Thoracic Injuries: From Conventional X-Ray to Multidetector CT

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LEARNING OBJECTIVES

- To familiarize radiologists with the broad spectrum of lesions to be assessed in thoracic trauma

- Have great medical importance, social and economic, with the high mortality, mainly in men between 30-40 years.
The etiology are: traffics (70%), precipitation, domestic accidents, blust and compression injuries.

Thoracic injuries can be classified in penetrating trauma, nonpenetrating and combined mechanism.
CHEST X-RAY

- Excludes injuries with vital commitment
  - Pneumothorax / Hemothorax
  - Mediastinal widening (aortic injury)
  - Multiple rib fractures (flail rib, injury to abdominal organs)

- Negative predictive value of normal chest X-ray is high (98%) for aortic injury
CLASSIFICATION OF TRAUMATIC INJURIES

- Chest wall
- Pleura
- Lung
- Mediastinum
- Diaphragm
INJURY OF CHEST WALL

- Subcutaneous emphysema
- Rib fractures
- Sternal fractures
- Vertebral fractures
- Clavicle and scapula fractures
- Sternum and acromioclavicular dislocation
TRAUMATIC SUBCUTANEOUS EMPHYSEMA

- **Etiology**
  - Mediastinal lesion (esophagus, tracheobronchial tree)
  - Chest wall injury (knife, rib fracture)
  - Parietal pleural injury
  - Subpleural lung injury
- **Chest X-ray and CT findings**
  - Radiolucent bands of air in fat and muscle planes

Figure 1A: Linear gas density in right chest wall (arrows). Image 1B shows extensive subcutaneous emphysema
RIB FRACTURES

- Are present in 85% of non-penetrating chest trauma
- 50% of rib fractures are associated with significant pleural and pulmonary injury
- Location: posterolateral from 4-9 th ribs
- Fracture of 1-3rd ribs: vessel and tracheobronchial injury or brachial plexus.
- Fracture 10 th -12 th ribs: liver, kidney or spleen damage

Figure 2A: non-displaced fractures in lower left costal arches (arrows).
Figure 2B: multiple rib fractures displaced (arrow) with pneumothorax.
Figure 2C: posterior fractures on 3D reconstruction.
STERNAL FRACTURES

- Direct trauma to the wheel
- Injuries associated
  - Retrosternal hematoma
  - Pneumothorax / Pneumomediastinum
  - Myocardial contusion

Figure 3A: Sternal fracture in adult.
In image 3B, sternal body fracture in a child secondary to trauma to the bicycle handlebars
SPINAL FRACTURES

- Chest X-ray
  - Morphological deformity of the vertebra
  - Detached paraspinal lines
- CT: Free intracanalicular fragments / Stability of fractures
- MRI
  - Spinal cord injury and paravertebral lesions
  - Symptomatic patients without CT lesions: spinal hematoma or edema

Figure 4: 8th vertebral fracture with wedging of body and widening of paraspinal lines (arrows)
Figure 5: Fracture in fifth, sixth and seventh dorsal bodies.
Figure 6: Images A and B, show broken clavicle. Image C, scapular fracture is identified. Image D, shows acromioclavicular dislocation.
Figure 7: Fracture of scapula

Iceberg type II
PLEURAL LESIONS

- Pneumothorax
- Hemothorax
- Empyema
- Chylothorax
PNEUMOTHORAX

- **Etiology**
  - Rib fracture, penetrating wound, barotrauma
  - Esophageal, bronchial or lung rupture

- **Radiological diagnosis**
  - Air in pleural cavity
  - Collapsed lung

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Figure 8. Image A, allows to identify right pleural line by pneumothorax. Image B, bilateral pneumothorax is seen on CT.
Figure 9: Traffic accident. Subcutaneous emphysema, pneumothorax and pleural effusion.
MASSIVE PNEUMOTHORAX

- **Etiology**
  - Valve mechanism
  - Positive pressure mechanical ventilation

- **Radiological diagnosis**
  - Radiolucency of affected hemithorax
  - Contralateral mediastinal shift
  - Investment hemidiaphragm
  - Extensive lung collapse

*Figure 10: Massive pneumothorax. Complete collapse of right lung (Star)*
HEMOTHORAX

- **Etiology**: chest injuries, abdominal visceral lesions
- **Chest radiography**
  - Increased vascular density without clear contours
  - Meniscus / Subpulmonary or paraspinal location
  - White hemithorax
- **Chest CT**
  - Location and amount of effusion
  - Injuries associated

Figure 11. In the CT image, the arrows indicate the presence of high-density pleural effusion (hemothorax)
TRAUMATIC LUNG INJURY

- Contusion
- Laceration
- Firearm injury
- Posttraumatic atelectasis
Is the more common lung injury in thoracic trauma (60-70%)

Pathogenesis: alveolar enlargement with exudation of fluid and blood into the interstitium and alveoli

Natural history: Starting at 6-8 hours, increases during the first 12-24 hours and resolves within 7-14 days

Figure 12. Extensive alveolar infiltrates corresponding to contusions (stars)
PULMONARY CONTUSION

- **Mild:** patchy alveolar infiltrates, peripheral location and segmental
- **Severe:** bilateral involvement usually backlash effect, with extensive alveolar infiltrates
- CT is more sensitive than chest X-ray for the detection and extent of contusions

Figure 13. Alveolar consolidations and ground glass opacities in both lung by multiple pulmonary contusions.
More common finding in penetrating trauma

Pathogenesis: tear with parenchymal hemorrhage.

In subpleural location, hemopneumothorax is associated.

Natural history: develops hours−days after trauma. Slow resolution in 3−5 weeks.

Figure 14. Ovoid lesions in the right hemithorax, homogeneous in relation to laceration (arrows)
Radiological findings

- Smooth contour rounded cavity (pneumatocele)
- Dense nodule, cyst filled with blood (hematoma)
- Cyst with fluid level
- Persistent focal scars/residual nodules

Figure 15. Ovoid lesions in the right hemithorax, homogeneous or fluid level in relation to laceration (arrows)
Figure 16. Gunshot injuries on CT: hyperdense image in relation to projectile (arrow). Subcutaneous emphysema, pneumothorax, pleural effusion and pneumothorax. Torpid course by infectious problems.
Figure 17. Posttraumatic atelectasis by intrabronchial clot. Image A shows multiple rib fractures (arrow). Image B shows pleural effusion and left upper lobe atelectasis.
TRAUMATIC MEDIASTINAL LESIONS

- Pneumomediastinum
- Traumatic aortic injury
- Cardiac trauma
- Esophageal rupture
- Tracheobronchial rupture
More common lesion in blunt trauma

Etiology: Alveolar or esophageal rupture, tracheobronchial rupture

Radiological findings

- Linear radiolucent images extending from the hilum to the neck
- Parietal pleura visibility in the left mediastinal border
- Good definition of the descending aorta and aortopulmonary window
- Good definition of left hemidiaphragm

Fig. 18: Pneumomediastinum (arrows)
Figure 19: In image A, is identified subcutaneous emphysema (thick arrow) adjacent to rib fracture in the right hemithorax. In image B, we can see extensive subcutaneous emphysema and pneumomediastinum (thin arrow) 48 hours after the initial radiography.
Figure 20: Pneumomediastinum in CT. Gas surrounding the great vessels and heart (arrows). It also identifies extensive subcutaneous emphysema and parenchymal laceration and contusions.
PNEUMOMEDIASTINUM

Figure 21: Motorcycle accident in CT.
Subcutaneous emphysema
Hidroneumothorax ★
Pneumomediastinum
Parenchymal contusions ▶
TRAUMATIC AORTIC INJURY

- Accounts for 12% of mediastinal bleeding
- Instantaneous mortality of 80-90%
- Patients who survive may develop pseudoaneurysms
- Most frequent in the aortic isthmus
- Etiology: Injury by bladed weapons or guns / deceleration
TRAUMATIC AORTIC INJURY

Radiological findings

- Widened mediastinum > 8 cm.
- Deviation of the trachea on the right
- Loss of aortic knob definition
- Obliteration of aortopulmonary window
- Line right paratracheal thickening > 5 mm.
- Line loss of the descending aorta
- Left apical thickening

Figure 22: Chest radiography with mediastinal widening (arrows). Tracheal deviation to the right. Loss of aortic knob definition and occupation of aortopulmonary window by aortic rupture.
TRAUMATIC AORTIC INJURY

Chest CT Findings

- Periaortic and mediastinal hematoma
- Extravasation of contrast
- Aortic morphologic changes
- Pseudoaneurysm: saccular diverticulum or increase in aortic diameter

Figure 23: Thoracic CT with intravenous contrast. Mediastinal hematoma (arrow), hemothorax (star), with aortic arch laceration collapsed by hypovolemia (thick arrows)
Figure 24: Chest radiography and CT. Male 40 years old. Previous history traffic accident 4 months earlier. Pseudoaneurysm in the aortic isthmus.
CARDIAC INJURIES

- Appears in penetrating and nonpenetrating trauma
- In association with rib and sternal fractures
- If pericardium is intact, the cardiac silhouette is normal or appears cardiomegaly
- If there is pericardial laceration, hemothorax exists
- Diagnosis of choice: echocardiogram

Figure 25: Chest CT. Pericardial thickening sheets of high density (arrow) diagnosis of hemopericardium. Hematic pleural effusion (star)
ESOPHAGEAL RUPTURE

- Serious cause of pneumomediastinum
- Etiology: penetrating trauma, cervical trauma by hyperextension
- Important complications: acute mediastinitis, hemo-pneumothorax
- Diagnosis: Soluble contrast CT, esophagoscopy, oral contrast esophagogram

Figure 26: Chest X-ray and esophagogram. Pneumomediastinum and subcutaneous emphysema (blue arrows) in image A. Esophageal rupture (black arrow) and extravasation of contrast material (asterisks) in image B.
Figure 27: Thoracic CT in post-traumatic esophageal rupture. Identify multiple gas bubbles in relation to pneumomediastinum (yellow arrow), pleural effusion (star) and mediastinal collection (blue arrow) 48 hours after the accident.
DIAPHRAGMATIC RUPTURE

Diagnostic techniques

- Barium Studies: EGD / barium enema
- Ultrasound: presence of supradiaphragmatic bowel loops, diaphragmatic disruption visualization
- CT / MR: herniation of solid viscera and omentum and show the diaphragmatic defect
- Findings on chest radiographs
  - Lobulation or elevation of the outline of a hemidiaphragm
  - Shade simulates arched high hemidiaphragm
  - Intrathoracic homogeneous density or air bubbles
  - Contralateral displacement of the heart / mediastinum
  - Abnormal course of nasogastric tubes in the chest
Figure 28: Diaphragmatic rupture on chest radiographs. Image A shows the presence of intrathoracic bowel loops (arrow) without identifying diaphragm. In image B, anomalous course of a nasogastric tube with distal end in the left hemithorax (arrow).
Figure 29: Chest radiography and CT with rupture of left hemidiaphragm. Absence of diaphragmatic contour. Stomach and colon in thoracic location.
Figure 30: Chest radiography and CT with rupture of left hemidiaphragm. Absence of diaphragmatic contour and nasogastric tube in thoracic location (arrows)
CONCLUSIONS

- Hemodynamic stabilization and accurate physical examination are priority before starting the diagnostic imaging tests.
- Chest radiography remains the initial diagnostic technique in mild trauma and stable patients.
- It is imperative to use CT if serious injuries are suspected and to rule out associated lesions in high-energy trauma.
REFERENCES


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