
  - Positive pressure
  - Still monitor
- Hemothorax on CT?
  - Moderate or large - drain
  - Blood in pleural cavity may progress to fibrinopurulent pleural reaction or infection leading to empyema

**Lung lacerations**

- Symptoms
  - Large air leaks
  - Hemoptysis
- Dx
  - Bronchoscopy
  - Careful control of airway - double lumen tube, etc
- Tx
  - OR
  - Majority - non-op
  - Tube thoracostomy for air/blood
  - Symptomatic - OR
  - Bleeding - thromboelastometry embolization if poor operative candidate

**Rib fractures**

- Fractured chest - 3 or more adjacent ribs are segmentally fractured
- Leading to paradoxical chest wall motion
- High rate of resp failure, underlying pulm contusion, infection
- Tx supportive
  - Plating - still determining role
- EAST practice management guidelines 2017
  - Meta-analysis with 22 studies, 3 prospective randomized trials
  - Fractured chest - conditional recommendation to:
    - Decrease mortality, hospital LOS, ICU LOS, duration of mechanical ventilation, incidence of pneumonia, need for mechanical ventilation

**Lung Trauma**


Lung Trauma

● Pulmonary contusion
  ○ Symptoms
    ■ Clinically silent to severe
    ■ Evolve over 3 days - resolve at about 1 week
    ■ May exacerbate hypoxia and shunting
    ■ Upright positioning
    ■ IS
    ■ Analgesia - epidural, medications

Lung Trauma

● Indications for operation
  ○ Massive hemothorax
    ■ 1500 cc or more upon initial tube placement
    ■ 200-250 cc/hr over 3 consecutive hours
  ○ Thoracic trauma with persistent hemodynamic instability
  ○ Monitor chest tubes closely
  ○ Cessation of bleeding - clotted chest tube, poor positioning
    ■ Consider VATS
  ○ Early VATS/thoracotomy

Lung Trauma

● Operative notes
  ○ Single lung ventilation not warranted in hemodynamically unstable patients
  ○ Unless massive hemoptysis
  ○ Evacuate blood and clot
  ○ Incise inferior pulmonary ligament
  ○ Lyse adhesions
  ○ Control bleeding
    ■ Finger compression
    ■ Hilar bleeding
      ○ Finger occlusion
      ○ Penrose around hilum
      ○ Hilar vascular clamp
      ○ Twist on itself
        ○ Occludes pulmonary artery, vein and mainstem bronchus

Lung Trauma

● Operative Notes
  ○ Lung repair
    ■ Pneumonectomy - running simple or mattress suture
  ○ Resection
    ■ Thoracotomy
    ■ Excision
  ○ Hilar injuries
    ■ Proximal
      ○ Need inflow occlusion to assess extent of injury
        ■ Open pericardium and control intrapericardial pulmonary artery and vein
      ■ May require pneumonectomy
        ■ Mortality approaches 100% if in shock
        ■ Perform early and treat right heart failure
          ■ Maybe ECMO - some improvement in outcomes

Lung Trauma

● Resection complications
  ○ Bronchial stump dehiscence
  ○ Devastating complication
  ○ Some reinforce bronchial stump with viable tissue
  ○ Muscles
    ■ Intercostal muscle flap
    ■ Diaphragmatic flap
    ■ Pedicled pericardial flap
    ■ Pericardial fat pad
    ■ Mediastinal pexis
  ○ Lacer
    ■ Omentum
    ■ Latissimus dorsi flap

Lung Trauma

● Damage Control in the Chest
  ○ Pack and leave chest open
  ○ Does not interfere with cardiac or pulmonary function
  ○ Series of 44 patients
    ■ Mean pH 7.07, ISS 29
    ■ Mortality 23%
    ■ All physiologically normal at time of chest closure
    ■ Average 2-3 days

Lung Trauma

- **Video-Assisted Thoracoscopic Surgery**
  - **Indications**
    - Alternative for diaphragm repair
    - Empyema, retained hemothorax, persistent air leak
    - Similar to open
  - **Lung isolation**
    - First port - 4th or 5th intercostal space in mid or anterior axillary line
    - Tip of scapula - good landmark
  - **Additional ports under visualization**

- **Complications**
  - **Pneumonia**
    - Thoracic injury requiring intubation?
    - ~7 times more likely to develop pneumonia
    - ~50% will develop pneumonia, barotrauma, and or major atelectasis
    - ~25% ARDS
  - **Empyema**
    - Dx - positive pleural cultures or frank purulence in the pleural space
    - Develops in ~26.8% of patients with a retained traumatic hemothorax
    - Stages
      - Exudative
      - Fibrinopurulent
      - Organizing
    - Tx: VATS/thoracotomy
  - **Retained hemothorax**
    - Failed to be drained by tube in 5%
    - Repeat chest CT
      - Less than 300 cc retained? Monitor
      - Early VATS
  - **Persistent air leak and bronchopleural fistula**
    - True bronchopleural fistula - centrally located communication between a lobar or segmental bronchus and the pleural cavity
    - Most resolve by 7 days
    - Dx: bronch
    - Tx: autologous blood pleurodesis, sealants, endobronchial one-way valves, Heimlich valves, OR
  - **Chylothorax**
    - Milky chest tube output
    - Triglyceride level greater than 110
    - Tx
      - Nonop: tpn, enteral medium-chain triglycerides, octreotide
      - Beyond 7 days: operative - maybe embolize thoracic duct or direct ligation

Tracheobronchial Injuries

- **Be aware of cervical tracheal injuries**
  - Underlying esophageal, vascular thoracic duct and nerve injuries
  - Presentation/evaluation
    - Subcutaneous air
    - Resp distress
      - Be careful during intubation of disruption
  - **Dx**
    - Bronch
      - 3/4 of blunt injuries occur within 2 cm of the carina
      - Carefully back up stt over bronch and then slide back over to avoid missed injury
    - CT
      - May be helpful if penetrating trajectory far from site

- **TX**
  - OR
    - Suture - interrupted absorbable
    - Distal half of trachea, right main stem, prox main stem bronchus
      - Right posteroanterior thoracotomy
      - Double ligate and divide azygos vein
      - Bougie or ngl in esophagus
    - Distal left main stem bronchus
      - Left posteroanterior thoracotomy
      - Arch will be in the way
    - Consider muscle flap to protect esophagus
    - Highly selected group - stents
      - Generally less than 2 cm, no transmural tears
Tracheobronchial Injuries

- Complications
  - Tracheal stenosis
    - Wheezing from narrowed airway
    - Dx
      - CT
      - Bronchoscopy
    - Tx
      - Control airway if high grade
      - Rigid or balloon dilation under direct visualization
      - OR only if very severe and short segment
      - End to end anastomosis

Esophageal Injuries

- Rare
  - Very critical to identify
- More common in neck than thorax
  - No bony protection
- 34 trauma center in US large multicenter trial
  - Penetrating esophageal injuries - 465
  - High mortality and morbidity

Esophageal Injuries

- Dx
  - Symptoms in less than 1/4 with an injury
  - Pneumothorax or hemothorax
  - Tube with saliva or food contents
  - CT scan
    - Oral contrast
    - Static exam
  - Contrast esophagography
  - EGD

Esophageal Injuries

- Tx
  - More prone to postoperative leak due to lack of serosal layer
  - Easily treated in neck
  - Mediastinal - more morbidity
  - Two layer
    - Mucosa interrupted sutures with absorbable or nonabsorbable
    - Muscular layer - interrupted nonabsorbable sutures

Esophageal Injuries

- Pearls
  - Appropriate debridement
  - Preservation of esophageal length
  - Buttress the repair
  - Wide drainage
  - Enteral feeding access
  - Side of access:
    - Right sided access for most of intra-thoracic esophagus
    - Left - distal esophagus, thoracoabdominal
    - Laparotomy, left thoracotomy
    - Consider fundal wrap
  - Control esophageal fistula with T tube if needed
    - With wide drainage
    - Retrograde esophageal drainage
    - EJ months later

Heart Injuries
Heart

● Epidemiology
  ○ Difficult to ascertain true quantity due to low volumes

● Mechanism
  ○ Area most prone to injury: right and left ventricles
  ○ Be wary of:
    ■ Coronary arteries
    ■ Valves
    ■ Intracardiac fistulas (ventricular septal defects)
  ○ Foreign bodies
  ○ Remove if greater than 1 cm in size, contaminated or symptomatic
  ○ Generally okay to leave intracardiac missiles
  ○ Right sided can embolize to PA then be removed with cath based technique if large

● Rare - embolize through a pfo or atrial septal defect


Heart

Blunt Injury

○ Replaced term “cardiac contusion”
  ■ Insignificant bruising to cardiac rupture
  ■ Direct energy to the heart or by compression (between sternal and vertebral column)
  ■ Can occur from cpr
  ■ Manifests as a spectrum:
    ■ Septal rupture, free wall rupture, coronary artery thrombosis, cardiac failure,
    dysrhythmia, rupture of chordae tendineae or papillary muscles
  ■ Pericardial tear
    ■ Right - can lead to twisting of heart and prevention of venous return
    ■ Left - heart can herniate through - strangulation
    ■ Sudden loss of pulse when the patient is repositioned or placed on a stretcher

Heart

Iatrogenic cardiac injury

○ CVC, cardiac cath, endovascular interventions, pericardiocentesis
  ○ SVC/atrial perforations - more common with left sided lines
  ○ Be wary of tamponade
    ■ Pericardiocentesis
    ■ Subxiphoid pericardial window
    ■ Median sternotomy
  ■ May be hard to find the injury

Heart

Electrical Injury

○ Acute myocardial necrosis with or without ventricular failure
  ○ Myocardial ischemia
  ○ Dysrhythmia
  ○ Conduction abnormalities
  ○ Acute htn with peripheral vasospasm
  ○ Ecg abnormalities

Heart

Overall Injury Presentation

○ 60-100 ml blood in pericardial sac to induce clinical picture
  ○ Best sign of pericardial tamponade: narrowing of pulse pressure

Blunt

○ Dysrhythmia
  ■ Most common: pvs (unclear etiology), sinus tach
  ■ Ventricular tach, fibr
  ■ Supraventricular tachydysrhythmias

Heart

Dx

○ Beck’s triad, Kussmaul’s sign - present in only 10% of patients with cardiac tamponade
  ○ FAST
  ○ CXR - for hemothorax, pneumothorax
  ○ CT scan for trajectory
  ○ Laparoscopy for diaphragm injury
  ○ ECG
  ■ Level 1 recommendation by EAST
  ○ Cardiac enzymes
    ■ Minimal evidence
  ○ ECHO
  ■ Often limited by chest wall injury
    ○ TEE or OR
Thoracic great vessel injury

90% due to penetrating injuries

- Iatrogenic included
  - CVC
  - Chest tubes
  - Increased rate with pigtails
- ED thoracotomy - aortic injury
- Swan-Ganz
- Esophageal/tracheal stents

Thoracic great vessel injury

- Aortic
  - Blunt usually full thickness - similar to ruptured AAA
  - Consider same tx - permissive hypovolemia
  - Dissection - longitudinal separation of the media extending along the length of the aorta
  - Rare
  - Blunt aortic injury better term
  - Hemodynamically stable aortic injury patients rarely die from aortic rupture
  - This subgroup that does die is usually from the injury

Thoracic great vessel injury

- Physical exam
  - Upper extremity hypertension
  - Unequal blood pressures
  - Sternal fx
  - Intra-acuacular murmur
  - Left fiad chest

- CXR
  - Most reliable signs:
    - Loss or “double shadowing” of the aortic knob contour
    - Mediastinal widening - suggestive of innominate artery injury
    - Mediastinal hematoma
Thoracic great vessel injury

**Dx**
- Chest tube output
- ED thoracotomy
- Subclavian - pack, clamp at thoracic apex or insert balloon catheter
- Pulmonary hilum - cross clamp hilum or left lung 180 degrees after releasing inferior pulmonary ligament
- CT chest
- Dx and operative planning
  - Angiography
- Permissive hypotension acceptable (sbp 60-90)
- BB for aortic injury?
  - Not proven in big studies

**Tx**
- Consider nonop in:
  - Severe head injury
  - Risk factors for infection
    - Major trauma
    - Septic
    - Heavily contaminated wounds
    - Severe multisystem trauma with hemodynamic instability and or poor physiologic reserve
    - Careful follow up with serial imaging
- Endograft repair
  - Need aortic diameter of greater than 18 mm
  - Can use intravascular ultrasound to accurately measure in systole
  - Seal zone length of 1-2 cm

**Open repair**
- Complications:
  - Paraplegia, stroke, recurrent nerve and brachial plexus injuries
  - Vessels greater than 5 mm - prosthetic graft
  - Especially in contaminated wounds (concern for saphenous vein graft being susceptible to collagenase)
- Damage control
  - Pneumonectomy
  - Shunts
  - Pulmonary tractotomy
  - Temporary chest closure

**Arterial injuries**
- Thoracic aorta
  - Clamp and direct reconstruction
  - Posterolateral thoracotomy through 4th intercostal space
  - Generally at level of the ligamentum arteriosum
  - Concern: paraplegia
  - Debate on bypass, pumps
  - Benefit of endograft
- Subclavian artery
  - Access
  - Right - Cervical extension of the median sternotomy
  - Left - Anterolateral thoracotomy
  - Possible superintervention incision separately for distal control
  - Some endovascular repair

**Arterial injuries**
- Right subclavian artery
  - Similar to innominate artery injury
- Aortic arch
  - Generally need extension of the median sternotomy to the neck
  - Expose brachiocephalic branches
  - Can also divide innominate vein for better exposure
- Innominate artery
  - Median sternotomy
  - Can divide vein if needed
  - Emergent management - compression through tracheotomy
    - 25% risk of neurologic complications but....
  - Do not attempt revascularization

**Arterial injuries**
- Left carotid artery
  - Similar to right carotid artery injury
  - Median sternotomy with a left cervical extension
- Pulmonary artery
  - Intrapericardial? Median sternotomy
  - Minimal dissection needed
  - Right - exposed by dissecting between svc and ascending aorta
  - Posterior injuries generally require cardiopulmonary bypass
  - Distal - generally posterolateral thoracotomy
  - Massive hemotherax
- Internal mammary artery
  - 300 ml/min in young patients
- Intercostal - circumferential sutures
Thoracic great vessel injury

- Venous Injuries
  - Thoracic vena cava
  - Total cardiopulmonary bypass
  - Superior vena cava
  - Lateral venorrhaphy
  - Fat needed
  - Vein

- Special Problems
  - Mediastinal Traverse Injuries
    - High probability of injury to thoracic great vessels and other critical vessels
    - Past mandatory exploration
    - Aortography
    - Bronchoscopy
    - Esophagoscopy
    - CT scan

- Systemic Air Embolism
  - Fistula between a pulmonary vein and bronchiule
  - Seizures, cardiac arrest
  - Consider cardiopulmonary bypass
  - Very few survivors

- References
  3. Bri...
References


