CT Imaging of Thoracic Trauma: What the Radiologist Needs to Know

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Learning objectives

Learn the signs of chest CT trauma and its contribution in the initial assessment of the lesions and in monitoring. Know and be able to describe the different elementary lesions found during chest injuries.
Background

Chest traumas are a significant cause of mortality and morbidity. These injuries are the third most common cause of trauma following injury to the head and extremities (1), especially in the younger population. Diagnostic imaging plays a key role in their management. Portable chest radiography can show a tension pneumothorax, a large hemothorax, tube and line malpositioning, and other conditions that require immediate treatment. Multidetector computed tomography (MDCT) has been increasingly used for trauma; it is the most important imaging method in this field. Its advantages include especially high speed and high geometric resolution in any plane. Studies have shown that CT may demonstrate significant disease (eg, thoracic aortic injury, Heart, tracheal and esophagus Injuries) in patients with normal initial radiographs. CT is more accurate than radiography for the evaluation of pulmonary contusion; it's also valuable in the diagnosis of fractures of the thoracic spine, especially at the cervicothoracic junction.
Findings and procedure details

Injuries of the Pleural Space

Pneumothorax

Pneumothorax, an air collection in the pleural space, is a very common traumatic condition. Pneumothoraces may be caused by ruptured alveoli due to a sudden increase in intrathoracic pressure or to blunt crushing force or deceleration force to the chest, with or without rib fractures. The diagnosis of pneumothorax is usually made at chest radiography. However, 10%-50% of pneumothoraces from blunt trauma are not visualized at chest radiography performed in supine patients but can be seen at CT (2). Pneumothoraces seen only at CT are called "occult pneumothoraces" (Fig. 1 on page 9). When air collects in the pleural space to the point where the intrapleural pressure exceeds that of the atmosphere, a tension pneumothorax occurs. Mediastinal shift, compromised venous return to the heart, and collapse of the ipsilateral lung may follow. Tension pneumothorax is a clinical diagnosis; however, it may be suggested at imaging when the following signs are present in addition to the pneumothorax (Fig. 2 on page 9): (a) mediastinal shift to the contralateral side, (b) flattening or inversion of the ipsilateral hemidiaphragm, and (c) hyperexpanded ipsilateral chest.

Hemothorax

Hemothorax represents blood in the pleural space (Fig. 3 on page 10), which may originate from a variety of thoracic injuries (eg, involving the lung, chest wall, heart, or great vessels) or abdominal injuries (liver and splenic injuries with diaphragmatic rupture). Massive hemothorax is defined as a hemothorax exceeding 1 liter with clinical signs of shock and hypoperfusion (3). Blood in the pleural space typically has an attenuation of 35-70 HU. Measurement of pleural fluid attenuation should be routine in the interpretation of chest trauma CT to distinguish simple fluid from acute blood (4).

Pulmonary Contusion

Pulmonary contusion is the most common lung injury from blunt chest trauma, with a prevalence of 17%-70% (5). It represents traumatic injury to the alveoli with alveolar hemorrhage, but without significant alveolar disruption. Pulmonary contusion occurs at the time of injury, usually at the site of impact but may be seen in the opposite portion of the lung (contrecoup contusion). The typical imaging appearance consists of patchy airspace opacities or consolidations with ill-defined borders that are distributed irrespective of bronchopulmonary segmental anatomy (Fig. 4 on page 11). The timing of the development of pulmonary contusion is often helpful in determining the
cause of areas of pulmonary opacity in trauma patients. Focal areas of pulmonary opacity appearing 24 hours or more after injury suggest diagnoses other than contusion, including aspiration, pneumonia, and fat embolism (4).

**Pulmonary Laceration**

Pulmonary laceration occurs when there is a disruption (tear, laceration) of the lung parenchyma, resulting in a cavity in the lung. CT shows a round or oval cavity, instead of having the linear appearance typically seen in other solid organs. The traumatic cavity may be filled with air (Fig. 5 on page 11) (traumatic pneumatocele), blood (Fig. 6 on page 12) (traumatic hematocele or pulmonary hematoma), or both air and blood (traumatic hematopneumatocele). Pulmonary lacerations heal more slowly than contusion and may last up to several months. In the acute setting, lacerations are usually surrounded by contusion. They may be single or multiple and unilocular or multilocular in appearance.

**Traumatic Lung Herniation**

Traumatic lung herniation occurs when a pleuracovered part of the lung extrudes through a traumatic defect in the chest wall. This condition is usually associated with rib fractures. Because lung herniation may increase with positive-pressure ventilation, patients may require treatment before undergoing intubation and general anesthesia.

**Injuries of the Airways**

Tracheobronchial injuries are rare because most patients die before arriving at the emergency department, from either associated injuries to vital structures, hemorrhage, tension pneumothorax, or respiratory insufficiency from an airway injury. Airway trauma with deceleration injuries may result from compression of the airways between the sternum and thoracic spine, shearing at fixation points, or elevated intrathoracic pressure against a closed glottis.

**Bronchial Lacerations**

Bronchial lacerations are more common than tracheal lacerations. Common imaging manifestations of bronchial injuries are pneumomediastinum and pneumothorax. The presence of a persistent pneumothorax, even with chest tube placement and suction, should raise concern for possible bronchial injury(4).

**Tracheal Lacerations**
Common findings of tracheal lacerations are cervical subcutaneous emphysema figure and pneumomediastinum (Fig. 7 on page 13). CT may help identify the site of tracheal laceration in 70%-100% of cases (6). If CT findings suggest an injury to the tracheobronchial tree, definitive diagnosis with bronchoscopy should be attempted to confirm the diagnosis.

Injuries of the Esophagus

Blunt trauma to the esophagus is extremely rare; since this structure is well protected in the mediastinum. Blunt esophageal injuries may result from a blow to the neck or a burst-type force (7). A blow to the neck typically results in cervical esophageal injuries, whereas a burst-type force may cause distal esophageal injuries. CT findings may suggest the diagnosis of traumatic esophageal perforation are the presence of pneumomediastinum, mediastinitis, hydropneumothorax. Water-soluble contrast esophagography, may be required to evaluate the site of injury.

Injuries of the Heart

Cardiac injury is among the most lethal injuries in thoracic trauma patients. The diagnosis of blunt cardiac injury relies on a high degree of clinical suspicion. Imaging manifestations of blunt cardiac injury include hemopericardium, contrast material extravasation into the pericardial sac or mediastinum, pneumopericardium, displacement of the heart due to cardiac herniation, and abnormal bowel gas in the chest due to diaphragmatic pericardial tear (4).

Injuries of the Aorta and Great Vessels Thoracic Aortic Injury

Thoracic aortic injury is usually fatal. Between 85% and 90% of patients die before reaching the hospital, and approximately 50% of those who initially survive may die within 1 week without appropriate treatment (8). Rapid deceleration results in an intimal tear of the thoracic aorta. Thoracic aortic injuries typically occur at the sites of aortic attachments, including the proximal descending aorta, aortic arch, aortic root, and distal descending aorta at the aortic hiatus. A periaortic hematoma typically accompanies thoracic aortic injury and is believed to represent bleeding from small veins in the area or from the vasa vasorum of the aorta itself. CT not only allows direct visualization of periaortic hematoma but also can show the actual aortic injuries, including aortic pseudoaneurysm, changes in aortic contour or diameter, intimal flap and thrombus, and contrast material extravasation.

Injury to the Internal Mammary Artery
Injury to the internal mammary artery is another potential cause of active mediastinal hemorrhage. The active bleeding is suggested by contrast material extravasation, which typically has an attenuation value close to that of an adjacent artery (9).

**Injuries to the Aortic Arch Branches**

Injuries to the common carotid artery may cause neurologic deficit, including stroke. The presence of periarterial hematoma in the superior mediastinum or lower cervical region is an important indirect sign of possible brachiocephalic or subclavian artery injury.

**Injuries of the Diaphragm**

Blunt injuries to the diaphragm are caused by a sudden increase in intraabdominal or intrathoracic pressure against a fixed diaphragm. The right hemidiaphragm is less frequently injured than the left, which may be explained by the greater strength of the right hemidiaphragm and the protective effect of the liver (10). Visceral organ herniation may result in organ incarceration, strangulation, or perforation. The type of herniated contents depends on the size and location of the injury. Imaging manifestations of diaphragmatic injury depend on the side of injury (left or right hemidiaphragm), the presence of herniated abdominal viscera, and concomitant pleural or pulmonary injuries. Conventional radiographic findings may suggest the diagnosis of blunt diaphragmatic injuries with a high specificity when there is herniation of a hollow viscus into the thorax. Multidetector CT with coronal and sagittal reformation can show even a small diaphragmatic discontinuity and help identify any herniated viscera. Injuries to the diaphragm are commonly accompanied by hemothorax and hemoperitoneum. CT has an overall sensitivity in the diagnosis of blunt diaphragmatic rupture of 70%-100%, with a greater sensitivity for left sided injuries, and a specificity of 75%-100% (10).

**Injuries of the Chest Wall**

Blunt injuries of the chest wall are very common in clinical practice, resulting from motor vehicle collisions, falls, and blows from blunt objects.

**Rib Fracture**

The most common skeletal injury in blunt chest trauma is rib fracture. Simple rib fractures are usually not significant in isolation and are rarely lives threatening. However, multiple or bilateral rib fractures may increase morbidity and mortality (Fig. 8 on page 14). Fractures of the first through third ribs are considered to be high-energy trauma because these ribs are well protected by the scapulae, clavicles, and musculature. These fractures may be associated with brachial plexus injury or subclavian vascular injuries. Chest radiography is routinely used to assist in the diagnosis of rib fractures. CT is the most sensitive technique for imaging rib fractures, since it can help determine the site and
Flail Chest

Flail chest is a traumatic condition in which there are three or more contiguous ribs with fractures in two or more places. These fractures create a flail segment that can move paradoxically relative to the remainder of the chest during respiration in a spontaneously ventilating patient.

Fractures of the Scapula

Significant force may be required to fracture a scapula, whether a direct blow to the scapula or an indirect axial force transmitted through the humerus. They are associated with other injuries including pneumothorax, hemothorax, pulmonary injuries, and spinal injuries. CT with multiplanar and volumetric reformation can provide additional information regarding intraarticular extension of the fractures. The majority of scapular fractures are treated conservatively, with nonunion occurring only rarely.

Sternal Fractures

Sternal fractures may result from deceleration injuries or direct blows to the anterior chest wall. Fractures commonly involve the sternal body and the manubrium. However, displaced sterna fractures and those with associated manubriosternal joint disruption frequently occur with thoracic, cardiac, and spinal injuries. Sternal fractures are best demonstrated at CT on multiplanar reformatted images, especially sagittal images.

Sternoclavicular Dislocations

Sternoclavicular dislocations may be either anterior or posterior. Posterior dislocations are more serious, since they may cause injuries to the mediastinal blood vessel
Fig. 1: Occult pneumothorax. CT scan helps confirm right pneumothorax; this air collection in the pleural space is not shows at Chest radiography. CT scan shows also subcutaneous emphysema.

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Fig. 2: Tension pneumothorax. CT scan shows the left pneumothorax with rightward displacement of the heart.

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Fig. 3: Bilateral hemothorax. Axial CT shows blood in the pleural space; the attenuation value is 60 UH. Note bilateral pneumothorax in the typical anterior location.

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Fig. 4: Pulmonary contusion. Axial CT images show non segmental patchy airspace opacities in the right lung with ill-defined borders associated with bilateral hemothorax

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**Fig. 5:** Pulmonary laceration. CT scan reveals oval cavity filled with air in the central portion of the right upper lobe.

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Fig. 6: Pulmonary laceration. CT scan reveals pulmonary laceration filled with blood in the right lower lobe; note bilateral pulmonary contusion

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Fig. 7: Tracheal laceration. Axial CT scan shows cervical subcutaneous emphysema

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Fig. 8: Rib fractures. CT scan shows a displaced right posterior rib fracture with a subpleural hematoma

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Conclusion

An accurate assessment of the lesions especially with multidetector scanner improve prognosis. Multidetector CT can quickly help diagnose a variety of thoracic injuries in trauma patients. These injuries can be clearly displayed with multiplanar and volumetric reformation.
References


