Imaging of Non-Cardiac, Non-Traumatic Causes of Acute Chest Pain

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Learning objectives

Non-traumatic chest pain is a common symptom in patients who present in the emergency department. From a clinical point of view, it is important to differentiate cardiac chest pain from non-cardiac chest pain (NCCP). Among the plethora of potential causes of NCCP, life-threatening diseases, such as aortic dissection, pulmonary embolism, tension pneumothorax, and esophageal rupture, must be differentiated from non-life threatening causes. The presentation of pain plays an important role in narrowing the differential diagnosis and initiating further diagnostic management and treatment.

Background

Non-traumatic chest pain is a common symptom in patients who present to the emergency department. Approximately 5% of all patients who seek medical attention in emergency departments present with sustained or recurring chest pain. In most cases, the onset of chest pain is acute, which is defined as pain with an onset of less than 24 hours prior to presentation. Typical locations described by the patient are in the anterior thorax between the sternum and the mid-axillary lines, or posteriorly, in the back, from the base of the skull to the lumbar region.

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Imaging findings OR Procedure details

Visceral chest pain

Acute Aortic Syndrome

The term acute aortic syndrome (AAS) encompasses four entities, the aortic dissection, the intramural hematoma, the penetrating atherosclerotic ulcer, and the unstable aortic aneurysm, all of which present with chest pain (Figure 1). The aortic dissection has the highest prevalence and highest mortality. Two very well known classification systems describe the aortic dissection based on anatomical locations, the De Bakey classification and, the more commonly used Stanford classification. A Stanford A dissection involves
the ascending aorta and a Stanford B dissection the descending part of the aorta, distal to the left subclavian artery. A 14-day period after the onset has been designated the acute phase, because morbidity and mortality are highest. Clinical symptoms of aortic dissection are highly nonspecific. In a cohort of 464 patients, 84.8% of patients had an acute onset, 72.7% with chest pain, whereas anterior chest pain was typical for patients with a type A dissection and posterior chest pain was found for patients with a type B dissection. Chest X ray to exclude an aortic dissection is highly nonspecific, as only 37% of the patients show a widening of the upper mediastinum. Multidetector CT (MDCT) plays a major role in the diagnosis of aortic dissection. MDCT scanners enable the entire chest and abdomen to be scanned within seconds, and help to distinguish the extent of the dissection, the entry and reentry, and can differentiate real and false lumen. Furthermore, the involvement of large branches can be excluded. Similar to classic aortic dissection, intramural hematoma is thought to be caused by an entry tear and is often associated with an aortic dissection. The treatment is essentially the same as for a classic aortic dissection. The penetrating atherosclerotic ulcer can typically be found in a highly atherosclerotic aorta in the middle or the lower part of the descending aorta. Thoracic aortic aneurysm, usually asymptomatic, may cause thoracic pain, by compression of thoracic structures.

**Gastroesophageal reflux disease and esophagitis**

Gastro-esophageal reflux disease (GERD) is the most common cause of NCCP, accounting for almost 60% of all cases. Clinically, GERD is characterized by heartburn symptoms that occur at least weekly. Notably, mucosal injury associated with GERD is found in only about 25% of patients who present with NCCP. The diagnosis of GERD relies on 24-h esophageal pH monitoring. Imaging plays no major role in the diagnosis of GERD. However, barium swallow studies are indicated, to exclude hiatal hernias. Persistent GERD may lead to esophagitis as an inflammatory reaction of the mucosa to the acidic secretions of the stomach. Esophagitis may also be caused by a prolonged contact of the mucosa of the esophagus with ingested medications. The diagnosis of esophagitis is mainly based on endoscopy. Barium swallow tests may be performed to demonstrate ulcerations or strictures. CT scans may demonstrate a diffuse esophageal thickening or a pronounced mucosal enhancement.

**Esophageal rupture**

Esophageal rupture (Figure 2) is a life-threatening condition, which may occur in a number of circumstances. Currently, the most frequent cause of esophageal rupture is iatrogenic, occurring primarily during endoscopic interventions, such as stricture dilatation or stent placement. Foreign-body ingestion may also lead to esophageal rupture. Spontaneous esophageal rupture, the so-called Boerhaave syndrome, results after incomplete relaxation during vomiting, leading to an abnormally increased intraluminal pressure of the esophagus. In most cases, the left posterolateral wall of the
esophagus ruptures, which results in a pneumomediastinum and left pleural effusion, which can be depicted on chest radiographs. In about 10% of the cases, however, chest radiographs remain inconclusive. In case of suspected esophageal rupture, an esophagram, using water-soluble contrast, should be performed to determine the exact location and extent of the tear. Additional CT scans may demonstrate periesophageal fluid retentions, pneumomediastinum, esophageal thickening, or pleural effusions.

**Esophageal motility disorders**

Esophageal motility disorders are characterized by uncoordinated contractions of the smooth muscles of the esophagus. The most common esophageal motility disorder that may cause NCCP is a hypotensive lower esophageal sphincter and the nutcracker esophagus. A hypertensive lower esophagus and nonspecific esophageal motility disorders are relatively uncommon causes of NCCP. The diagnosis of esophageal motility disorders is established by esophageal manometry. Barium swallow test are performed to differentiate achalasia from diffuse esophageal spasms.

**Pleural chest pain**

**Pulmonary Embolism**

One of the main causes of acute chest pain is pulmonary embolism (PE). As chest pain has been described to be a very nonspecific symptom for pulmonary embolism, several explicit clinical prediction rules have been developed in the past few years, such as the Wells score and the Geneva score. These scoring systems help to separate three categories of patients, a low, an intermediate, and a high probability category, where the proportion of patients with PE is around 10%, 30%, and 65%, respectively. In daily routine, the plasma D-Dimer, a degradation product of cross-linked fibrin, plays a central role in the exclusion of PE. In cases where there is a high clinical probability of PE and a positive D-Dimer, further diagnostic imaging is performed. The technetium-based ventilation perfusion scintigraphy (V/Q test) can help to exclude a PE, as follow-up studies show a low event rate for negative V/Q scans. However, a high fraction of inconclusive V/Q tests has been found for patients with an intermediate likelihood of PE. In these patients, a spiral scan of the chest has been used for further work-up. Both, single-detector CT (SDCT) and MDCT have been used for the diagnosis of PE and have an excellent sensitivity of 83% and a specificity of 96%, as described in the Prospective Investigation of Pulmonary Embolism Diagnosis (PIOPED) II study. Furthermore, a high negative predictive value has been reported in several studies, which describe a three-month event rate of only 1.3% in 1,436 patients with a negative CT scan. In addition, when adding a post contrast CT venography of the upper part of the lower limb to a CT angiography of the thorax, the sensitivity of the detection of pulmonary embolism can be increased from 83% to 90%.
Pneumothorax

Pneumothorax is defined by the presence of air between the visceral and parietal pleura that leads to lung collapse and may be life-threatening (Figure 3). The most common sign of pneumothorax is acute chest pain that is well-localized and unilateral. In most cases, the pain associated with pneumothorax starts during rest and subsides within 24 hours, even if the pneumothorax persists. The primary form typically occurs spontaneously in young healthy patients between 10 and 30 years of age, especially in asthenic patients and in men rather than women. About 80% of the patients are smokers, and there is a recurrence rate from 16-33% within one year, depending on the management strategy. Secondarily, spontaneous pneumothorax can also occur in patients with underlying airway disease, infectious disease, interstitial lung disease, connective tissue disease, or neoplasm. The major radiographic finding is a thin line parallel to the chest wall with no lung structure beyond and attenuated margins of the mediastinum and cardiac border. In case of doubt, chest X rays during expiration, computed tomography, and ultrasound may be utilized to increase the sensitivity for pneumothoraces. In patients with traumatic pneumothorax, additional rib, clavicle, and vertebral body fractures are frequently depicted. The major life-threatening complication of pneumothorax is tension-pneumothorax that can lead to cardiac decompensation. Radiological findings include a shift of the mediastinum to the contralateral side and a hyperexpansion of the ribs. Management of pneumothorax depends on the pathophysiology, the size of the pneumothorax, and the patient’s condition.

Pleurisy and Pleural effusion

Another pleural pathology that goes along with chest pain is pleurisy (syn. Pleuritis). Pleurisy is an inflammatory process of the pleura caused by either infectious microorganisms or by another inflammatory mechanism. Pain associated with pleurisy is usually characterized as sharp, well-localized, and reproducible during movement, coughing, or breathing. Sometimes, patients feel the pain caused by pleurisy in the ipsilateral shoulder due to an irritation of the central portion of the diaphragmatic parietal pleura. The diagnosis is usually made clinically. Pleurisy may be present with or without pleural effusion, which can be considered as an indirect sign of pleurisy when narrowing the differential diagnosis. Besides a pleural effusion associated with pleurisy, a pleural effusion associated with trauma or infection may also manifest with chest pain. Infectious pleural effusions are commonly associated with pneumonia and are usually exudative, and are defined as a parapneumonic effusion. Parapneumonic effusion can be classified into three stages. The first stage is pleuritis sicca, caused by an underlying lung inflammation that provokes pleural rub, and may lead to chest pain. The exudative stage is characterized by exudative effusions, with pleural thickening in 50% of cases, and the "split-pleura sign". The fibropurulent stage, also called empyema (Figure 4), is caused by pus in the pleural space as a consequence of an infected pleural effusion. CT findings include an elliptical shape in a nondependent location, sharp demarcation from the lung, the split-pleura sign, and contrast enhancement of the thickened pleura. Contrast-
enhanced CT examinations allow the visualization and separation of intraparenchymal lung pathologies from those pathologies that arise from the pleura. Lung abscess, in particular, must be considered when narrowing the differential diagnosis that can lead to chest pain. Complications that may occur are bronchopleural fistula and empyema necessitatis (in 70% associated with tuberculosis). In the chronic stage, depending on the fibroblast growth rate, pleural fibrosis, and the development of a so-called "pleural peel" with extensive calcifications and consecutive volume reduction of the affected hemithorax, can be depicted.

**Pleural tumors, Pancoast tumor, bronchogenic carcinoma**

All tumors involving the parietal pleural may cause chest pain, which is often not well-localized and is referred to the shoulder or the back. The severity of pain associated with pleural tumors may vary from discomfort to stabbing pain, which commonly occurs 2-3 months before the diagnosis is made. The most common pleural tumors are pleural metastases, primarily caused by adenocarcinomas. Primary pleural tumors are rather rare and include mesothelioma, fibrous pleural tumors, pleural lymphoma, synovial sarcomas, and leiomyosarcomas. Peripheral intrapulmonary tumors that directly infiltrate the pleura and Pancoast tumors may also lead to chest pain. On contrast-enhanced CT, the appearance of a tumor helps to narrow the differential diagnosis. In addition to CT, PET, integrated PET-CT and MRI play an increasing role in the diagnosis of malignant pleural tumors and pulmonary tumors that invade the chest wall.

**Chest wall pain**

Diseases of the musculoskeletal system are responsible for up to 15% of cases of non-traumatic acute chest pain in adults. Musculoskeletal chest pain is usually a localized pain that worsens upon movement. A number of degenerative, inflammatory, or neoplastic processes may cause non-traumatic chest wall pain. The most frequent cause of non-traumatic musculoskeletal chest pain is reported to be costochondritis, which is defined as pain in the costochondral region without swelling and inflammation. About 42% of all causes of non-traumatic musculoskeletal chest pain are reported to be caused by chostochondritis. The diagnosis of chostochondritis is mainly based on physical examination, and imaging is only indicated in doubtful cases.

**Inflammatory processes**

Inflammatory causes of non-traumatic chest wall pain include chest wall abscesses, sternoclavicular septic arthritis, osteomyelitis, spondylodiscitis, and rheumatic diseases. Imaging in patients with a suspected inflammatory process of the chest wall depends on the clinical suspicions. In many cases, directed sonography at the region of the pain and/or swelling is frequently helpful in establishing an early diagnosis or in narrowing the
differential diagnosis and guiding further imaging studies. Particularly in more extensive inflammatory processes, tailored MRI examinations are necessary to delineate the extent of disease and bone involvement.

**Chest wall tumors**

Primary chest wall tumors make up less than 2% of all tumors and include tumors originating from the soft tissue, the bones, and the lymphatic system. The distribution of benign and malignant chest wall tumors is almost equal. Localized chest pain and swelling are the most frequent presenting symptoms, with pain occurring in almost 50% of benign tumors and almost 80% of malignant tumors. As painful benign and malignant chest wall lesions overlap in their imaging appearance, they should be considered malignant until proven otherwise. The first imaging modality to evaluate primary chest wall tumors is usually CT, which depicts the extent of the lesion, as well as calcifications and bone destruction. MRI is helpful for investigating the extent of soft tissue involvement and infiltration of the bone marrow (Figure 5).

**Chest pain in psychogenic disorders**

Chest pain that cannot be explained cardiologically should be considered to be psychogenic, especially in younger patients and females with no history of cardiac disease. Panic, depressive, obsessive, and anxious disorders are common causes of non-cardiac chest pain.

**Images for this section:**
Fig. 1: Axial contrast enhanced CT scan shows an intimal flap in the ascending aorta (Stanford type B aortic dissection) and a hemothorax on both sides.
**Fig. 2:** Axial contrast enhanced CT shows water based contrast medium within the pleural space. In addition, pneumomediastinum is apparent with irregular extraluminal gas collection along the lateral esophagus. The final diagnosis is a rupture of the esophagus.
Fig. 3: Chest radiograph shows a pneumothorax on the right side with a thin line parallel to the chest wall with no lung structure beyond (arrows).
Fig. 4: Axial contrast enhanced CT scan shows two pleural collections on the left side, with the so-called split-pleura sign, and diffusely enhancing parietal pleura due to the pleural space infection.
Fig. 5: Axial MRI sequence in a patient shows a mass in the dorsal paravertebral muscles on the left side with two components, a hyperintens myxoid like part and a hypointensity component similar to muscle. The diagnosis of a low grade fibromyxoid sarcoma was confirmed histologically.
Conclusion

Non-cardiac, non-traumatic chest pain is a common reason patients seek medical advice at emergency departments. Since recurrence is frequent, especially for the benign causes of NCCP and because of the immense costs of chest pain management, estimated at up to eight billion dollars per year, a meticulous evaluation of the patients is necessary to diagnose the underlying disorder or disease not only to alleviate the anxiety of these patients but also provide them with a better quality of life.

Personal Information

References


