Learning objectives

To describe the most frequent patterns of injury in thoracic trauma and to show the imaging appearance of these lesions.

Background

In traumatic patients, thoracic injuries are in 4th place of frequency after cranio-encephalic injuries, abdominal and pelvic injuries, and lesions in the extremities.

Thoracic trauma is an important cause of death, especially in young adults. It occurs in 20% of people who suffer trauma. Mortality rate is approximately 20%, and it reaches 77% when it is associated to shock and brain trauma.

In developed countries more than two thirds of cases are caused by car accidents, and the remaining are the result of falls or blows from objects.

Imaging plays a prevalent role in the diagnosis of these lesions, since many of the entities exposed below, may have little, if any, initial clinical manifestations.

Imaging findings OR Procedure details

Even though it is not very sensitive, conventional radiography is usually the first exam.
Computed Tomography (CT) shows that 85% of the lesions are omitted by plain films, becoming crucial in the demonstration of pneumomediastinum, mediastinal hemorrhage, aortic injury, pulmonary contusion and tracheobronchial injury, among others.

Otherwise, CT of the thorax is included in the diagnostic routine in polytraumatized patients, together with the examination of the brain and the abdomen. Magnetic resonance imaging (MRI) is useful to identify diaphragm injuries.

In this exhibit we show the spectrum of traumatic injuries of thoracic wall, pleural space, lungs and mediastinum.

**WALL CHEST TRAUMA**

**Subcutaneous Emphysema**

Plain chest radiography reveals the air in the subcutaneous tissue as radiolucent bands and striations, for example between the bundles of the pectoralis major. Air can spread through the fascial planes to the rest of the chest wall, abdomen, or even into the head, neck and extremities. In severe cases it can cause tracheal compression and severe dyspnea [1]. For this reason, CT is preferable as it shows better the pneumothorax or lung injury, and so we can establish guidelines to continue more rapidly (Fig. 1) on page 8.

**Rib Fractures**

They are the most common lesions, observed in 81% of patients.

When there is only one fractured rib, there are no greater risks. However, when the fractures are multiple or bilateral, there is more severity, increasing morbidity and mortality, because they may indicate a coexistent abdominal or thoracic injury. Fractures of the upper costal arcs usually occur at severe trauma, as they are well protected by the scapula, clavicles and muscles.

Given the increased sensitivity of CT, it is also possible to determine the site and number of fractures, as well as other associated injuries [2] (Fig. 2) on page 9.

**Sternal Fractures**

They usually occur in severe trauma and involve the sternal body and manubrium, often associated to lung, cardiac and spinal injury.
Flail Chest

Flail chest is a traumatic condition in which there are three or more contiguous ribs with fractures in two or more places. When a "Flail Chest" presents (about 10% of cases), it indicates that there has been a severe trauma, and probably half of the patients will require surgical treatment [2].

Shoulder Fracture

Scapular fractures are relatively common, being necessary a significant force for its production. In a chest trauma, they are not easily visualized on the plain films, unless different projections of the scapula are made. CT, however, provides additional information on the extent of the fracture [2] (Fig. 3) on page 9.

DIAPHRAGM TRAUMA

Approximately 8% of patients with chest or abdominal trauma have a traumatic rupture of the diaphragm.

Plain radiographic findings suggest the diagnosis with high specificity when there are abdominal viscera into the chest, but there may be other signs, with less specificity.

CT not only detects small diaphragmatic discontinuities, but also identifies the involved viscera, with high sensitivity and a specificity close to 100%. (Fig. 4) on page 10.

An undiagnosed diaphragmatic injury has a mortality rate of approximately 30% as it is frequently associated with other thoracic and abdominal concomitant lesions.

MRI is the ideal method for visualization of the diaphragm. On T1WI it appears as a hypointense thin band of soft tissue surrounded by hyperintense mediastinal and abdominal fat, especially on the left side. It is difficult to see the right side, given the position and contour of the liver. In general, MRI is used in cases in which CT results are not completely clear [3].

INJURIES OF THE PLEURAL SPACE

Pneumothorax
Pneumothorax is a common traumatic condition that is seen in 48% of all patients with closed chest trauma, being the second most common injury. It may be caused by broken alveoli due to a sudden increase of intrathoracic pressure by a mechanism of chest deceleration (with or without rib fractures), by broken emphysematous bullae, by pulmonary laceration, by tracheobronchial injury or due to the "Macklin effect" [3].

The diagnosis of pneumothorax is usually done by plain chest radiographies. However, 10% to 50% of the cases are not displayed in the supine position, and can only be seen on CT, which is why they are known as "hidden pneumothorax" [4].

With the increased use of CT in trauma patients, pneumothorax is easily recognized. However, which patients should be treated with pleural drainage tube, really poses a clinical dilemma. Furthermore, when the air that accumulates in the pleural space reaches the point where intrapleural pressure exceeds that of the atmosphere, there is a "tension" pneumothorax. The mediastinal displacement, the difficult venous return to heart and the ipsilateral lung collapse can continue growing, turning into a medical emergency. Although the diagnosis is clinical, it may also be suggested by the images when the following signs are present in addition to the pneumothorax: 1) displacement of the mediastinum to the contralateral side, 2) flattening or inversion of the ipsilateral hemidiaphragm, and 3) expansion of the ipsilateral hemithorax.

The diagnosis of air in the pleural cavity is made by the visualization of the visceral pleura as a thin line with no parenchyma beyond.

**Hemothorax**

It is the presence of blood into the pleural space, which can come from multiple chest wounds (involving the lung, chest wall, heart or great vessels) or abdominal injuries (liver and splenic injuries with diaphragmatic rupture). It occurs in 29% of patients with chest trauma (Fig. 5) on page 11.

A massive hemothorax is defined when it exceeds one liter and is accompanied by clinical signs of shock and hypoperfusion.

CT easily characterizes the pleural fluid and determines the value of attenuation. Blood in the pleural space typically has an attenuation of 35-70 Hounsfield Units (HU). The density measurement of the pleural collection should be made routinely in the interpretation of chest CT after trauma, in order to differentiate simple fluid from acute blood [2].

**INJURIES OF THE LUNG**
Lesions in the lung parenchyma are seen in 14% of patients with chest trauma. Mortality varies from 14 to 40% depending on the extent and severity of it, and the presence of associated thoracic and no-thoracic injuries.

**Pulmonary contusions**
They represent the traumatic injury of the alveoli. It is a focal parenchymal injury in the alveolar epithelium, with interstitial edema and alveolar hemorrhage. They are produced at the time of injury, usually at the impact site, and they are seen in CT, rather than in plain chest films, appearing as a poorly defined area of consolidation, usually in the lung periphery, adjacent to the area of trauma [4] (Fig. 6) on page 12. Contusions are also frequent on the opposite side of the lung (contusion for backlash). The typical radiological appearance consists in opacities or consolidations with undefined margins, and a confluent aspect, which do not exhibit anatomical or bronchopulmonary distribution (non-segmental distribution). The air bronchogram sign is absent as a result of bronchial obstruction caused by secretions or blood.

**Lung laceration**
A pulmonary laceration occurs when there is a pulmonary break or tear, causing a cavity in the lung parenchyma. Because of the normal lung elastic recoil, the lung tissues surrounding a laceration tries to get away from it. This is seen on CT as a round or oval cavity, instead of having the linear appearance typically seen in other solid organs. The traumatic cavity can be filled with air (traumatic pneumatocele), blood (traumatic hematocoele or pulmonary hematoma), or both (traumatic hemopneumatocele). The acute lung laceration on CT is characterized by the presence of air collections located in an area of consolidation. When they are acute, lacerations are usually surrounded by contusions, and therefore, often not displayed on chest films. However, almost all acute lacerations can be detected with CT.

**Indirect-injury**
They are a consequence of the lesions view above, such as neurogenic pulmonary edema (where the heart is shown with conserved radiological features and no pleural effusion), adult respiratory distress (in which proteinaceous material is deposited in the pulmonary interstitium and alveoli, as well as diffuse infiltrates) (Fig. 7) on page 13, and fat embolism (which, although common, they rarely have clinical manifestations).

**MEDIASTINAL TRAUMA**

**Pneumomediastinum**
The air may enter into the mediastinum after a tracheobronchial or esophageal rupture, but mainly from alveolar rupture. As a result of alveolar rupture, air fills the interstitium and then reaches the hilum and mediastinum, dissection along the bronchovascular sheaths (Macklin effect).
The radiographic signs are represented by hiperlucent bands that delineate the parietal pleura and other mediastinal structures, often best seen on a lateral chest radiographs. Occasionally, normal anatomic structures (such as the major fissure, the anterior contact line, etc.) can simulate air within the mediastinum. Digital radiography or CT are the methods used to establish or confirm the diagnosis [5] (Fig. 8) on page 14.

**Tracheobronchial injury**

Tracheobronchial injuries are rare in clinical practice because most patients die when they are coming to the emergency center. Bronchial lacerations are more common than tracheal lacerations and they are typically located in the bronchial cartilage rings. Bronchial tear is an uncommon lesion, radiographically suggested when the lung fails to re-expansion after tube placement for pleural drainage.

When there is an entire rupture of a bronchus, the ipsilateral lung can be moved posterolaterally, separated from the hilum ("fallen lung sign"). The lung "falls" towards the lower region if the patient is standing and towards the posterior region when the patient lies supine.

Tracheal lacerations are usually vertical and longitudinal, being located at the cartilage - membranous junction. The findings are subcutaneous emphysema and pneumomediastinum (Fig. 9) on page 14. CT helps to identify the site of tracheal laceration in 70 to 100% of cases. If CT findings suggest a lesion in the tracheobronchial tree, bronchoscopy should be performed to obtain a definitive diagnosis, and to evaluate the site and extent of injury.

**Aortic Lesions**

A wound of the thoracic aorta is usually fatal. It occurs in 40% of deaths from automobile accidents, being the most lethal of all injuries of the chest.

The wounds of the thoracic aorta typically occur (in descending order of frequency): in binding sites, in the proximal aorta, aortic arch, aortic root and descending aorta at the diaphragmatic hiatus. A periaortic hematoma accompanies the wound, representing the bleeding of the vasa vasorum and small veins, seen in the chest plain films as mediastinal widening or blurring of the aortic contour (Fig. 10) on page 15. CT not only allows direct visualization of periaortic hematoma but also can show the true aortic injuries, including aortic pseudoaneurysm, or contour changes in aortic diameter, the intimal flap, thrombus and extravasation of contrast material. The exact characterization of the wound is crucial to determine the optimal treatment of aortic lesion [6].

**Esophageal Injury**

Blunt trauma of the esophagus is extremely rare, because it is well protected in the mediastinum. Most esophageal lesions occur in penetrating trauma. The CT findings that may suggest traumatic esophageal perforation are: pneumomediastinum, mediastinitis, hydropneumothorax, or the escape of oral contrast material in the mediastinal or pleural space [2].

**Heart Injury**
The diagnosis of cardiac injury in the context of chest trauma must always be suspected because, although it is frequent, the clinical manifestations are rare. However, patients with myocardial contusion, pericardial lacerations, valvular damage or small myocardial rupture or laceration, can survive to reach an emergency center. On plain films, after a cardiac trauma, we can find hemopericardium, extravasation of contrast material into the pericardial sac and mediastinum, pneumopericardium, cardiac displacement due to an hernia, and the presence of the intestinal gas in the chest due to a diaphragmatic laceration [2].

Although cardiac tamponade is diagnosed clinically, imaging studies play an important role in counseling and intervention. The associated CT findings include pericardial effusion, usually large, associated with dilation of the superior and inferior vena cava; reflux of contrast material into the azygos vein and inferior vena cava; deformation and compression of cardiac chambers and other intrapericardial structures; and bulging of the interventricular septum [7].

Images for this section:
Fig. 1: Subcutaneous emphysema.

Fig. 2: Right rib fracture.
Fig. 3: Right scapula fracture, associated to clavicular fracture and subcutaneous emphysema.
Fig. 4: Diaphragmatic injury on the left side, with abdominal viscus in thoracic space.
Fig. 5: Hemo and pneumothorax.
Fig. 6: Bilateral contusions.
Fig. 7: Adult respiratory distress.

Fig. 8: Pneumomediastinum.
Fig. 9: Tracheal injury associated with pneumomediastinum and subcutaneous emphysema.
Fig. 10: Aortic lesion with wide mediastinum.
Conclusion

The correct diagnose of traumatic thoracic injuries depends on the different clinic and radiologic manifestations. Both MR and especially CT provide a high accuracy in the diagnosis, associated to the capability to evaluate other organs.

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References


