Pleural Diseases

Selen Bayraktaroglu and Chiara Andreoli

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Abstract

Pleurisy and Empyema

Pleural diseases are common and represent a significant contribution to the workload of emergency department.

Patients with pleural effusions may be asymptomatic; however, they generally present with symptoms such as pleuritic chest pain or dyspnea.

Imaging of Spontaneous Pneumothorax

Spontaneous pneumothorax is a relatively common cause of thoracic pain in young, thin, and tall males without preexistent lung diseases, although it is known that its occurrence is due to the rupture of underlying small subpleural bullae and blebs at the lung apices, found at thoracoscopy or detected on CT.

Signs and symptoms may be nonspecific, and often the clinical suspicion requests a diagnostic confirmation, primarily based on X-rays and, in complicated cases, on CT: in this chapter, the authors will review the radiological and CT signs of spontaneous pneumothorax and will discuss signs which can predict its recurrence and informations which strongly influence the management and the treatment choice.

S. Bayraktaroglu (✉)
Department of Radiology, Ege University Hospital, Izmir, Turkey
e-mail: selenb2000@gmail.com

C. Andreoli
Radiology, Emergency Department, La Sapienza University of Rome, Rome, Italy
e-mail: chiarandreoli@gmail.com

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1 Pleurisy and Empyema

Selen Bayraktaroglu

1.1 Introduction

Pleural diseases are common and represent a significant contribution to the workload of emergency department.

Patients with pleural effusions may be asymptomatic; however, they generally present with symptoms such as pleuritic chest pain or dyspnea.

1.2 Terminology and Clinical Issues

The pleura is composed of visceral and parietal layers. The lungs and interlobar fissures are covered by the visceral pleura. The parietal pleura lines the mediastinum, ribs, and diaphragm. These two layers of pleura are continuous with one another. The area between the two layers is the pleural space. Normally, there is a small amount of fluid within pleural cavity (Collins and Sten 2008; White et al. 2009). Pathological processes may lead to the development of pleural effusions by causing disequilibrium between the rates of pleural fluid formation, pleural permeability, and pleural fluid absorption (Sahn 2008). The pleural fluid can originate from the pleura or may be extrapleural in origin. Pleural effusions may also be seen in the setting of infectious and inflammatory diseases, malignancies, and cardiovascular and systemic diseases (Table 1).

Table 1 Causes of pleural effusion

1. Infectious diseases (bacterial and viral pleurisy, tuberculosis)
2. Collagen vascular diseases (lupus pleuritis, rheumatoid pleurisy)
3. Neoplasm (pleural metastases, mesothelioma, leukemia, Non-Hodgkin lymphoma)
4. Pulmonary embolism
5. Cardiovascular disease (congestive heart failure, constrictive pericarditis)
6. Uremic pleuritis
7. Hypoalbuminemia
8. Chylothorax
9. Drug-induced pleural disease
10. Hypothyroidism
11. Pancreatitis
12. Subdiaphragmatic abscess
13. Hepatic hydrothorax
14. Trauma

1.3 Imaging

The chest X-ray (*CXR*) remains the initial examination of choice in the investigation of pleural disease. *Ultrasound* (*US*) is an easily applicable, cheap, and radiation-free method and is most frequently used to assess pleural disease detected on CXR. It can be performed at bedside. In addition to confirmation of pleural effusion, it may be used to guide aspiration or chest-drain insertion (Evans and Gleeson 2004). *Computed tomography* (*CT*) is a method that not only detects pleural space but also gives information about the lung parenchyma, mediastinum, and chest wall. CT has ability to determine the presence of pleural fluid loculations and pleural thickening, and it is the best method to differentiate peripheral lung abscess from empyema (King and Thomson 2002; McLoud 1998). Pleural fluid collections and pleural thickening that remain undetermined after CT may undergo *magnetic resonance imaging* (MRI) (Falaschi et al. 1996).

Positron emission tomography (*PET*) or *positron emission tomography-computed tomography* (*PET-CT*) is used in the detection of pleural malignancy and in differentiation between benign and malignant pleural disease (Duysinx et al. 2004; Goldsmith and Kostakoglu 2000).

1.4 Pleural Effusion and Emphyema

The appearance of pleural effusion depends on the patient's position at the time of the radiologic examination. Pleural fluid tends to collect along dependent surfaces. In an upright person, fluid collects mainly in the lower pleural space, and accumulation of 200 mL or

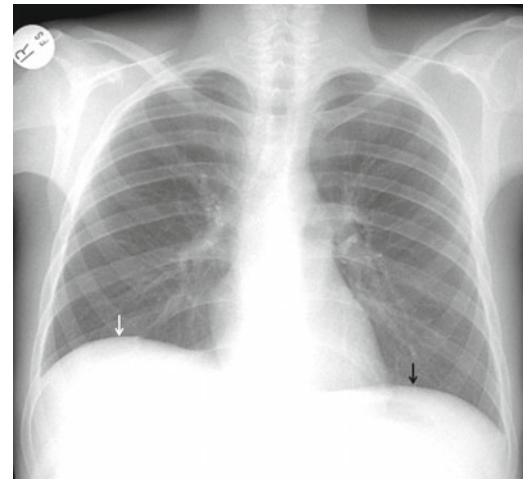


Fig. 1 Posteroanterior chest X-ray of a patient with right subpulmonic pleural effusion. Subpulmonic effusion can simulate elevated diaphragm. The peak of the elevated pseudo-diaphragm is more laterally located than normal (The *black arrow* demonstrates the peak point of left diaphragm, the *white arrow* shows the laterally located peak point of left pseudo-diaphragm)

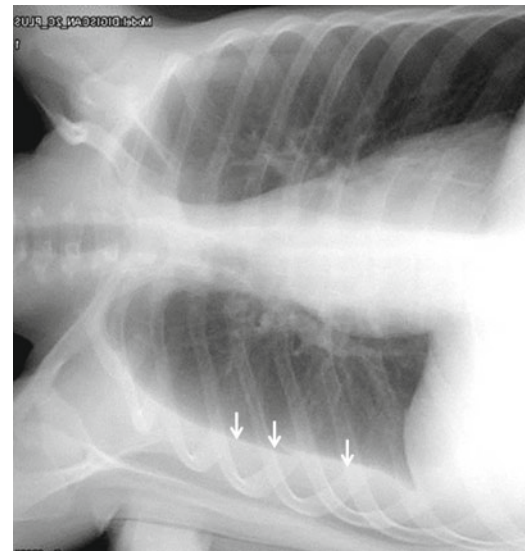


Fig. 2 Right lateral decubitis projection shows right pleural effusion by demonstrating the dependent layering of pleural fluid (*white arrows*)

more of fluid leads to blunting of the lateral costophrenic sulcus. However, it is important to note that the plain film can be normal with up to 500 mL fluid (Blackmore et al. 1996; Collins et al. 1972). As the amount of pleural fluid increases, the diaphragm appears flattened and a homogeneous lower zone opacity with a concave upward border develops. Occasionally, a large amount of pleural fluid may accumulate in the subpulmonic location and may be difficult to diagnose on erect CXR. In case of subpulmonic effusion, the upper edge of the fluid mimics the contour of the diaphragm on the chest radiograph creating an appearance similar to elevated diaphragm (pseudo-diaphragm). However, the peak of the elevated pseudo-diaphragm is more laterally located than normal (Müller 1993) (Figs. 1 and 2). The lateral decubitus view is sensitive in the detection of pleural fluid and can demonstrate as little as 5 mL of fluid. Large amounts of fluid can be missed on a supine radiograph. On a supine radiograph, as fluid accumulates on dependent surfaces, a general increased haziness over the lower pulmonary zones or a density over the apex of hemithorax develops (Fig. 3). Blunting of costophrenic angle may be seen (Müller 1993; Henschke et al. 1989).

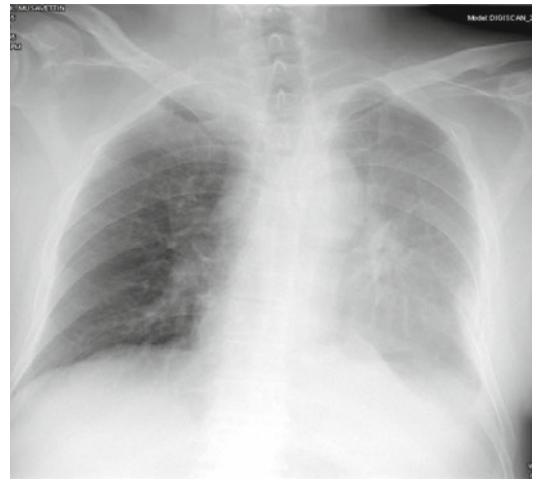


Fig. 3 Pleural effusion on left hemithorax on a supine radiograph. The pleural fluid accumulates on dependent surfaces leading to an increased haziness over the left pulmonary zones. There is blunting of left costophrenic angle

Loculated effusions can appear confusing on CXR and may be difficult to distinguish from a peripheral lung abscess. The loculated effusion is generally lenticular in shape and does not shift freely in the pleural space with changes in patient position. Incomplete layering may be detected on decubitis films (King and Thomson 2002). Infectious pleural effusions are most commonly associated with pneumonia and are defined as a parapneumonic effusion. Other mechanisms where the pleura may be contaminated by infecting organisms are the rupture of subpleural tuberculous foci or dissemination of infectious particles by the bloodstream. Intra-abdominal infections may reach the pleural space passing through the diaphragm. Penetrating injury to the chest wall or rupture of esophagus can also result in the introduction of organisms into the pleura (Rahman and Davies 2008).

Parapneumonic effusions can be separated into three stages.

1. Exudative stage
2. Fibropurulent stage
3. Organizing stage

In the *exudative stage* of parapneumonic effusion, pneumonic process causes inflammation of the visceral pleura and results in the accumulation pleural fluid. The pleural fluid in this stage is characterized by negative bacterial studies. Pleural thickening may be seen in 50 % of cases at this stage (Rahman and Davies 2008; Kienzl et al. 2012). The *fibropurulent stage* is caused by pus in the pleural space. The pleural fluid in this stage is infected and is characterized by positive bacterial studies. Progression to emphyema occurs in this stage. At this stage, the split pleura sign is seen on contrast material–enhanced CT images. There is enhancement of the thickened inner visceral and outer parietal pleura, with separation by a collection of pleural fluid (Fig. 4) (Rahman and Davies 2008; Kraus 2007). As the disease progress to *organizing stage*, fibroblasts grow into the pleural fluid from both the visceral and parietal pleura leading to pleural fibrosis. CT findings at this stage include thickened pleura with multiple loculations. The thickened pleura may calcify. Expansion of extrapleural fat and periosteal changes at adjacent ribs develops. Inability of the lung to expand after tube thoracostomy is seen at this stage (Light 2006). Extensive pleural calcifications may be associated with minimal pleural fluid. This finding is important because residual infection in pleural space may extend to adjacent chest wall and lead to empyema necessitatis or may result in bronchopulmonary fistula formation (Fig. 5a, b) (Collins and Sten 2008). On ultrasound, pleural fluid is most frequently seen as an anechoic or hypoechoic collection.

The majority of parapneumonic effusions and empyemas are associated with septations, and the pleural fluid at this stage appears hyperechoic on US examination. Pleural thickening is hard to

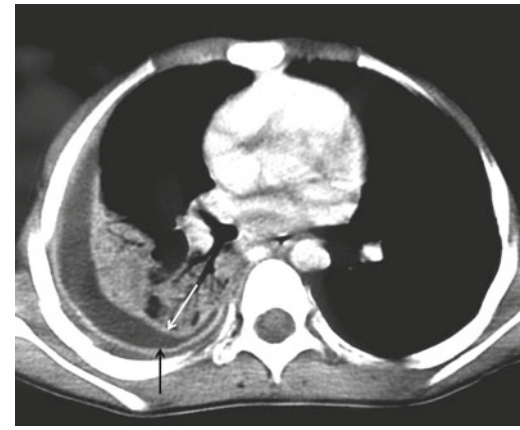


Fig. 4 The split pleura sign in emphyema. Contrast-enhanced axial CT image show enhancement of the thickened inner visceral (*white arrow*) and outer parietal pleura (*black arrow*) with separation by a collection of pleural fluid

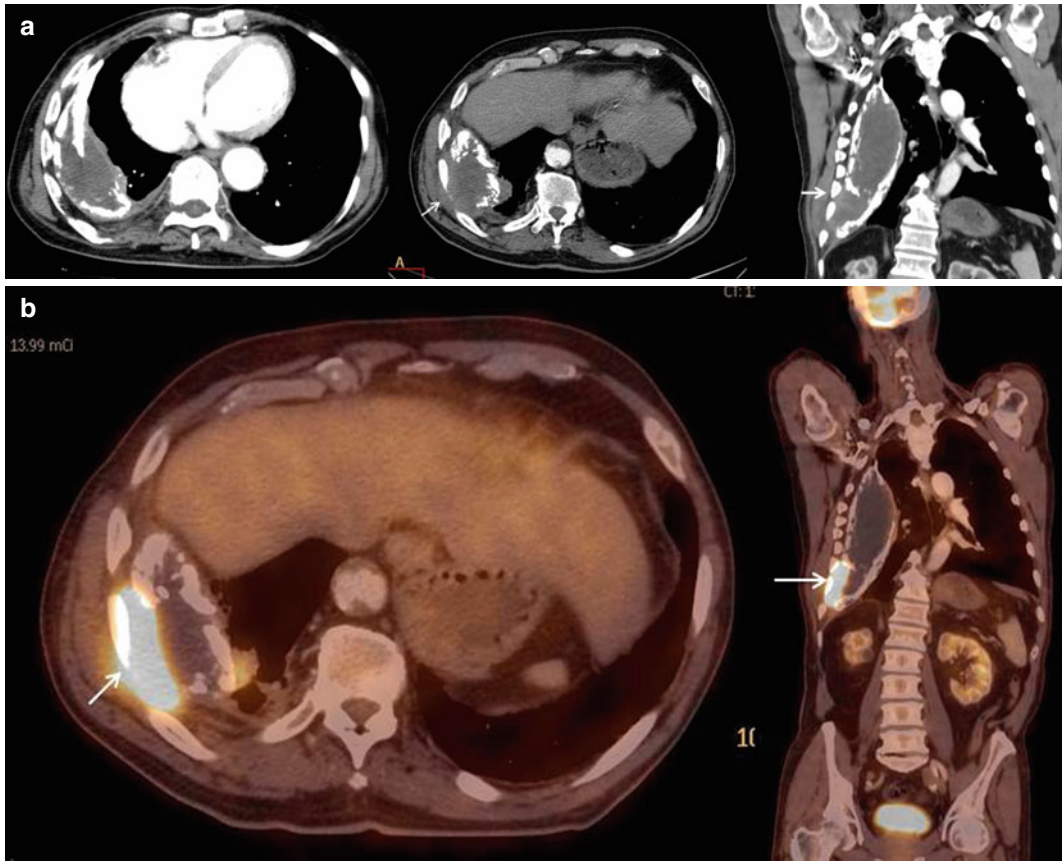


Fig. 5 (**a**) Empyema necessitatis in a patient with prior history of tuberculosis pleurisy. Contrast-enhanced axial and coronal CT images show thick and calcified pleural layers and associated pleural fluid between the pleural layers. There is extension of pleural infection to the thoracic wall (*white arrows*). (**b**). Axial and coronal fused PET-CT images show increased ^{18}F-flurodeoxyglucose (^{18}F-FDG) uptake at level of chest wall extension of pleural infection (*white arrow*)

visualize sonographically and if confirmation of this is required, contrast-enhanced CT should be performed. Apparently, there is no definitive correlation between US appearance and the stage of evolution of the effusion (Gleeson 2008).

Sometimes it may be difficult to differentiate between empyema and a pleural-based pulmonary abscess. The pulmonary abscess appears round in shape and forms an acute angle with the chest wall. However, empyemas usually form an obtuse angle with the chest wall. Pulmonary abscesses tend to have thicker walls than empyemas. The "split pleura" sign referring to the separation of enhancing parietal and visceral pleura is seen in empyema and can be used also to differentiate it from an abscess (Gleeson 2008).

1.5 Chylothorax

Chylothorax is defined as an accumulation of chyle in the pleural space most often secondary to thoracic duct injury or malignant invasion. The largest part of the thoracic duct lies in the right hemithorax, and the thoracic duct drains into the junction of the left axillary and internal jugular veins. Most chylous effusions are right sided as expected from this anatomic location. The attenuation of chylous effusions at CT may be low due to the fat content of the fluid. However because of the rich protein content of the chyle, it is generally difficult to differentiate it from other effusions (Radiographic et al. 1997).

1.6 Malignant Effusion

Metastatic seeding of the pleura is seen most commonly in lung, breast, ovarian, and gastrointestinal carcinomas. Primary pleural tumors such as mesothelioma and pleural lymphoma are rare. Certain infiltrative hematologic malignancies (e.g., acute myeloid leukemia) may also involve the pleura (Kienzl et al. 2012; Bonomo et al. 2000; Sahn 1997). Most patients with pleural metastases have large amount of effusions. However, the definitive diagnosis of malignant pleural disease generally requires pleural fluid cytologic examination, pleural biopsy, or even open chest surgery (Collins and Sten 2008; Gleeson 2008). Contrast-enhanced CT is the most commonly performed study in patients with suspected malignant pleural effusion and negative cytology on aspiration. CT signs indicating for both primary and metastatic diseases of pleura include thickening of the mediastinal pleura, parietal pleural thickening of greater than >1 cm, and focal and/or diffuse nodularity of the pleura. Using these criteria for assessment, contrast-enhanced CT has been shown to have a sensitivity of >80%. CT examination may also give information about associated metastases (Fig. 6). Pleural or diaphragmatic nodules can be detected sonographically in cases with pleural metastases, but CT is better than US for the evaluation of pleural thickening (Evans and Gleeson 2004; Leung et al. 1990). US can be used as a tool to aid thoracentesis. MRI is superior to CT in the detection of small pleural nodules. However, the respiratory and cardiac motion artifacts are the major drawbacks of MRI examination (McLoud 1998; Gleeson 2008). PET and PET-CT have an increasing impact in the diagnosis of malignant pleural tumors. Several studies have mentioned the high accuracy of 18F-FDG PET/CT in differentiating benign and malignant pleural disease, especially in the setting of indeterminate CT findings. Increased pleural FDG uptake usually indicates the presence of pleural metastases (Fig. 7) (Schaffler et al. 2004; Kramer et al. 2004). PET/CT also plays an important role in tumor staging to detect distant metastases and to monitor therapy response. The disadvantage of PET or PET-CT is that they poorly discriminate between infective and malignant causes. Nonspecific FDG uptake can be seen in patients who have undergone prior talc pleurodesis, radiotherapy, intrapleural chemotherapy, etc. (Duysinx et al. 2004; Erasmus et al. 2000). Small volume disease or low grade malignancies such as epitheloid mesothelioma can hardly be detected with PET (Makis et al. 2012).

1.7 Management and Treatment

Interventional procedures such as thoracentesis, percutaneous drainage, and pleural biopsies are generally performed with the guidance of imaging

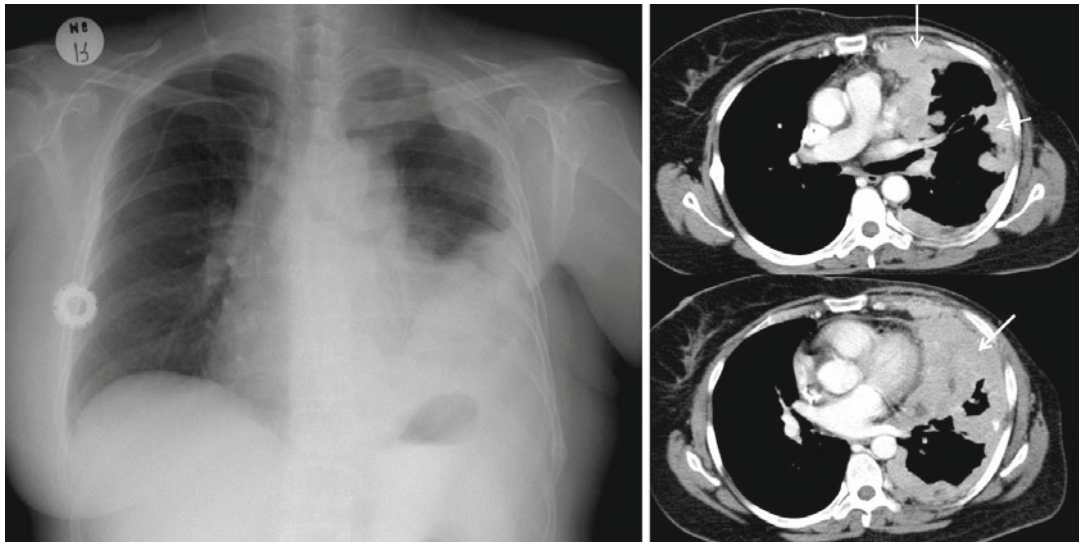


Fig. 6 Pleural metastases in a patient with breast cancer. Posteroanterior chest X-ray and axial contrast-enhanced CT images show left-sided pleural effusion, pleural thickening, and pleural mass lesions (*white arrows*). There is asymmetry at level of soft tissues due to left mastectomy

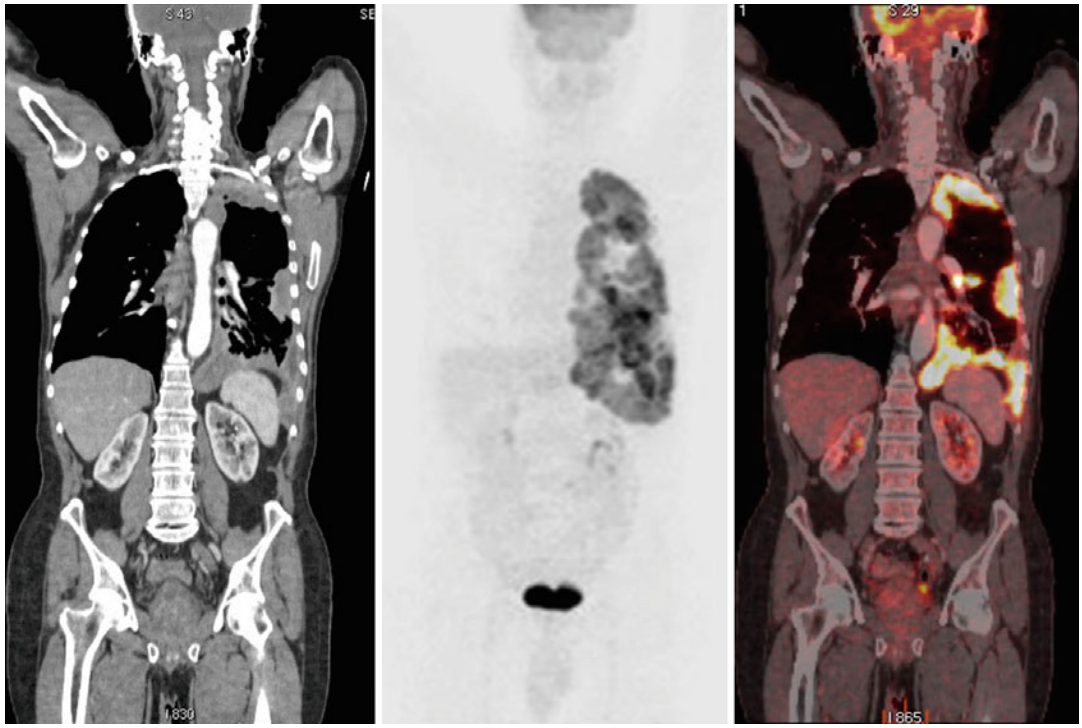


Fig. 7 Pleural carcinomatosis. Coronal CT, PET, and PET-CT fusion images show pleural thickening and increased pleural ^{18}F-flurodeoxyglucose (^{18}F-FDG) uptake

techniques. Imaging guidance helps identification of the correct placement site and proper insertion of the catheter into the pleural cavity and also helps to avoid complications that can occur during the procedure. The modality of choice depends on several factors such as the location, size, complexity of pleural fluid, local availability of the equipments, and experience of the operator. US can detect small amount of fluid in pleural cavity so it is commonly preferred in bedside percutaneous aspiration and catheter drainage of uncomplicated pleural fluid. CT is generally preferred in case of encapsulated, loculated complex pleural collections. Depending on the characteristics of the pleural fluid such as the amount, pH, glucose levels, bacteriological features, the proper therapeutic method is selected in case of parapneumonic effusion (Light and Rodriguez 1998). Therapeutic methods can vary from therapeutic thoracentesis, insertion of thoracostomy tube, administration of thrombolytics to decortication surgery. Malignant pleural effusion which cannot be controlled by systemic chemotherapy is treated interventionally. The treatment options may be repeated thoracentesis, pleural sclerosis by injection of intrapleural drugs, and long-term pleural catheters (Noukoua Tchuisse et al. 2007).

Reexpansion pulmonary edema (RPE) is a rare but important complication that may occur after treatment of lung collapse caused by pleural effusion. The rapid reexpansion of a chronically collapsed lung, after removal of a large amount of fluid from the pleural space may lead to RPE. The condition appears within 1–24 h after the evacuation. Radiologically, alveolar filling pattern is seen within a few hours of reexpansion of the lung. It is usually unilateral and is detected in those portions of lung that were previously collapsed (Fig. 8) (Tarver et al. 1996). The

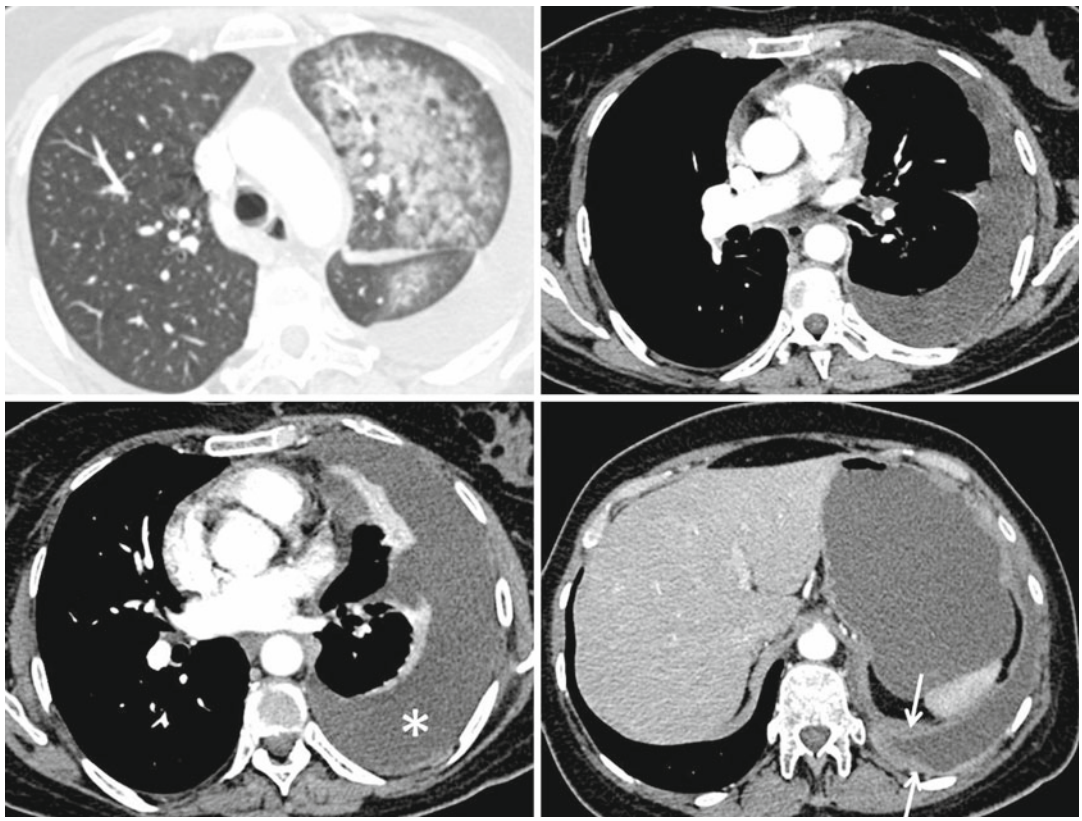


Fig. 8 Reexpansion pulmonary edema in a patient with mesothelioma. Axial chest CT image at lung window settings show ground glass areas and air space opacities in left lung after thoracentesis. CT images at mediastinal window settings shows left pleural effusion (*white asterisk*) and pleural thickening at level of left costophrenic sinus (*white arrows*)

treatment is generally supportive. As a prevention, limitation of therapeutic thoracentesis to 1000 mL is advised (Light et al. 1980).

2 Imaging of Spontaneous Pneumothorax

Chiara Andreoli

2.1 Introduction

Pneumothorax is defined as the presence of air in the pleural cavity, between the lung and the parietal pleura.

It represents a relatively common cause of admission to the emergency department, with a reported incidence of 18–28/100,000 cases per year for men and 1.2–6/100,000 cases per year for women (Noppen 2010; Bense et al. 1987; MacDuff et al. 2010).

Pneumothorax can be distinguished in "primary spontaneous pneumothorax" (PSP) that occurs in healthy patients without obvious causes and secondary spontaneous pneumothorax (SSP), due to underlying predisposing diseases, such as emphysema, tuberculosis, fibrosis, etc (MacDuff et al. 2010).

Primary pneumothorax occurs more frequently in young, thin, and tall males without predisposing lung disease, although it is known that its occurrence is due to the rupture of underlying small subpleural bullae and blebs at the lung apices, found at thoracoscopy or detected on CT: these conditions are called *emphysema-like changes* (ELCs) (Currie et al. 2007; Lesur et al. 1990; Donahue et al. 1993).

It seems that smoking increases the risk of developing primary pneumothorax nine times in young people, although the mechanism is unknown. Secondary pneumothorax (SSP) occurs when an underlying lung pathology exists: the most frequent predisposing pathological conditions are obstructive airway disease, emphysema, tuberculosis, interstitial lung disease, pulmonary fibrosis, histiocytosis X, sarcoidosis, and pulmonary infections (Currie et al. 2007).

Clinically, patients with SSP are more severe than those with PSP, because of preexisting pulmonary disease, which reduces their ventilation ability and requires several days of hospitalization and a more complex management.

Pneumothorax can be clinically silent for several days before the onset of symptoms, and often, their severity is independent from the extension of pneumothorax. The severity of symptoms is the factor that most of all influences the diagnostic-therapeutic management; the more typical symptoms are chest pain, dyspnea, and breathlessness (MacDuff and MacDuff 2009; Harcke et al. 2007). When severe symptoms and signs as cyanosis, sweating, severe tachypnea, tachycardia and hypotension, and cardiorespiratory distress appear, tension pneumothorax must be considered, which is a true medical emergency, causing mediastinal shift and cardiovascular collapse.

2.2 Diagnosis

The clinical suspicion, based on typical symptoms as abrupt onset of pleuritic pain and breathlessness and typical signs as reduced breath sounds, decreased ipsilateral chest expansion, and hyperresonant percussion at clinical examination, is usually confirmed by imaging techniques which may also yield informations about the size of the pneumothorax and the amount of air visible between the lung and chest wall: according to the British Thoracic Society guidelines, small pneumothorax is considered when the space between the lung edge and chest wall is <2 cm and large pneumothorax when this space is >2 cm at chest radiograph (MacDuff et al. 2010; Currie et al. 2007).

Chest radiography is routinely used for the diagnosis, while in complex cases, the use of CT is recommended. Chest ultrasound is used in some centers, especially in case of pediatric patients and pregnant women, in order to reduce radiation dose exposition.

2.2.1 X-ray

Usually, the standard erect posteroanterior chest radiograph is considered adequate for the diagno-

sis, although it is limited in accurately quantifying pneumothorax size.

The advent of digital chest imaging has implemented the visualization of pneumothorax due to the ability to change the window, allowing to better visualize the interface between the lung edge and pleural cavity.

Specific signs of pneumothorax at chest radiograph are (Figs. 9, 10, and 11):

- The visualization of the visceral pleural edge as a very thin, sharp, white, convex-shaped line which runs parallel to the chest wall
- The absence of the lung parenchyma peripheral to this line
- Radiolucency of the peripheral space compared to adjacent lung
- In up to 50 % of cases, an air-fluid level visible in the costophrenic angle (arrow in Fig. 9a)
- In severe cases, collapse of the lung
- Mediastinal shift in case of tension pneumothorax (Fig. 11a)

While the diagnosis of PSP is easier because of the normality of the adjacent parenchyma, the diagnosis of the SSP may be harder: the presence of bullous lung disease can indeed lead to the erroneous diagnosis of pneumothorax; in complex cases, the use of CT is recommended, especially if interventional treatment is the choice (MacDuff et al. 2010).

Generally there is no need to request an expiratory film in the daily practice, because it does not always provide additional benefits in the routine assessment of pneumothorax (Schramel et al. 1996; Seow et al. 1996). In expiratory phase, the lung becomes smaller and denser, and the pneumothorax is better visible, although it seems more conspicuous.

In patients who cannot stand erect, if the use of CT scan is avoided for dosimetric reasons, and it is uncertain whether a pneumothorax is present or not, the use of additional projections such as the lateral view may provide additional informations (Glazer et al. 1989), although it is not routinely used in daily clinical practice: it should be performed with the suspected affected side up, and it is based on the assumption that the lung will "fall away" from the chest wall and that

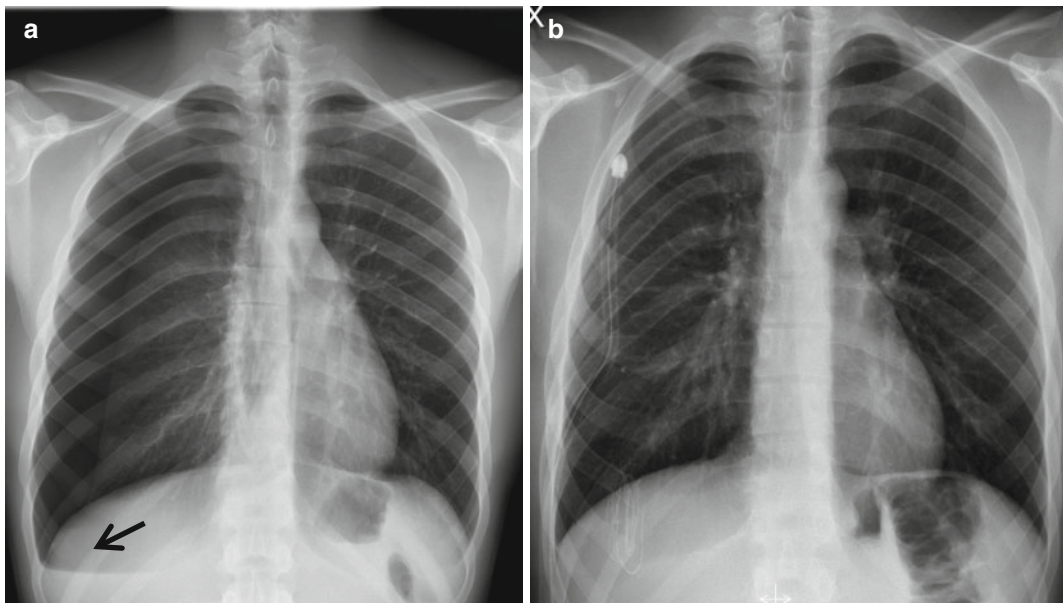


Fig. 9 In (**a**) Spontaneous pneumothorax causing partial collapse of the right lung, denser than the contralateral. The thin pleural line and the lack of the pulmonary parenchyma peripherally are clearly demonstrated. An air-fluid level is seen in the costophrenic angle (*black arrow*), due to pleural effusion. No mediastinal shift is visible. In (**b**), check after placement of drainage tube, with apex to the third intercostal space

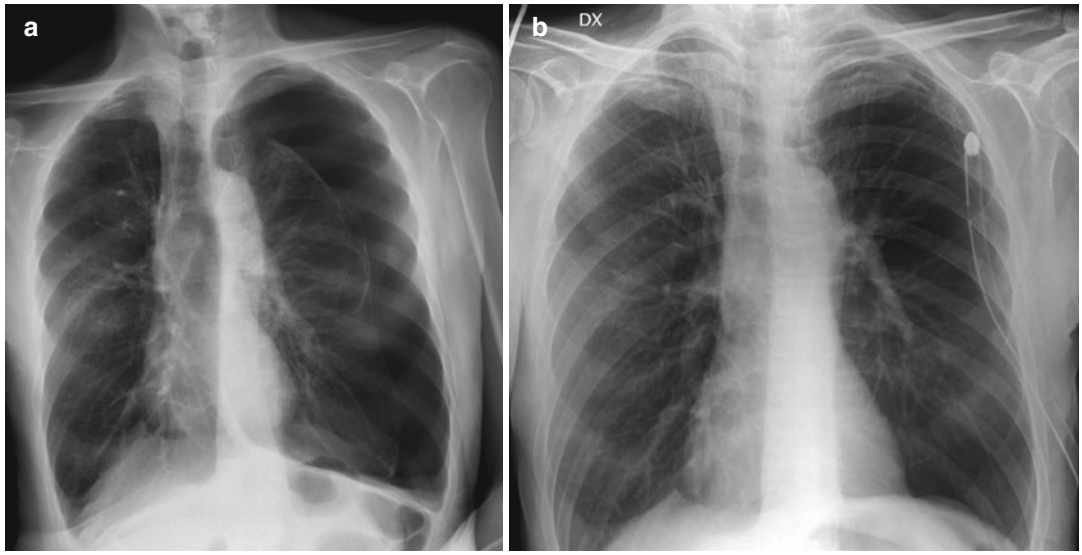


Fig. 10 In (**a**) Large pneumothorax causing compression of the left lung, depression of the hemidiaphragm and mediastinal shift. In (**b**), after placement of drainage tube, the pneumothorax is well drained

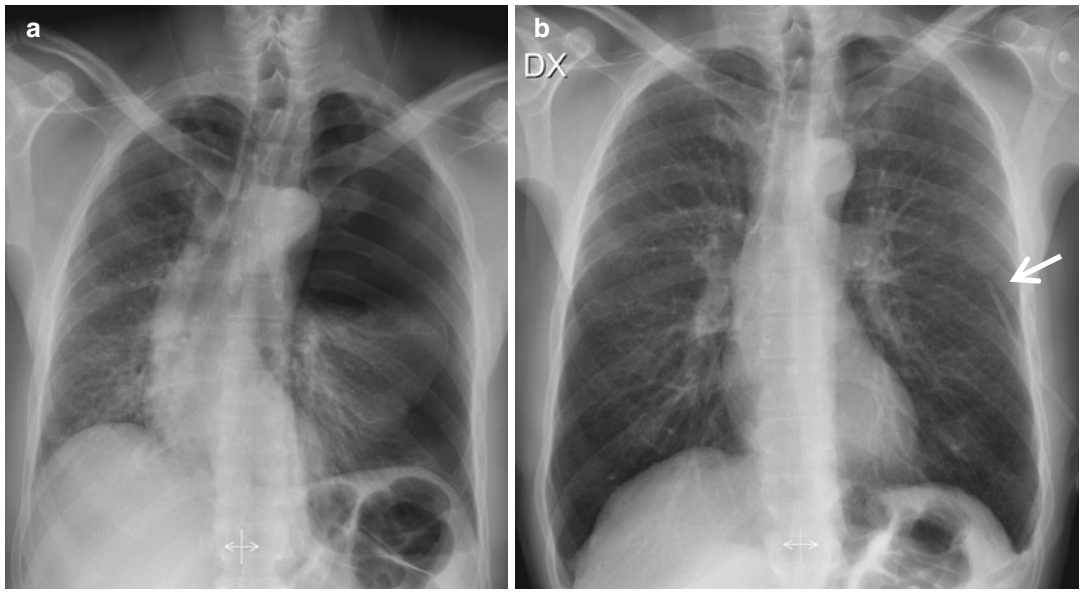


Fig. 11 Tension pneumothorax. In (**a**) a large pneumothorax causes compression of the mediastinal structures, with shift of the heart and trachea and depression of the hemidiaphragm. The left lung is collapsed. In (**b**), after positioning of a small drainage tube (*white arrow*), the pneumothorax is totally resolved

allows to better visualize the free air in the pleural space.

The tension pneumothorax represents a true thoracic emergency, due to compression of the air on mediastinal structures, and it should be promptly treated.

The compression of mediastinal structures is clearly visible on the X-rays as the shift of the heart and trachea to the contralateral side and depression of the hemidiaphragm on the affected side (Fig. 11). Often, it is clinically suspected and should be treated promptly even before performing an X-ray.

Mimics on X-radiographs

In the clinical practice, we are often facing with artifacts that can mimic the presence of a pneumothorax and that should be known to avoid mistakes, especially if the treatment is the choice: the medial border of the scapula can mimic the lung edge, and skin folds overlying the chest wall also can simulate a visceral pleural line; these mistakes are accentuated by the fact that a characteristic reduction of lung markings is often present in the upper zones of the lung, especially in children.

If the doubt persists, it is useful to repeat the radiographs removing the clothes or repositioning the arms.

Occasionally, a large bulla can mimic a pneumothorax: in that case, if there is still doubt, CT can be performed (MacDuff et al. 2010).

2.2.2 Ultrasound

Thoracic ultrasound is a promising technique, increasingly used in the shock room to quickly diagnose the presence of traumatic pneumothorax in unstable trauma patients. In B mode modality, normal lung interface with pleura shows lung sliding with vertical comet tails running down from the pleural surface. In case of pneumothorax, this sliding and the comet tail artifacts are absent. M mode can be used to confirm or to exclude movement of the lung within the rib interspace. Small air collections in the pleural space are best appreciated anteriorly in the supine position, whereas large pneumothorax is well seen laterally in the midaxillary line (Husain et al. 2012; Stone 2008; Lichtenstein et al. 2005; Ianniello et al. 2014; Zhang et al. 2006). According to the literature, in polytrauma patients, the sensitivity and specificity of US for the detection of pneumothorax ranged from 86 to 98 % and 97 to 100 %, respectively, against the supine AP chest radiographs that has a sensitivity for the detection of pneumothorax from 28 to 75 % (Wilkerson and Stone 2010).

As well as for trauma patients, in which it is impossible to perform X-rays in the upright position, thoracic ultrasound can be useful to check spontaneous pneumothorax in limited cases, such as in children and pregnant women, for dosimetric reasons.

2.2.3 Computed Tomography (CT)

As mentioned above, computed tomography is occasionally performed when the radiographic diagnosis of pneumothorax is unclear or in complex cases, for example, in order to distinguish a pneumothorax from a large emphysematous bulla, or when there is a clinical-radiological discrepancy (MacDuff et al. 2010).

CT is considered a highly reliable and decisive technique only if done with rigorous method: a high-resolution CT scan of the thorax should be performed with spiral scanner, acquiring images with slice thickness of 1 mm and section spacing of 10 mm. The lung window is used to analyze the lung parenchyma, looking for underlying pathological conditions, while the mediastinal window is useful to confirm the presence of pleural fluid or hemorrhagic collections (Shi-ping 2010).

If carried out following these parameters, CT is a method considered the "gold standard" in the detection of small pneumothorax, also called "occult pneumothorax," and in size evaluation (MacDuff et al. 2010). If the surgical procedure is the choice, it's also often used before it, in order to better study the underlying lung abnormalities, such as interstitial lung disease and enphysematic disease (Figs. 12 and 13).

Pneumothorax is very easily identified on CT and should not be a diagnostic challenge: it shows as a black band (air) around the often collapsed lung; sometimes, pleural fluid or hemorrhagic collections are present, and this condition are called hydro-/pneumothorax or hemo-/pneumothorax.

In addition to the diagnostic confirmation in emergency setting, the added value of CT scan is that CT findings can predict pneumothorax recurrence (Mitlehner et al. 1992; Warner et al. 1991), through direct visualization of invisible findings on radiographs such as little bullae and blebs located in lung apices (Fig. 14) (Ouanes-Besbes et al. 2007; Verschoof et al. 1988; Lippert et al. 1991).

Indeed, the finding of dystrophic lesions in the lung of patients affected by recurrent pneumothorax is very common: in a recent paper, Lamia

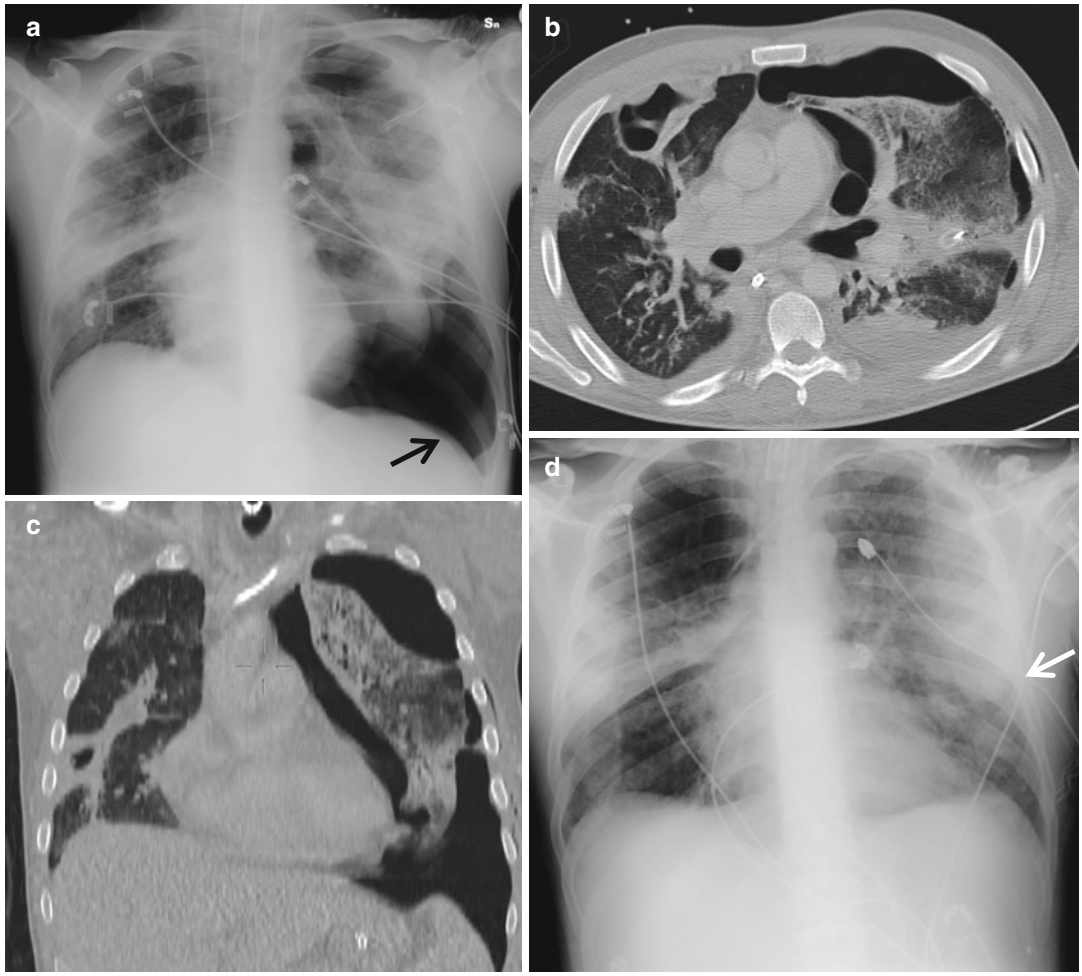
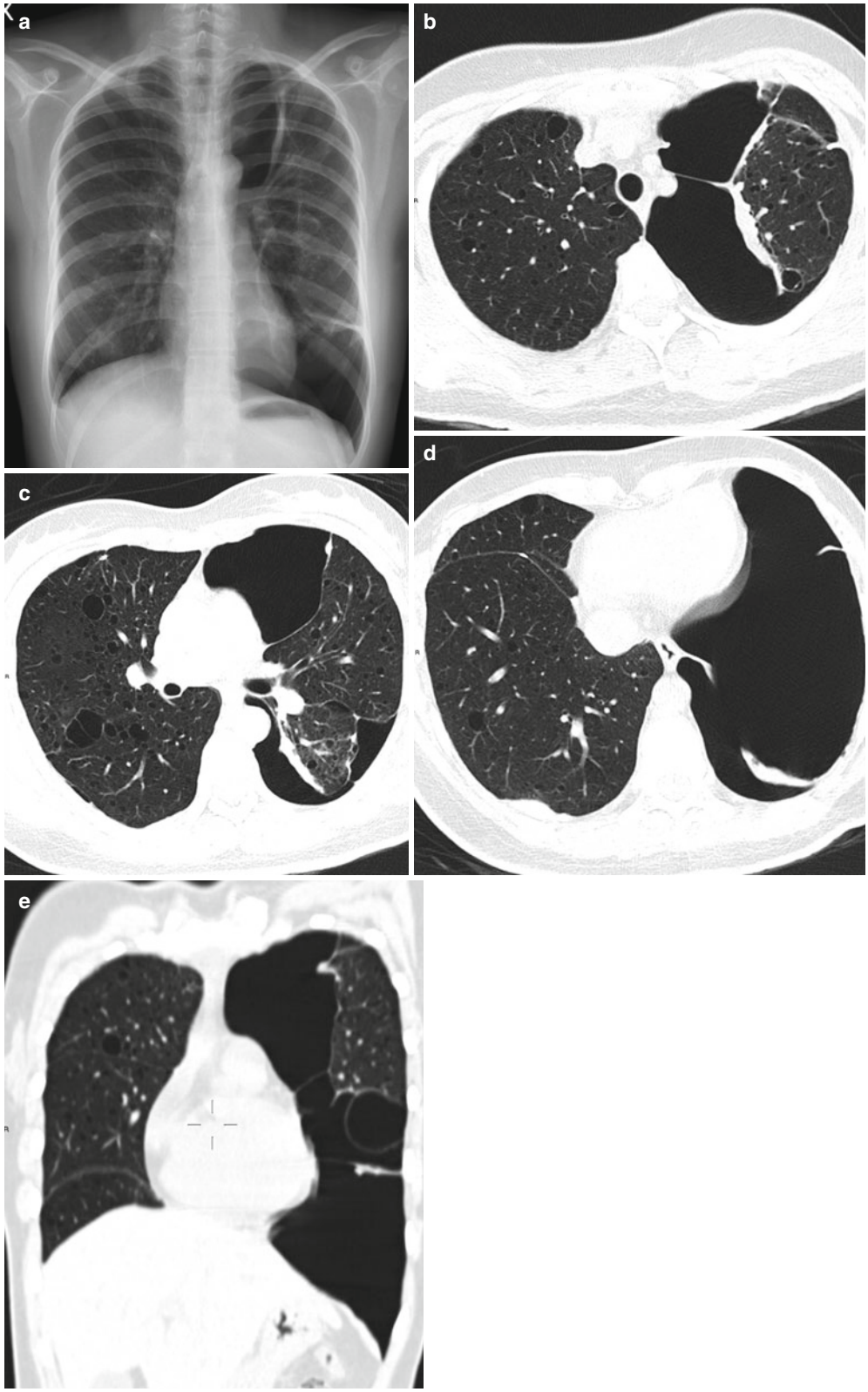


Fig. 12 In (**a**), the radiogram shows diffuse fibrosis of the lung parenchyma bilaterally and a voluminous air collection confined in the left base (*black arrow*). The CT scans (axial in **b** and coronal in **c**) confirm the severe lung fibrosis but demonstrates that the pneumothorax is more conspicuous than the amount shown at X-ray. In (**d**), it has shown the optimal positioning of the drainage tube with the resolution of pneumothorax

found dystrophic lesions in 72.5 % of cases. After that, several studies suggested that pulmonary CT scan findings, including the number and size of bullae and blebs, can predict pneumothorax recurrence, although it's known that this is not the only factor that predicts the rate of recurrence (Ouanes-Besbes et al. 2007).

The two dystrophic lesions most frequently associated with the development of recurrent pneumothorax are the pulmonary blebs and bullae, often not detected at chest X-ray: pulmonary blebs are defined as small subpleural thin-walled air spaces, not larger than 1–2 cm in diameter, with a wall thickness less than 1 mm; pulmonary bullae are cystic air spaces that have an imperceptible wall (less than 1 mm), as the blebs, but the difference between blebs and bullae is in their size, because bullae have a transverse diameter >2 cm. It should be considered that blebs can coalesce to form bullae (Lippert et al. 1991; Cantin et al. 2010; Hansell et al. 2008; Sahn and Heffner 2000; O'Connor and Morgan 2005).

There is a lot of disagreement in the literature about this topic: some studies revealed no correlation between recurrence and lung CT


a
b
c
d
e

findings, while most of the authors agree that the incidence of recurrence derives from the therapeutic choice (as the size of the drainage tube, chemical pleurodesis rather than surgical) (Ouanes-Besbes et al. 2007).

However, in addition to assessing the need of surgical intervention, CT scan can also be used to localize the bullae/blebs at unusual sites (Shiping 2010) and to detect the presence of hemopneumothorax, which influences the treatment choice: these above informations can help in planning surgical strategies and in explaining the indication, risks, and benefits to the patients (Chen et al. 2009).

CT scans can also be used to detect the presence of bullae and blebs on the contralateral lung, which predicts the risk of contralateral spontaneous pneumothorax (Sihoe et al. 2000): one-fourth of patients with contralateral blebs developed PSP in the untreated lung.

Conclusions

Pneumothorax is a relatively common condition that needs to be promptly managed in an appropriate way. It may represent a true medical emergency, as is the case of tension pneumothorax, which requires an immediate operative treatment, while in most cases a conservative treatment is the choice.

Imaging plays a crucial role at the time of diagnosis, through the evaluation of the extent of the pneumothorax and the anatomical modifications of the lung parenchyma, which represents essential information in order to choose the best and most appropriate treatment for that patient.

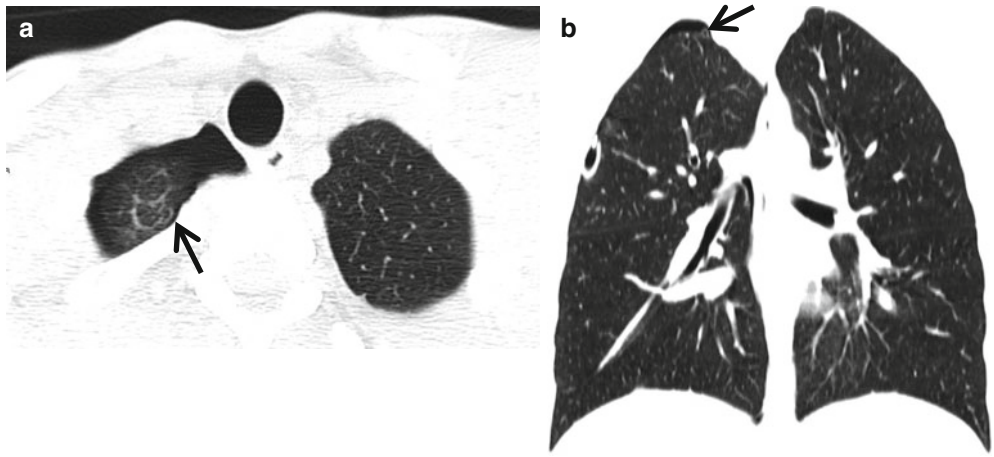


Fig. 14 The same patient of Fig. 9. Axial CT scan (**a**) and coronal reconstruction (**b**) the day after positioning of the drainage tube show the presence of some small bubbles in the right pulmonary apex (*black arrow*), clearly visible through the window of the lung parenchyma

Fig. 13 In (**a**), the radiograph shows air collection in the apical and basal zone of the left hemithorax, but no abnormalities of the parenchyma are suspected. In axial CT scans (**b**–**d**) and in the reformatted coronal reconstruction (**e**), centrilobular emphysema is seen, with multiple diffuse bullae spread in the parenchyma, and a conspicuous pneumothorax is well demonstrated

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