Thoracic Trauma

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Disclosure

- I have no relevant commercial relationships to disclose.

Objectives

- To develop an approach for assessing traumatic injuries of the chest
- To identify CT findings of traumatic aortic injury
- To apply MPR’s, CT angiography and volumetric CT to communicate the abnormal findings to clinicians

Background

- 100,000 deaths/year in US
- 12/million/day – thoracic trauma
- 20-25% of all deaths
- Major cause of mortality in young <40 y
- 33% - require hospital admission

Blunt Trauma-Biomechanics

Specific Injuries
- direct blows can crush and fracture soft tissue and bone
- chest wall compression with abrupt increase in intrathoracic pressure – rupture viscera
- differential deceleration - shearing stresses and torsional deformations

Imaging Modalities

- CXR – first line test
  - may not show some of the severe/lethal injuries
- CT – more sensitive
- Angiography ± IVUS
Technique – ECG-gated

- Contrast: 120 cc UV 300 @ 4cc/sec, 50 cc saline @ 4 cc/sec
- 1.25-mm collimation, interval 1.25-mm
- kVp 120
- mA – 500 – 750
- Gantry 0.35/0.4
- Pitch varies ~ heart rate
- Retro recon – bone, sag and coronal reformats of thoracic spine
- Sternum – sag and oblique coronal

Technique – Nongated

- Contrast: 120 cc UV 300 @ 4cc/sec, 50 cc saline @ 4 cc/sec
- 2.5-mm collimation, interval 1.25-mm
- kVp 120
- mA – 300
- Pitch 1.375:1
- Speed 27.50
- Gantry 0.8
- Retro recon – bone, sag and coronal reformats of thoracic spine
- Sternum – sag and oblique coronal

Thoracic Spine

Sternum

Systematic Approach

The ABC’s

Clinical ABC’s

A – Airway
B – Breathing
C – Circulation
D – Drugs
E – Electricity
Radiology ABC’s

A – Aorta
B – Bronchus
C – Cord
C – Contusion and Laceration
D – Diaphragm
E – Esophagus
F – Fracture
G – Gas
H – Heart
H – Hemothorax, Hematoma, and Hemorrhage
I – Iatrogenic

Aortic Trauma

Acute Thoracic Aortic Injury - ATAI

• 75% - 80% ATAI – high speed MVA 50 km/h due to rapid deceleration
• Side-impact collision > head-on collision - mortality↑
• Seat-belts largely ineffective
• Side curtain airbags ?? ↓ - ATAI

ATAI - Outcome

• High mortality – fatal in 80 – 90%
• Of 20% survive the 1st hr, estimated mortality:
  ➢ 30% - 6 hours
  ➢ 49% - 24 hours
  ➢ 72% - 8 days
  ➢ 90% - 4 months
• If detected in timely manner – 60-80% survive following definitive Rx
• 2-5% chronic pseudoaneurysms if not detected

ATAI

• Prompt recognition and treatment of ATAI – critical for long time survival
• Radiologists play a pivotal complex and multifaceted role in diagnosis and management

ATAI

• Injuries occur where aorta is fixed
  – Isthmus (90%)
  – Ascending aorta (5-10%)
  – Descending aorta (1-3%)
• Multiple sites (6-8%)
CXR
• 7% of ATAI – deceptively normal CXR
• Mediastinal widening >8cm &/25% width of chest – not sensitive
• Abnormality of transverse aortic arch – loss of AP window
• Rightward deviation of trachea, esophagus/N/G tube
• Left main stem bronchus depression
• Left apical cap

MDCT
• Diagnostic modality for initial evaluation
• Direct and indirect findings immediately seen on axial images
• MPR useful for exact morphology and extent of vascular injury – esp at isthmus
• MPRs aid surgical planning – sag oblique particularly for distance from left subclavian

Indirect Sign – Med Hematoma

Aortic Injury – Direct Signs
• Pseudoaneurysm
• Aortic transection
• Traumatic aortic dissection
• Traumatic acute intramural hematoma
• Minimal aortic injury
• Chronic pseudoaneurysm

Aortic Injury – Grading
• Type I – Intimal tear
• Type II – Intramural hematoma
• Type III – Pseudoaneurysm (contained rupture)
• Type IV – Rupture (free rupture)
Aortic Injury: Isthmus

- Most common location
- Aorta immobile, tethered by lig arteriosum (minimal injury → frank rupture)
  - Medial curvature of arch at level of LPA & LMB

Pseudoaneurysm

Aortic Transection

- Involves all three layers
- Most common injury pattern at autopsy
- Usually results in immediate death
- Pseudoaneurysm formation with clot at injury site – may result in survival
- Intact ends of aorta separated by cms

Minimal Aortic Injuries

- ~10%
- Only intima affected
- Angiography can be normal in ~ 50%
- IVUS may be required to confirm diagnosis
- Very little data on optimal therapy or long term outcomes
- May not require immediate surgical intervention
- Many may remain stable or resolve over time
Aortic Root & Ascending Aorta
- 5-14% autopsy studies
- Extremely rare in clinical practice
- Lethal
- 3 main patterns of injury:
  - Laceration of Asc A bet root and Innominate A
  - Injury to root involving aortic valve
  - Injury to root without involvement of valve

Aortic Arch & Branch Vessel Injury
- Less common (4%)
- Innominate and common carotids
- Potentially fatal
- Subtle intimal injuries → complete transection → contained rupture
- Mediastinal hematoma – no direct sign of aortic injury
- Important implications for surgical approach (branch vessel injury – median sternotomy)

Mid and Distal Descending Aorta
- 1-12% of autopsies
- Distal descending tethered to spine by diap crux – shear forces
- Asso diaphragmatic injury in 10%
- Asso T Spine compression fractures

Chronic Pseudoaneurysm
Pulmonary Parenchymal Trauma

- Common - up to 70% of patients
- Direct impact/deceleration
  - torsional shearing forces on alveolar walls
- Lung injury at impact point and “contrecoup”
- More extensive in young > old – plastic thoracic cages
- Sudden increase in intro-alveolar pressure against closed glottis
- May relate to fracture

Pulmonary Contusion

- Unilateral or bilateral (more frequent)
- In “contrecoup” areas
- Appears 4-6 hours following trauma
- Resolves in 48-72 h and disappears in 1-2 w
- Rapid migration
- Radiological pattern evolves hourly
- May worsen with treatment – excess fluid, O2, ventilation

Sangster et al, Eur Rad 2007 14:297

Pulmonary Contusion

CT:
- Ill-defined and confluent areas of GGO
- No anatomic boundary
- No air-bronchograms
- Subpleural in periphery of lungs
- Subpleural sparing in children

RUL Contusion
Pulmonary Laceration

- Shearing forces – disruption of alv walls
- Intrapulmonary cavities, round or ovoid
  - Filled with blood (hematocele)
  - Filled with air (pneumatocele)
  - Filled with air and blood (hematopneumatocele)
- Small/large
- Uni/multilocular
- Single/multiple
- Located mainly in area of blunt impact

Pulmonary Laceration - Classification

- Type I: frequent, centrally located – shearing between lung parenchyma and TB tree
- Type II: lower chest suddenly compressed, squeezing lower lobes against vertebral bodies - tubular
- Type III: small, round, peripherally located, freq asso with rib # and pneumothoraces

Wagner et al. Radiology 1988; 167

Type I

Type II

Type III

Intrapulmonary hematoma

- Slowly resorbed and evacuated through bronchi over weeks/months
Tracheobronchial Injury

Tracheobronchial Laceration
- ↑ Intrathoracic pressure against closed glottis
- < 1% of blunt thoracic trauma
- Bronchial injuries > tracheal injuries
- Usually on right side appx 2.5 cm from carina
- 85% tracheal lacerations 2 cm above carina
- Diagnosis often delayed

Tracheobronchial Laceration
- Direct/Indirect CT findings can suggest TB injury
- Direct: Discontinuity of tracheal wall with adjacent air-leak
- Indirect Specific Findings:
  - Collapsed lung resting on most dependent area away from hilum “fallen lung”
  - Persistent pnx after thoracostomy
  - Herniation/overdistension of ETT cuff in intubated pt

Pleural Trauma
**Pneumothorax**
- 30-40% of blunt thoracic trauma
- CXR – see one unless very small (anterobasal)
- Clinical significance does not depend only on size but also on hemodynamic condition
- Small undiagnosed Pnx can become large if mechanically ventilated – if missed, dire consequences

**Hemothorax**
- 30-50% of cases of blunt trauma
- Usually due to laceration of lung/pleura
- High-attenuation blood layers in the dependent portion of the pleura
- Different degrees of coag – “hematocrit sign”

**Diaphragmatic Trauma**

**Diaphragmatic Rupture**
- Rare -0.8-5.8% of patients
- Results from sudden increase in intra-abdominal pressure
- Tears posterolateral portion of diaphragm at the musculotendinous junction
- 75% left sided usually involving the stomach and/or colon
- Diagnosis is often delayed
MDCT of Diaphragmatic Rupture

- Diaphragmatic discontinuity
  - 58% right-sided injury
  - 71% left sided injury
- Herniation of bowel/solid organs into thorax
- “dependent viscera” sign
  - abdo organs against posterior ribs, obliterate post CP recess from loss of support of intact diaph
- “collar” sign
  - Liver, stomach, bowel – strangulated at site of herniation
  - Sensitivity: 63%, specificity: 100%

Diaphragmatic Rupture

Esophageal Injury

- Occurs in less than 1% of blunt trauma
- Caused by sudden increase in intra-esophageal pressure
- Most common site is the left posterolateral wall of the distal esophagus
- Must use indirect signs to identify the tear
  - pneumomediastinum
  - left pneumothorax
  - left pleural effusion

Fractures/Skeletal Trauma

Rib Fractures

- Occur in up to 81% - most common injury
- Mechanism: steering wheel, dashboard/seatbelt
- Subcut emphysema + 27%
- CP and guarded breathing – decreased BS – atelectasis and bronchopneumonia
Rib Fractures – Flail chest

- 3 or more adjacent fractured ribs, each broken at 2/> sites
- 5 or more neighboring ribs fractured
- Paradoxical motion during breathing – ventilatory failure
- Impairment of normal resp mechanics – atelectasis and/or ARDS from impaired pulmonary drainage

Sternum, Scapula, Sternoclavicular Dislocation

- Indicators of high impact blunt trauma
- ↑ level of suspicion for serious internal organ injury
- Along with rib fractures – “seat-belt” synd

Sternal Fracture

- 8% of blunt trauma
- Seatbelt, air-bag, steering wheel
- MDCT and MPR’s
- Retrosternal hematoma
- Sternal # if significantly displaced
  - Concomitant chest injuries – 30%
  - Cardiac contusion – 20-40%

Sternal Fracture

Thoracic Spinal Fractures

- 25-30% of all spine fractures
- Most occur at the functional thoracolumbar junction (T9 to T11)
- 10% at multiple levels
  - 80% of which will be noncontiguous
- Result from MVA’s/falls from a great height
- Produced by hyperflexion and/or axial loading
Thoracic Spinal Fractures

Radiographic Signs
• Direct -
  – Abnormal vertebral body, size, shape, opacity, and location. Cortical disruption
• Indirect
  – Paravertebral hematoma, can overlap with signs of aortic injury
• If a T-spine fracture is suspected then further evaluation with CT and/or MRI is indicated.

Summary
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