INTRODUCTION
Thoracic emergencies are mainly diagnosed and differentiated through clinical history, physical examination, electrocardiography and laboratory investigations. For a substantial proportion of patients presenting to the emergency department (ED), a specific diagnosis remains elusive and imaging plays an important role in the assessment of patients with cardiac and noncardiac chest conditions. This article aims to discuss the role of radiography and computed tomography (CT) of the chest in evaluating noncardiovascular thoracic diseases encountered in the ED. It illustrates the spectrum of noncardiovascular thoracic emergency conditions and reviews specific imaging features of conditions that are commonly encountered. Although clinical presentations may vary, there are many similarities in presenting symptoms, signs and clinical history across different conditions. Based on the dominant clinical features, acute conditions can be divided into seven categories (Table I).

ROLE OF IMAGING
Chest pain
Chest pain is the most common, specific and principal reason for ED visits by adults.1 Cardiac causes are the most alarming, followed by pulmonary, musculoskeletal and oesophageal causes. Imaging does not play a major role in diagnosing musculoskeletal aetiologies. However, chest radiography and CT are useful for evaluating chest pains of pleuropulmonary origin, such as pneumothorax, pneumohaemothorax and pneumomediastinum.

Erect chest radiography is sufficient to demonstrate pneumothorax and pneumomediastinum. CT is performed to identify the underlying aetiology, so that proper treatment can be planned to prevent a recurrence. In patients with pneumothorax, CT can reveal underlying blebs, emphysema, cystic lung disease, infection or interstitial lung disease (Fig. 1). Primary spontaneous pneumothorax is seen in patients who are young, tall and thin; the cause is postulated to be the rupture of subpleural blebs.2 However, blebs are identified on imaging and during surgery in only a small proportion of these patients.3 Spontaneous haemopneumothorax, in which haemothorax and pneumothorax occur concurrently, is another rare entity observed in men aged 20–40 years (Fig. 2). Spontaneous haemothorax is a complication in 3%–7% of cases of spontaneous pneumothorax.4 The postulated mechanisms

Table I. Common clinical presentations and noncardiovascular diseases encountered in the emergency department that require radiological investigations.

<table>
<thead>
<tr>
<th>Category</th>
<th>Conditions</th>
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<tbody>
<tr>
<td>(1) Chest pain</td>
<td>• Pneumothorax • Pneumohaemothorax • Spontaneous pneumomediastinum • Oesophagitis</td>
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<tr>
<td>(2) Infection (fever, signs of sepsis)</td>
<td>• Pneumonia • Lung abscess • Septic pulmonary infarcts • Aspiration pneumonia</td>
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<tr>
<td>(3) Dyspnoea</td>
<td>• Tumour • Asthma and its complications • Acute interstitial pneumonitis • Acute exacerbation of interstitial lung disease • Inhalational injury • Acute exacerbation of chronic obstructive pulmonary disease</td>
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<td>(4) Hypovolaemic shock</td>
<td>• Bleeding vascular malformation</td>
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<td>(5) Haemoptysis</td>
<td>• Diffuse alveolar haemorrhage • Bronchiectasis • Tuberculosis • Lung cancer • Dieulafoy’s disease of the bronchus</td>
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<tr>
<td>(6) Haematemesis</td>
<td>• Boerhaave syndrome • Oesophagitis</td>
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<tr>
<td>(7) Foreign body</td>
<td>• Tracheoesophageal foreign bodies</td>
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for spontaneous haemopneumothorax are: (a) torn adhesion between the parietal and visceral pleura; (b) tear in a small noncontractile vessel on the parietal pleura; or (c) rupture of a vascularised bulla.\(^4\) Pneumomediastinum usually results from perforation of the oesophagus, tracheobronchial trees or lungs. When no sources of air in the mediastinum are identified on endoscopic studies, CT and barium examinations, a diagnosis of spontaneous pneumomediastinum is considered (Fig. 3).
The pathophysiology of spontaneous pneumomediastinum has been attributed to the Macklin effect. Macklin reported that mediastinal emphysema is secondary to tears in the alveolar sacs near the pulmonary ligament. The leaked air then dissects along the bronchovascular sheaths and tracks into the mediastinum.

Oesophageal inflammation and gastro-oesophageal reflux disease can lead to chest pain. A moderate-to-large hiatal hernia can be visualised on chest radiography, but it may or may not be the cause of the pain. Life-threatening cardiogenic pain needs to be excluded before the diagnosis of gastro-oesophageal reflux disease can be considered. Infrequently, severe oesophagitis (Fig. 4) can be diagnosed on CT.

**Infection**

Chest radiography remains the initial investigation of choice for all patients presenting with signs of pneumonia at the ED. Frontal radiography of the chest provides useful information about the extent and severity of the pneumonia and associated pleural effusions. Chest radiography followed by CT can help in identifying the source and aetiology of the pneumonia in a small fraction of patients. In patients with *Klebsiella* pneumonia, a classical bulging fissure sign (Fig. 5) has been described. Aspiration pneumonia may be suggested on CT and is typically found in the lower dependent lungs, along with a dilated oesophagus. The characteristic appearance of septic pulmonary emboli can also be identified on imaging. In a patient with clinical features of sepsis, multiple peripheral wedge-shaped consolidations, with or without cavitations, suggest the diagnosis of septic pulmonary emboli. CT can also identify other foci of infection (Fig. 6) and/or jugular vein thrombophlebitis, as well as filling defects in the left cardiac chambers. CT is also used to investigate transpleural hepatopulmonary abscesses (Fig. 7), which are almost always due to *Entamoeba histolytica* in endemic areas.

**Dyspnoea**

Most patients who present to the ED with dyspnoea as the predominant symptom have an underlying cardiac disease, but a significant proportion of them have an underlying pulmonary pathology. Chest radiography is a useful tool to differentiate between these two subsets of patients. Imaging also plays an important role in diagnosing the most common pulmonary causes of dyspnoea – acute lung collapse (Fig. 8) and acute exacerbation of chronic obstructive pulmonary disease, asthma and interstitial lung disease (ILD). Asthmatic patients mainly present to the ED with acute episodes of asthma. For these patients, the role of imaging is identifying complications such as pneumothorax, pneumomediastinum (Fig. 9), infective pneumonia, eosinophilic...
pneumonia, allergic bronchopulmonary mycosis and lobar collapse from mucus plugging.\(^\text{[10]}\)

Acute interstitial pneumonitis, a rare acute condition that affects an otherwise normal lung, is characterised by progressive dyspnoea and multifocal pulmonary opacities.\(^\text{[11]}\) Diffuse alveolar damage is the histological hallmark of this condition.\(^\text{[12]}\) Acute interstitial pneumonitis worsens rapidly and has a mortality rate of more than 50%.\(^\text{[12]}\) Radiological findings are similar to acute respiratory distress syndrome and vary according to the phase of the disease.\(^\text{[12]}\) CT is considered the gold standard in characterising ILD. The presence of new ground-glass opacities in a background of honeycombing suggests an acute exacerbation of ILD or superimposed infection.\(^\text{[14]}\) The mortality rate is more than 80% within one month of acute exacerbation.\(^\text{[14]}\)

**Hypovolaemic shock**

Pleuropulmonary bleeding can be life-threatening, leading to hypovolaemic shock. In patients with haemoptysis, haemothorax can remain clinically undiagnosed or underestimated even when pulmonary sources of bleeding are suspected. Causes of nontraumatic haemothorax include spontaneous pneumothorax, coagulopathy, malignancy and, rarely, pulmonary arteriovenous malformation (PAVM). Imaging, particularly CT, can demonstrate the presence of blood in the pleural cavity, which appears as high-density fluid. Contrast-enhanced CT can identify the source of bleeding (Fig. 10) in cases of ruptured PAVM.\(^\text{[13]}\)

**Haemoptysis**

Life-threatening haemoptysis in patients presenting to the ED could be due to malignancy, bronchiectasis, tuberculosis or...
Spontaneous haemothorax from an actively bleeding pulmonary arteriovenous malformation in a 26-year-old woman presenting to the emergency department with hypovolaemic shock, which was preceded by an episode of sharp right-sided chest pain. (a) Frontal chest radiograph shows a large amount of right-sided pleural fluid. (b) Axial CT image shows high-density dependent fluid (black arrow) and low-density nondependent fluid (white arrow) with an enhancing tortuous vascular malformation (arrowhead).

Massive haemoptysis in a 54-year-old man. (a) Frontal chest radiograph on presentation to the emergency department shows right upper lung consolidation and a thick-walled cavity in the left upper lung (black arrow). (b) Frontal chest radiograph taken two hours later shows increased fluid level in the cavity (black arrow). (c) Axial CT image shows a small enhancing Rasmussen’s aneurysm (white arrow) in the wall of the cavity. The fluid in the cavity is hyperdense, which suggests blood.

Haemoptysis in a 51-year-old woman with pulmonary tuberculosis. (a) Frontal chest radiograph shows consolidation in both lungs. Angiograms of (b) the right bronchial artery (arrow) shows tortuous hypertrophied vessels in the right upper zone and (c) the left bronchial artery injection (arrow) also shows multiple tortuous hypertrophied branches that were embolised using polyvinyl alcohol particles.

pulmonary haemorrhage syndrome. The parenchymal changes associated with most of these cases can be identified on chest radiography. CT can identify lesions that are invisible on radiographs and provide more details about underlying pathology, such as demonstrating hypertrophied bronchial arteries, pseudoaneurysms and PAVMs. CT can also provide a road map for bronchoscopy or radiological intervention.\(^{16,17}\) In a majority of cases (90%), bronchial arteries are the source of bleeding, while in a small number of cases (10%), the culprit vessel originates from pulmonary circulation. Rare entities like Rasmussen’s aneurysm, a mycotic aneurysm of the pulmonary artery (Fig. 11), can also be identified on CT.\(^{18}\) Transcatheter angiography and embolisation can be performed, if indicated (Fig. 12). The presence of a dilated, tortuous bronchial artery around the bronchus should be carefully evaluated in the absence of any pulmonary changes on CT. It may be the only clue indicating Dieulafoy’s disease of the bronchus, which is a rare vascular anomaly characterised by dilated vessels in the bronchial submucosa.\(^{19}\)

Diffuse pulmonary haemorrhage or diffuse alveolar haemorrhage (DAH) can present with life-threatening haemoptysis.
DAH is also associated with pulmonary infiltrates, dyspnoea and chronic anaemia. Its diagnosis is supported by the finding of haemorrhagic fluid in bronchoalveolar lavage. DAH is a clinical syndrome and includes a number of conditions, which are broadly divided into two categories: DAH with and without vasculitis. In clinical practice, the three most common causes of DAH are vasculitis, collagen vascular diseases and drugs (Fig. 13).

**Haematemesis**

Haematemesis is the result of acute upper gastrointestinal bleeding, commonly due to peptic ulcer disease, varices and oesophagitis. The role of imaging is limited and endoscopy remains the investigation of choice. Boerhaave syndrome is a rare but historically and clinically important condition that causes haemoptysis and can be suspected on imaging. In Boerhaave syndrome, a tear occurs in the posterior wall of the lower oesophagus, usually in the left wall. Classically, the patient has a history of overindulgence in food and drink, with violent vomiting and associated haemoptysis. Delayed diagnosis results in subcutaneous emphysema, chest pain and cardiovascular collapse. Chest radiography typically shows large pleural effusions, pneumomediastinum, pneumothorax and chest wall emphysema (Fig. 14). CT can demonstrate intramural haematoma in the oesophageal wall and perioesophageal air. Oesophagography may show leakage of contrast and oesophagopleural fistula.

**Foreign body aspiration**

A foreign body lodged in the tracheobronchial tree can be life-threatening due to airway obstruction (Fig. 15), while a foreign body ingested into the oesophagus (Fig. 16) can lead to serious complications such as haematemesis, oesophageal perforation and mediastinitis. Imaging is useful to localise radio-opaque foreign bodies and evaluate any associated complications.

**CONCLUSION**

Chest radiography and CT are useful tools for examining patients with emergency chest conditions. Normal chest radiography helps to rule out noncardiovascular emergencies. Abnormal or equivocal radiography findings can be due to various pathologies affecting the thoracic structures. Noncardiovascular acute conditions are less common and require a high index of suspicion on the part of the radiologist. Early diagnosis prevents a delay in definitive management in an often overcrowded ED.
REFERENCES

SINGAPORE MEDICAL COUNCIL CATEGORY 3B CME PROGRAMME
(Code SMJ 201511B)

Question 1. The Macklin effect explains:
(a) Spontaneous pneumothorax.
(b) Spontaneous pneumomediastinum.
(c) Spontaneous haemopneumothorax.
(d) Boerhaave syndrome.

Question 2. The mechanisms postulated for spontaneous haemopneumothorax are:
(a) Torn adhesion between the parietal and visceral pleura.
(b) Tear in a small noncontractile vessel on the parietal pleura.
(c) Rupture of a vascularised bulla.
(d) Dissection in the intercostal artery.

Question 3. Are the following statements true or false?
(a) The pulmonary artery is the usual source of bleeding in cases of haemoptysis.
(b) Rasmussen’s aneurysm is a type of mycotic aneurysm.
(c) Diffuse alveolar haemorrhage can be seen in collagen vascular disease.
(d) Chest radiography can show parenchymal changes that account for haemoptysis.

Question 4. The bulging fissure sign is present in:
(a) Bronchogenic carcinoma.
(b) Boerhaave syndrome.
(c) Klebsiella pneumonia.
(d) Pulmonary arteriovenous malformation.

Question 5. The following complication(s) can be seen in asthmatic patients:
(a) Pneumothorax.
(b) Lobar collapse.
(c) Allergic bronchopulmonary mycosis.
(d) Eosinophilic pneumonia.

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