Extremely rare but potentially catastrophic complications of CT-guided percutaneous chest biopsy: review of risk factors, prevention, and management

Poster No.: C-2397
Congress: ECR 2017
Type: Educational Exhibit
Keywords: Outcomes, Education and training, Diagnostic procedure, CT, Thorax, Mediastinum, Lung
DOI: 10.1594/ecr2017/C-2397

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR's endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method is strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org
Learning objectives

1. To show radiologic features of usual and unusual computed tomography (CT)-guided percutaneous chest biopsy complications.

2. To review and discuss risk factors associated with complications development.

3. To explain how to effectively prevent and manage procedure-related complications when they occur with established protocols.
Background

Types of Lung Biopsy

Lung biopsies may be classified according to the method of access (percutaneously, bronchoscopically, or open surgery) or by the reason for biopsy (sampling of diffuse lung disease or obtaining tissue from a mass when neoplasm is suspected). Sometimes, the type of tissue obtained also defined percutaneous biopsy (cytological or histological). Fine needle aspiration biopsy gives cytological specimens and, although these needles tend to be of narrow bore, cutting needles that produce histological specimens can also be of similar gauge. Accordingly, lung biopsy in general is referred to as percutaneous transthoracic lung biopsy.

1. Percutaneous Transthoracic Lung Biopsy

Percutaneous transthoracic needle aspiration or biopsy of the lung is performed with imaging guidance. Usually the aim is to diagnose a defined mass. Imaging modalities could be ultrasound, CT-fluoroscopy, and CT. Magnetic resonance imaging currently has a limited use because of costs, difficulty accessing the patient within the magnet, the relatively poor visualisation of lung lesions, and difficulties with ferromagnetic instruments within the magnetic field.

Ultrasound is useful mainly where the tissue mass is in contact with the chest wall since the ultrasound beam does not pass through air and, hence, the aerated lung.

CT fluoroscopy is capable of operating in two modes: continuous (real time) or intermittent (quick check). Nevertheless, continuous CT fluoroscopy can result in long CT fluoroscopy exposure times and substantial radiation doses to patients and personnel.

CT-guided biopsy is playing an increasing role in the diagnosis of benign disease, cellular differentiation, somatic mutation analysis, and molecular fingerprint analysis due to an accurate and safe needle advancement and a less radiation exposure.

2. Bronchoscopic Lung Biopsy

Biopsy via a bronchoscope is useful for proximal endobronchial lesions but is unable to access more peripheral lesions. Transbronchial biopsy of diffuse lung disease may be assisted by some imaging guidance. Because it does not cross the pleura, pneumothorax is much less common than in percutaneous biopsy.
3. Open Lung Biopsy and Video Assisted Thoracoscopic Surgery

Although these surgical procedures are able to provide larger samples of tissue with improved accuracy and specificity, the morbidity and length of stay are greater than with the other two methods of biopsy.

CT-guided percutaneous chest biopsy Fig. 1 on page 6

After appropriate patient positioning, a radiopaque marker or grid is placed on the patient's skin over the area of interest to focus the optimal access point. A short spiral CT scan of the region of interest is obtained, and from these images, an appropriate table position and needle trajectory are chosen. The shortest straight pathway from the skin to the lesion is preferred over a longer oblique pathway.

The coaxial technique (needle introducer remains in position during multiple cutting needle passes) to obtain a core lung biopsy is suggested for the following reasons: It yields good stabilization in the chest wall because of the lightness of the coaxial needle; and it allows multiple specimens to be obtained with a single pleural puncture. When performing the coaxial technique, never leave the outer cannula inside the patient without the inner stylet. To do so in a small branch of a pulmonary vein could result in a devastating air embolism, leading to myocardial infarction, stroke, or even death.

For local anaesthesia, the depth from the skin entry site to the lesion should be measured. The needle tip should never advance through pleura when injecting local anaesthesia. Otherwise, pneumothorax might develop, making the following procedure more difficult.

CT-guided percutaneous chest biopsy has become an indispensable tool in the diagnosis of thoracic lesions as it yields tissue samples for detection, staging, and differentiation of primary cancer from metastases or inflammatory diseases. CT provides relevant information about needle trajectory within the lung. However, it does not allow for real-time monitoring of both needle movement and lesion displacement with respiratory motion.

Pneumothorax and pulmonary haemorrhage, quite easily treatable and usually non-associated with long-term sequelae, are frequent complications. However, most potential catastrophic complications are extremely rare and difficult to recognize.
This pictorial essay aimed to describe and illustrate imaging appearance and diagnostic clues of chest interventional complications.
**Fig. 1:** Thoracic axial nonenhanced CT examination shows patient in supine position, with radiopaque markers on patient's skin overlying a left upper lobe nodule (yellow arrows) and a biopsy needle inserted through left lateral chest wall with the needle tip within the nodule (red arrow).

© 2016 Department of Radiology, Vall d'Hebron Hospital. Barcelona, Spain.
Findings and procedure details

Radiologists should be familiar with percutaneous transthoracic lung biopsy complications to be able to quickly discover and provide required acute care.

Attention to biopsy planning (respiratory and cardiac motion, chest wall vessels, pre-procedural laboratory check, and informed consent) and post-procedural cares help to prevent or minimize complications.

Chest biopsy complications included in this exhibit are as follows:

1. Pneumothorax
2. Pulmonary haemorrhage
3. Massive hemothorax
4. Air embolism
5. Pneumomediastinum
6. Tumour seeding
7. Infection

1. Pneumothorax

**Epidemiology**

CT-guided lung biopsy is safe, but pneumothorax and bleeding are the two most frequently encountered complications.

Definition of pneumothorax is presence of gas within the pleural space. Although it can be spontaneous or traumatic, most pneumothoraces are iatrogenic and caused by a physician during surgery, central line placement, lung biopsy, or bronchoscopy.

The most common complication of percutaneous transthoracic lung biopsy is pneumothorax, with a frequency rate of 17-26.6%, whereas the incidence of pneumothorax requiring chest tube drainage ranges from 1% to 14.2%.

However, the reported incidence of pneumothorax is highly variable, most likely the result of multiple factors such as differences in patient population, procedural technique, operator experience, and methods of detection (chest radiograph or CT).

**Procedure and Complication Mechanism**
Physiologically, the alveolar pressure is greater than the intrapleural pressure, while the intrapleural pressure is less than atmospheric pressure. Therefore, if a communication develops between an alveolus and the pleural space or between the atmosphere and the pleural space, gases will follow the pressure gradient and flow into the pleural space. This flow will continue until the pressure gradient no longer exists or the abnormal communication has been sealed. Because the thoracic cavity is normally below its resting volume, and the lung is above its resting volume, the thoracic cavity enlarges and the lung becomes smaller when a pneumothorax develops.

With coaxial biopsy systems, multiple fine-needle aspirates and core biopsy specimens can be obtained through an introducer needle, which remains within the lung parenchyma for a variable time. This time between pleural puncture and needle removal has been called as "dwell time". Investigators have shown that the incidence of pneumothorax is higher when performed with CT rather than fluoroscopic guidance because of the longer procedure duration and the fact that biopsy of smaller lesions is often performed under CT guidance. Smaller size and greater depth of lesions have been shown to correlate with an increase in pneumothorax frequency due to longer "dwell time".

Pneumothoraces can occur during or immediately after the procedure, which is why it is important to perform a CT scan of the region following removal of the needle.

A sign of emphysema on CT scans was defined as the presence of centrilobular or panlobular emphysema, bullae, and blebs in the lungs selected for needle biopsy. Immediate post biopsy pneumothorax while the patient was still on the CT scan table was graded as mild (lung surface retraction of 2 cm), moderate (measured lung surface retraction of between 2 and 4 cm), and severe (lung surface retraction of 4 cm).

**Causes and Risk Factors**

Factors predisposing patients to pneumothorax can be divided into those related to underlying pathology and those related to procedural technique.

A patient-related risk factor for this complication is the presence of chronic obstructive pulmonary disease. Fish et al. found that the pneumothorax rate was 46% in patients with pulmonary function test and chest radiographs showing obstructive airway disease compared with 7% in patients with normal findings for both criteria. Another patient-related risk factor for pneumothorax is the lack of a history of ipsilateral surgery. Certain lesion characteristics also predispose patients to pneumothorax. In cases in which the
lesion is in the chest wall, mediastinum, pleura, or subpleural lung and no aerated lung is traversed by the biopsy needle, the likelihood of pneumothorax is minimal. Increased depth of the lesion from the skin or long needle path (> 4 cm) is associated with an increased risk of pneumothorax. Small lesion size also plays a role in the development of pneumothorax.

Technical factors also affect the pneumothorax rate. The risk of pneumothorax increases with increased number of pleural punctures and wider insertion angle of the needle that is, when the needle is inserted less perpendicular to the pleura.

**Tips to Avoid Complications**

To reduce the number of pleural punctures, interlobar fissures should be avoided. Careful planning is necessary to traverse the least amount of aerated lung without puncturing bullae or pneumatoceles if possible. Infusion of normal saline to expand the extrapleural space and displace the adjacent lung can be performed to avoid traversing aerated lung when biopsying a subpleural lesion. A technique of obliterating, or "patching," the needle track by injecting 2-3 mL of autologous blood or a self-expanding hydrogel plug, during the final withdrawal of the introducer needle to minimize the incidence of post biopsy pneumothorax may be considered in patients at high risk for developing pneumothorax. The plug expands, creating an airtight seal that closes the pleural puncture. Finally, after removal of the introducer needle after the biopsy, patients should immediately be positioned with the puncture site down. Oxygen is administered through a nasal cannula during and after the procedure to speed the resorption of the pneumothorax if one does develop.

If a pneumothorax develops during the procedure, it can be manually aspirated before the introducer needle is removed or by inserting a separate needle into the pleural space. The needle is attached to tubing with a three-way stopcock and 50-mL syringe, and aspiration of the air is performed as the needle is retracted and removed. Aspiration of the excess pleural air allows better apposition of the visceral and parietal pleura and prevents further enlargement of pneumothorax. Chest tube placement can frequently be avoided using this manoeuvre. However, as suggested by Yamagami et al., when the amount of aspirated air is large (> 670 mL), chest tube placement should be considered.

Chest tube placement is indicated if a post biopsy pneumothorax becomes symptomatic or continues to enlarge on chest radiographs, usually obtained 1 and 3 hours after the procedure at our institution. Small calibre, 6- to 9-French, catheters can be safely and easily placed under CT guidance. The catheter can be attached to a one-way Heimlich valve, which allows the patient to remain ambulatory. Alternatively, the catheter can be attached to underwater seal drainage device and wall suction. The chest tube can usually be removed 1-2 days after the procedure. However, in patients with pre-existing pleural effusions, a larger catheter is usually required because the small catheters invariably become clogged with a clot or debris.
**Biopsy Under Pneumothorax**

CT-guided biopsy of lung lesions can be done under stable pneumothorax, if the lesion is close to the pleural surface. The pneumothorax may be caused by previous sonographically guided biopsy or by the first coaxial needle entry. When pneumothorax occurs, scan the same position 3 minutes later to see if the pneumothorax is progressing. If progressing, we suggest insertion of a pigtail catheter and stopping the procedure. If the pneumothorax is stable, with the final manipulation technique, diagnostic specimens can be obtained.

Many measures can be taken to help prevent the development of a pneumothorax and reduce the number of pneumothoraces requiring chest tube placement. Patients are instructed not to move, talk, cough, or breathe deeply during and immediately after the procedure.

**2. Pulmonary Haemorrhage**

**Epidemiology**

Localised pulmonary haemorrhage is a descriptive term for a pulmonary haemorrhage restricted to a particular focal region of the lung. It can range from involving a small focus of haemorrhage to a whole lobe. It is the second most common complication of needle biopsy of the chest, with reported frequencies ranging from 4% to 27%.

**Procedure and Complication Mechanism**

Pulmonary haemorrhage results from widespread damage to the pulmonary small vessels, leading to blood collecting within the alveoli. If enough alveoli are affected, gas exchange is disrupted and potentially lead to inadequate oxygen levels. This complication may present a technical problem during the procedure in that the lesion may become obscured by surrounding blood, limiting accuracy of needle placement and diminishing the diagnostic yield.

**Imaging Features** Fig. 12 on page 31  Fig. 13 on page 32  Fig. 14 on page 33  Fig. 15 on page 34  Fig. 16 on page 35
Parenchymal haemorrhage is usually an incidental finding on follow-up CT after percutaneous lung biopsy and is typically self-limited.

At CT image, pulmonary haemorrhage manifests as ground-glass opacities, crazy paving pattern, and areas of consolidation around the nodule, or a combination of those. In the subacute phase may show fine diffuse nodular densities. In later stage there may also be evidence of interlobular septal thickening due to intralymphatic accumulation of haemosiderin.

**Causes and Risk Factors**

Patients with pulmonary arterial hypertension, autoimmune disorders (systemic vasculitides, Goodpasture syndrome, antiphospholipid antibody syndrome, connective tissue disorders), pulmonary infections (hantavirus infection), toxic exposures (trimellitic anhydride, isocyanates, crack cocaine, certain pesticides), drug reactions (propylthiouracil, diphenylhydantoin, amiodarone, methotrexate, nitrofurantoin, bleomycin, montelukast, infliximab), cardiac disorders (mitral stenosis), coagulation disorders caused by diseases or anticoagulant drugs isolated pauci-immune pulmonary capillaritis, idiopathic pulmonary hemosiderosis, bone marrow or solid organ transplantation may also be at higher risk for haemorrhage.

Small lesion size and greater lesion depth or long biopsy path are associated with a higher risk of bleeding. Haemorrhage may also be related to CT evidence of emphysema, perhaps because of the lack of effective tamponade by adjacent tissue.

**Tips to Avoid Complications**

Pre-procedural laboratory check is crucial to avoid life-threatening pulmonary haemorrhage. Coagulation factors, such as platelet count, prothrombin time, and activated partial thromboplastin time, should be checked before the procedure. Percutaneous needle biopsy is contraindicated in patients who are taking an anticoagulant medication or who have a bleeding diathesis. Anticoagulants and anti-platelet medications should be withheld for the appropriate amount of time depending on the half-life of the medication.

Although puncturing a pulmonary vessel should not lead to massive haemorrhage under normal physiologic conditions, one should, nevertheless, avoid major central vessels. Generally, it is important to avoid all vessels greater than 5 mm seen on planning chest CT. When biopsying an anterior lesion behind vessels in the upper chest, such as the subclavian or internal thoracic vessels, a path should be chosen that avoids the vessels. Also, to avoid intercostal arteries, insert the needle above rather than below the rib. When possible, the trajectory of the needle should aim away from the aorta and the heart to
avoid inadvertent injury of these structures in the event of unexpected advancement of the needle.

When pulmonary haemorrhage manifests as a focal opacity on CT during the procedure, it is usually self-limited and the procedure should continue. However, if haemorrhage becomes clinically evident with cough and haemoptysis, the biopsy should be terminated. The patient should be placed in the decubitus position with the biopsy side dependent to prevent spillage of blood into the contralateral lung. Once the needle has been removed, the patient should be encouraged to cough up any blood clots that may obstruct an airway.

3. Massive Hemothorax

Epidemiology

Hemothorax is the presence of blood in the pleural space. Massive hemothorax is most often defined as rapid accumulation of ≥ 1000 mL of blood. It is an extremely rare lung biopsy complication, with an incidence of 0.092% in one study. Shock is common.

Procedure and Complication Mechanism

The source of pleural blood may be the chest wall, lung parenchyma, heart, or great vessels. In percutaneous transthoracic lung biopsy this complication results from inadvertent passage of the introducer needle through a variety of structures, including systemic arteries as subclavian, axillary, internal mammary, and intercostal arteries.

Imaging Features Fig. 17 on page 36 Fig. 18 on page 37 Fig. 19 on page 38 Fig. 20 on page 39

CT is a highly accurate diagnostic study for pleural fluid or blood. It may also be value later in the course of the complication for localization and quantification of any retained collections of clot and potential empyema within the pleural space.

Causes and Risk Factors
Hemothorax is more easily developed in patients who are taking an anticoagulant medication or who have a bleeding disorder, especially if the biopsy lesion is small and depth.

**Tips to Avoid Complications**

Pre-procedural laboratory check and pre-procedural CT planning to avoid chest wall vessels are the vital importance.

Prompt identification and treatment of hemothorax is an essential part of the care of the patient.

Thoracotomy is the procedure of choice for surgical exploration of the chest when massive hemothorax or persistent bleeding is present. Traditional criteria indicating the necessity to proceed with urgent thoracotomy are as follows:

- More than 1,500 mL of blood immediately evacuated by tube thoracostomy.
- Persistent bleeding from the chest, defined as 150 mL/h to 200 mL/h for 2 hours to 4 hours.
- Persistent blood transfusion is required to maintain hemodynamic stability.

Tube thoracostomy drainage is the primary mode of treatment for hemothorax. In adult patients, large-bore chest tubes, usually 36- to 42-French, is the traditional means used to achieve adequate drainage in adults. Surgeons debate how large a hemothorax can be safely observed. Billelo et al. contended that collections 1.5 cm on CT can be observed, but their report is severely limited by a lack of long-term follow-up to determine the true risk of fibrothorax or empyema. Others contend that empyema can be prevented entirely by evacuation of hemothorax in the first 7 days. Conversely, radiographically apparent hemothorax after chest tube placement leads to a 33% rate of empyema. Most authors have used the estimated volume of 500 mL, the amount needed to be seen on plain chest radiograph, as the entry point into studies looking at evacuation of retained hemothorax. It is unknown whether complications of retained hemothorax including empyema and fibrothorax could be decreased by a more aggressive approach.

After tube thoracostomy is performed, a repeat chest radiograph should always be obtained. This helps identify chest tube position, helps determine completeness of the hemothorax evacuation, and may reveal other intrathoracic pathology previously obscured by the hemothorax. The presence of retained hemothorax on postplacement chest radiograph has been shown to be an independent predictor of the development of an empyema in 33% of patients. If drainage is incomplete as visualized on the post-thoracostomy chest radiograph, placement of a second drainage tube should be discouraged. In a prospective randomized trial, Meyer et al. showed that patients who had retained hemothorax on plain films 72 hours after initial chest tube output benefited from early video assisted thoracic surgery instead of a second chest tube. Patients undergoing
video assisted thoracic surgery had significantly shorter duration of chest tube drainage, fewer days in the hospital after the procedure, and lower hospital costs than putting in a second chest tube. In addition, 10 of the 24 patients who underwent a second chest tube required surgical intervention later in their hospital stay.

4. Air embolism

**Epidemiology**

An air embolism, also known as a gas embolism, is an embolism or blood vessel blockage caused by one or more bubbles of air or gas in the circulatory system. Air embolism is a rare but potentially fatal complication of percutaneous biopsy of the lung. In a large series of 9783 biopsies, there were only six cases (0.061%) of air embolism. Rapid death may result if embolism to the cerebral or coronary circulation occurs.

**Procedure and Complication Mechanism**

Air embolism is thought to occur by two mechanisms. First, if the tip of the biopsy needle is lodged in a pulmonary vein and the inner stylet is removed, air embolism can occur during rapid inspiration when the atmospheric pressure exceeds the pulmonary venous pressure. Second, when a needle simultaneously traverses an air-containing space and adjacent pulmonary vein, a fistula can occur and air will enter the vein when the alveolar air pressure is greater than the pulmonary venous pressure, for example, with coughing.

**Imaging Features**

Chest radiographs are usually normal unless there is a massive load of emboli. In the event of a large volume of air emboli, there may be areas of hyperlucency overlying the heart shadow, main pulmonary artery, or hepatic veins. Features of focal pulmonary oligemia, pulmonary oedema, or enlargement of the central pulmonary arteries or superior vena cava may be seen.

At CT, air embolism may show some of the above plain film features in detail as well as allow direct visualisation of air in the systemic veins, right-sided cardiac chambers or main pulmonary arteries.

**Causes and Risk Factors**
The risk of air embolism is thought to be increased with cystic or cavitary lesions, vasculitis, and positive pressure ventilation. Presentation can vary dependant on the degree of air emboli where patients with small amount of air can be asymptomatic. Commonly reported clinical manifestations include sudden dyspnoea, chest pain, hypotension and/or convulsions.

**Tips to Avoid Complications**

To prevent air embolism, the inner stylet, saline drops, or a finger should always occlude the introducer needle. The patient should be instructed to avoid breathing deeply and coughing during the biopsy. A cough suppressant may be given before the biopsy if necessary. Biopsy should be avoided if the patient has an intractable cough. In patients on mechanical ventilation, respiration should be suspended during needle manipulation. Patients should not undergo lung biopsy while in an upright or semiupright position.

Air embolism usually manifests as fatal arrhythmias and circulatory collapse if the air enters the coronary arteries and results in coronary ischemia. Cerebral air embolism can lead to generalized seizures and neurologic deficits.

If air embolism is recognized in the left heart or aorta during the procedure or is clinically suspected, the patient should be placed in the mild Trendelenburg position to prevent embolization of the air into the cerebral circulation; 100% oxygen should be administered immediately, which promotes the exchange of oxygen for nitrogen within the air bubbles and accelerates their resorption. Early hyperbaric oxygen therapy is recommended for patients with cerebral air embolism. Supportive therapy with an anticonvulsant medication or steroids may be administered as indicated for cerebral air embolism.

5. Pneumomediastinum

**Epidemiology**

Pneumomediastinum is defined as the presence of air or other gas in the mediastinum, and is also known as mediastinal emphysema. Pneumomediastinum after lung biopsy is an extremely rare complication and has not been commonly reported.

**Procedure and Complication Mechanism**
Traumatic pneumomediastinum is caused by blunt or penetrating trauma to the chest, or iatrogenic injury, such as that produced by mechanical ventilation, thoracic surgery or lung biopsy.

Laceration to the lung parenchyma rather than air entry through biopsy needle is the most likely pathogenetic mechanism. The injury probably produced a bronchopleural fistula, allowing air to track along the continuum between the endothoracic fascia of outer chest wall, pleural space and mediastinum, resulting in subcutaneous emphysema, pneumothorax and pneumomediastinum.

Pathophysiology involves increased intralveolar pressure such as from cough or vomiting which ruptures alveolus, air tracks back along blood vessels to mediastinum. When air builds up in mediastinum and can't pass into the neck this produces mediastinal air block, which can reduce flow of blood in great vessels. Occasionally, the air in mediastinum usually progresses into the neck and the subcutaneous tissue.

**Imaging Features** Fig. 21 on page 40 Fig. 22 on page 41 Fig. 23 on page 42

Diagnostic challenges include differentiating pneumomediastinum from medial pneumothorax and pneumopericardium. If there is no other evidence of pneumothorax, medial collections of air within the pleural space are very difficult to differentiate from pneumomediastinum.

Air within the pericardium is suspected when the pericardial sac itself is visualized. The line formed by the pneumopericardium will be confined to the length of the pericardial sac. Rarely, patients with congenital partial absence of the pericardium will present with a spontaneous pneumothorax. In such cases, air outlines the pericardium and its contents, particularly the roots of the great vessels. The embryologic development of the pleuropericardial membrane is such that a defect in the pericardium is associated with a communicating defect in the pleura. Sub pulmonary pneumothorax and pneumoperitoneum can sometimes be difficult to differentiate from an extrapleural collection of air. Decubitus views can often help make this distinction.

Occasionally, normal anatomic structures may simulate air within the mediastinum. With lordotic positioning, the superior aspect of a major fissure can manifest as a white line, thereby mimicking pneumomediastinum or medial pneumothorax. On occasion, the anterior junction line can also give this spurious impression, particularly if the patient is imaged in a slight degree of obliquity or lordosis.

In addition, pneumomediastinum may be simulated by the Mach band effect. The Mach band effect is associated with convex surfaces, appearing as a region of lucency adjacent to structures with convex borders. The absence of an opaque line, which is typically seen in pneumomediastinum, can aid in differentiation.
Causes and Risk Factors

Post-procedural pneumomediastinum can arise from several causes including spontaneous pneumomediastinum, complication by underlying disease, complication related to biopsy procedure, and anesthetic complications if involved.

Numerous technical, lesion, and patient factors may also contribute to the pneumomediastinum development.

Some authors distinguish between primary pneumomediastinum, in which there is no underlying lung disease that would predispose the individual to air leak, and secondary pneumomediastinum, in which there is an underlying airway disease, such as cystic fibrosis or asthma.

Procedural factors also directly increase the chance of pneumomediastinum. As pneumothorax rate increases with increased number of pleural punctures and wider insertion angle of the needle, pneumomediastinum rate also does.

Tips to Avoid Complications

If the distance between skin and pleura is short, the fixing force from the chest wall to stabilize the coaxial needle may be weak. In such circumstances, to shape a sterile drape into a needle holder during scanning could be a solution. The needle can then be fixed in the planned direction to provide more information during the following scan. If the needle is aimed at the lesion on the following scan, you may insert the needle farther according to the direction indicated by your handmade needle holder.

When inserting the needle, a rapid thrust to the subpleural region for at least 1 cm should be done to avoid needle tip laceration to the pleura with a consequent pneumomediastinum and to avoid the outer cannula slipping into the pleural space during breathing. It is a dynamic process from skin to the lesion; always use the latest scan for planning, and do not strictly adhere to the initial planning and angle. During the whole procedure, the patient moves, lung parenchyma moves, and pneumomediastinum might develop. Thus, only some procedures exactly follow your initial planning; most cases require adaptation and modification during the procedure.

Final manipulation is an important technique for increasing diagnostic yield and avoiding complications. If the coaxial needle is inserted to the periphery of the tumour rather than the centre, aligning the coaxial needle to the lesion before biopsy can get diagnostic tissue. Direct inspection can confirm if the specimen is adequate. Also, post-procedural CT can help in localizing the biopsy direction by visualizing the small haemorrhage caused by the shock wave of the biopsy gun. The final manipulation technique is
6. Tumour seeding

**Epidemiology**

Tumour seeding of the pleura or chest wall along the needle track is an extremely rare complication with a reported incidence of 0.012-0.061%. The reported incidence of needle track seeding from imaging-guided core needle biopsy specifically of pleural mesothelioma is 4%, higher than generally reported for transthoracic needle biopsy. There are also a few case reports of needle track seeding after biopsy of thymoma.

**Procedure**

There are two common methods of obtaining tissue from a tumour or lesion for the microscopic examination and diagnosis. One is biopsy, which is the removal of living tissue by surgical means and the other is aspiration of cells from the tumour with the help of a fine-needle. These procedures are associated with the risk of seeding tumour cells either into the interstitial tissue fluid from where they are carried to lymph nodes, or into the veins draining the tissue from where they enter the vasculature and may travel to lodge into any organ or tissue. There is also a risk of dragging cells along the surgical incision or needle track leading to the possibility of increasing the spread of cancer through biopsy.

Cancer cells, besides reproducing uncontrollably, lose cohesiveness and orderliness of normal tissue, invade and get detached from the primary tumour to travel and set up colonies elsewhere. Dislodging neoplastically altered cells from a tumour during biopsy or surgical intervention or during simple procedure like needle aspiration is a possibility because they lack cohesiveness, and they attain the capacity to migrate and colonize.

**Radiological Features** Fig. 24 on page 43 Fig. 25 on page 44 Fig. 26 on page 45

Malignant seeding has been described months after biopsy of primary bronchogenic carcinoma as well as other primary chest tumours and metastases, including squamous cell carcinoma, malignant mesothelioma, and thymoma.

At CT, tumour seeding manifests as local neoplasm recurrence in a straight line from the primary lesion along the biopsy needle track.
**Risk Factors**

No definitive risk factor related to needle size, tumour size, or tumour location has been identified.

**Tips to Avoid Complications**

For any invasive procedure care needs to be taken during pre-preprocedural, procedural and post-procedural stages to prevent tumour cell seeding.

Related to pre-procedural care it is said that to use a needle of 22 gauge or less and to avoid injecting local anaesthesia into or closely adjacent to a lesion for biopsy could reduce the tumour cell seeding.

While biopsying multiple insertions should be avoided. Using a coaxial cutting needle technique protects normal tissue along the tract and may reduce seeding.

Following diagnostic procedures, daily local radiotherapy has been demonstrated to be beneficial in preventing seeding in patients with mesothelioma. Depending on the tumour cell type, when tract metastasis does occur, the treatment may include radiation therapy or radical full-thickness surgical resection with musculocutaneous flap. If the needle track metastasis is isolated to the chest wall without evidence of distant metastases, wide en bloc resection can be considered.

Other prophylactic solutions could be surgical removal of the needle track and Periodical CT scans for 3 years after fine-needle aspiration biopsy.

**7. Infection**

**Epidemiology**

Lung infection symptoms can include shortness of breath, cough, chest pain or fever. Any procedure where that causes a break in the skin can lead to an infection. The chance of infection requiring antibiotic treatment appears to be less than one in 1,000.

**Procedure and Complication Mechanism**
Infectious complications following lung biopsy occur after introduction of microorganisms into the parenchyma of the lung, the bloodstream, the respiratory tract, or any combination of those, from the hollow core biopsy needle. Residual bacteria in the material or improperly prepared needle guides used in lung biopsy have been suggested as potential mechanisms for contamination.

**Imaging Features** *Fig. 27 on page 46 Fig. 28 on page 47*

Imaging plays an integral role in the diagnosis and management of suspected pulmonary infections and may reveal useful signs on chest radiographs and CT scans. When the imaging manifestations of a known disease entity form a consistent pattern or characteristic appearance, those manifestations may be regarded as an imaging sign of that disease. Imaging signs by themselves are sometimes nonspecific and may also be manifestations of non-infectious diseases. Various imaging signs of thoracic infection can be clinically useful, sometimes suggesting a specific diagnosis and often narrowing the differential diagnosis.

The signs those are most commonly seen or associated with bacterial, viral, fungal, and parasitic infections: consolidation and air bronchogram sign, silhouette sign, tree-in-bud sign, bulging fissure sign, feeding vessel sign, inhomogeneous enhancement sign and cavitation, air-fluid level sign, split-pleura sign, halo sign, air crescent sign of angioinvasive aspergillus infection, air crescent or monod sign of mycetoma, finger-in-glove sign, crazy-paving sign, grape-skin sign, miliary pattern, reverse halo and bird's nest signs, meniscus, cumbo, and water lily signs of echinococcal infection, burrow sign of paragonimiasis. Signs such as the water lily and burrow signs almost always indicate a specific infection, whereas findings such as the split-pleura sign often suggest a specific diagnosis of empyema in the clinical setting of pneumonia. Several signs, such as the halo and reverse halo signs, may indicate potentially serious fungal infections in an immunocompromised patient. Imaging signs of lung abscess, such an air-fluid level sign in a cavity, may also be predictive of prognosis and guide duration of therapy.

**Causes and Risk Factors**

Individual risk factors to develop infection could be as follows: Having other medical problems or diseases, being an elderly adult, overweight, smoking, cancer, weak immune system, and diabetes.

The most common microorganisms related to biopsies and surgeries include bacteria *Staphylococcus*, *Streptococcus*, and *Pseudomonas*. Germs can infect a biopsy wound through various forms of contact, such as from the touch of a contaminated caregiver or instrument, through germs in the air, or through germs that are already on or in your body and then spread into the wound.
Tips to Avoid Complications

Aseptic technique plays a crucial role in infection prevention and includes: "barriers", "environmental controls" and "contact guidelines".

Some examples of barriers used in aseptic technique include: sterile gloves, gowns, drapes and masks, sterile instruments and equipment. Cleansing and bacteria-killing preparations are also applied to the skin before a procedure.

Environmental controls are related to keeping doors closed during an operation or only necessary health personnel at the procedure.

Contact guidelines are related to avoid touching no sterile items at all costs.

Patients with risk factors for sepsis may represent a better target population for intervention with alternative preventative strategies.

Generally, lung infection complications after a biopsy of the lungs can be resolved through treatment with antibiotics.
Fig. 2: Case 1. Pneumothorax in a 69-year-old male with a pulmonary nodule in the right upper lobe. Thoracic axial nonenhanced CT examination shows a laminar pneumothorax after lung biopsy (yellow arrows). The pneumothorax was manually aspirated before the introducer needle by inserting a separate needle into the pleural space attached to tubing with a three-way stopcock and 50-mL syringe (red arrow). Last image shows near complete resolution of pneumothorax after aspiration (white arrow).

© 2016 Department of Radiology, Vall d'Hebron Hospital. Barcelona, Spain.
**Fig. 3:** Case 2. Pneumothorax in a 56-year-old male with a pulmonary mass in the right lower lobe and multiple pulmonary nodules in both right and left lungs. Thoracic nonenhanced coronal reformatted CT examination shows a pulmonary mass in the right lower lobe and multiple pulmonary nodules in both right and left lungs (arrows).

© 2016 Department of Radiology, Vall d’Hebron Hospital. Barcelona, Spain.
Fig. 4: Case 2. Pneumothorax in a 56-year-old male with a pulmonary mass in the right lower lobe and multiple pulmonary nodules in both right and left lungs. Thoracic axial nonenhanced CT examination shows a pneumothorax after lung biopsy (yellow arrow). A self-expanding hydrogel plug was deployed into the pleural space following the lung biopsy (red arrow). The plug expands creating an airtight seal that closes the pleural puncture.

© 2016 Department of Radiology, Vall d’Hebron Hospital. Barcelona, Spain.
**Fig. 5:** Case 3. Pneumothorax in a 75-year-old male with a pulmonary mass in the left lower lobe and multiple pulmonary nodules in both right and left lungs. Posteroanterior and lateral conventional chest radiographs show a pulmonary mass in the left lower lobe and multiple pulmonary nodules in both right and left lungs (arrows).

© 2016 Department of Radiology, Vall d'Hebron Hospital. Barcelona, Spain.
Fig. 6: Case 3. Pneumothorax in a 75-years-old male with a pulmonary mass in the left lower lobe and multiple pulmonary nodules in both right and left lungs. Thoracic axial nonenhanced CT examination shows a laminar pneumothorax during and immediately after the procedure (arrows). The pneumothorax resolved without treatment. The patient was discharged home the same day.

© 2016 Department of Radiology, Vall d'Hebron Hospital. Barcelona, Spain.
Fig. 7: Case 4. Pneumothorax in a 50-year-old male with a pulmonary nodule in the left upper lobe. Thoracic axial nonenhanced CT examination and Positron emission tomography-CT scan show a pulmonary nodule in the left upper lobe (yellow arrows) with increased glucose metabolism (white arrow).

© 2016 Department of Radiology, Vall d'Hebron Hospital. Barcelona, Spain.
**Fig. 8:** Case 4. Pneumothorax in a 50-year-old male with a pulmonary nodule in the left upper lobe. Thoracic axial nonenhanced CT examination shows an enlarging pneumothorax after lung biopsy (arrows).

© 2016 Department of Radiology, Vall d'Hebron Hospital. Barcelona, Spain.
Fig. 9: Case 4. Pneumothorax in a 50-year-old male with a pulmonary nodule in the left upper lobe. Upper posteroanterior and lateral conventional chest radiographs show a 7-French chest tube (arrows) placed by trocar method. Lower posteroanterior and lateral conventional chest radiographs show near complete resolution of pneumothorax after aspiration.

© 2016 Department of Radiology, Vall d’Hebron Hospital. Barcelona, Spain.
Fig. 10: Case 5. Pneumothorax in a 76-year-old male with a pulmonary mass in the right upper lobe. Thoracic axial nonenhanced CT examination shows an enlarging pneumothorax after lung biopsy (arrows).

© 2016 Department of Radiology, Vall d'Hebron Hospital. Barcelona, Spain.
Fig. 11: Case 5. Pneumothorax in a 76-year-old male with a pulmonary mass in the right upper lobe. Thoracic axial nonenhanced CT examination and posteroanterior and lateral conventional chest radiographs show a 7-French chest tube (arrows) placed by trocar method.

© 2016 Department of Radiology, Vall d'Hebron Hospital. Barcelona, Spain.
**Fig. 12:** Case 6. Pulmonary haemorrhage in a 72-year-old male with a pulmonary mass in the right upper lobe. Thoracic axial nonenhanced CT examination shows ground-glass opacities posterior to the nodule (arrows) that correspond to pulmonary haemorrhage after percutaneous lung biopsy. The patient experienced haemoptysis that was resolved. Stability was verified by conventional chest radiograph and the patient was discharged home the same day.

© 2016 Department of Radiology, Vall d'Hebron Hospital. Barcelona, Spain.
Fig. 13: Case 7. Pulmonary haemorrhage in a 65-year-old male with a pulmonary mass in the left upper lobe. Posteroanterior and lateral conventional chest radiographs show a pulmonary 3.5 cm in diameter pulmonary mass in the left upper lobe (arrows).

© 2016 Department of Radiology, Vall d'Hebron Hospital. Barcelona, Spain.
Fig. 14: Case 7. Pulmonary haemorrhage in a 65-year-old male with a pulmonary mass in the left upper lobe. Thoracic axial nonenhanced CT examination shows a consolidation posterior to the nodule, consistent with pulmonary haemorrhage after percutaneous lung biopsy (arrows). The patient experienced haemoptysis immediately after a core specimen was obtained.

© 2016 Department of Radiology, Vall d’Hebron Hospital. Barcelona, Spain.
Fig. 15: Case 8. Pulmonary haemorrhage in a 58-years-old male with a right hilar and multiple pulmonary nodules in both right and left lungs. Positron emission tomography-CT scan shows a right hilar with increased glucose metabolism (yellow arrows). Thoracic axial nonenhanced CT examination shows pulmonary bleeding along the needle track after percutaneous lung biopsy of a left lower lobe nodule (red arrow).

© 2016 Department of Radiology, Vall d'Hebron Hospital. Barcelona, Spain.
Fig. 16: Case 9. Pulmonary haemorrhage in a 59-year-old female with a pulmonary nodule in the right upper lobe. Thoracic axial nonenhanced CT examination shows pulmonary bleeding along the needle track (yellow arrows) and a laminar pneumothorax (red arrow) after percutaneous lung biopsy of a right upper lobe nodule.

© 2016 Department of Radiology, Vall d’Hebron Hospital. Barcelona, Spain.
**Fig. 17:** Case 10. Massive hemothorax in a 73-year-old female with a pulmonary mass in the left upper lobe. Thoracic axial nonenhanced CT examination shows a pulmonary mass in the left upper lobe (yellow arrows). Lower images show a single core biopsy (red arrows).

© 2016 Department of Radiology, Vall d'Hebron Hospital. Barcelona, Spain.
Fig. 18: Case 10. Massive hemothorax in a 73-year-old female with a pulmonary mass in the left upper lobe. Thoracic axial intravenous contrast material-enhanced CT examination, obtained in arterial and portal phases shows a massive active contrast material extravasation that corresponds to active bleeding in the hole left hemithorax (arrows).

© 2016 Department of Radiology, Vall d'Hebron Hospital. Barcelona, Spain.
**Fig. 19:** Case 10. Massive hemothorax in a 73-year-old female with a pulmonary mass in the left upper lobe. Thoracic axial intravenous contrast material-enhanced CT examination, obtained in arterial and portal phases shows a massive active contrast material extravasation that corresponds to active bleeding in the hole left hemithorax (arrows).

© 2016 Department of Radiology, Vall d'Hebron Hospital. Barcelona, Spain.
Fig. 20: Case 10. Massive hemothorax in a 73-year-old female with a pulmonary mass in the left upper lobe. Digital subtraction angiogram examination with a selective catheterization (yellow arrow) shows massive active contrast material extravasation that corresponds to active bleeding from a left intercostal artery (red arrow). The patient died due to hypovolemic shock.

© 2016 Department of Radiology, Vall d'Hebron Hospital. Barcelona, Spain.
Fig. 21: Case 11. Pneumomediastinum in a 49-year-old male with a pulmonary nodule in the right upper lobe. Posteroanterior and lateral conventional chest radiographs show a 2 cm in diameter pulmonary nodule in the right upper lobe (yellow arrow). Thoracic axial nonenhanced CT examination shows the advancement of an introducer to a point just abutting the nodule (red arrow) and pulmonary bleeding along the needle track after percutaneous lung biopsy of a left upper lobe nodule (white arrow).

© 2016 Department of Radiology, Vall d'Hebron Hospital. Barcelona, Spain.
**Fig. 22:** Case 11. Pneumomediastinum in a 49-year-old male with a pulmonary nodule in the right upper lobe. Posteroanterior conventional chest radiographs acquired in the inspiratory phase (left image) and expiratory phase (right image) of the respiratory cycle show pneumomediastinum (arrows).

© 2016 Department of Radiology, Vall d'Hebron Hospital. Barcelona, Spain.
**Fig. 23:** Case 11. Pneumomediastinum in a 49-year-old male with a pulmonary nodule in the right upper lobe. Lateral conventional chest radiographs show pneumomediastinum without (left image) and with drainage chest tube (right image) (arrows). The pneumomediastinum was resolved and the patient was discharged 2 days after.

© 2016 Department of Radiology, Vall d'Hebron Hospital. Barcelona, Spain.
Fig. 24: Case 12. Tumour seeding in a 75-year-old male with a pulmonary nodule in the right lower lobe. Posteroanterior and lateral conventional chest radiographs show a pulmonary nodule in the right lower lobe (arrow).

© 2016 Department of Radiology, Vall d'Hebron Hospital. Barcelona, Spain.
**Fig. 25:** Case 12. Tumour seeding in a 75-year-old male with a pulmonary nodule in the right lower lobe. Thoracic axial nonenhanced CT examination shows proper placement of introducer needle at edge of left lower lobe nodule (yellow arrow) and a laminar pneumothorax during and immediately after the biopsy (red arrows).

© 2016 Department of Radiology, Vall d'Hebron Hospital. Barcelona, Spain.
Fig. 26: Case 12. Tumour seeding in a 75-year-old male with a pulmonary nodule in the right lower lobe. Thoracic axial CT examination, 4 years after the lung biopsy, shows a soft-tissue mass in the posterior chest wall along the needle track (arrows). Tumour seeding was histologically proved.

© 2016 Department of Radiology, Vall d'Hebron Hospital. Barcelona, Spain.
**Fig. 27:** Case 13. Pulmonary infection in a 55-year-old female with a pulmonary nodule in the left upper lobe. Thoracic axial nonenhanced CT examination shows proper placement of introducer needle at edge of left upper lobe nodule (yellow arrows). Lower images show a pulmonary cavity in the left upper lobe 6 months after lung biopsy (red arrows).

© 2016 Department of Radiology, Vall d'Hebron Hospital. Barcelona, Spain.
**Fig. 28:** Case 13. Pulmonary infection in a 55-year-old female with a pulmonary nodule in the left upper lobe. Thoracic nonenhanced coronal and sagittal reformatted CT examinations show a pulmonary cavity in the left upper lobe 6 months after lung biopsy (arrows). Culture of the biopsy material revealed gram-cocci and Aspergillus fumigatus.

© 2016 Department of Radiology, Vall d'Hebron Hospital. Barcelona, Spain.
Conclusion

Summary of recommendations

1. Mortality and morbidity

Operators should audit their own practice and calculate their complication rates to inform patients before consent is given.

Operators should try to achieve the lowest quoted complication rates. These should be similar to, or better than, those from the national survey: pneumothorax (20.5% of biopsies), pneumothorax requiring a chest drain (3.1%), haemoptysis (5.3%), and death (0.15%).

2. Indications for lung biopsy

Patients with lesions on the chest radiograph should be discussed in a multidisciplinary meeting with a respiratory physician and radiologist at a minimum.

Percutaneous transthoracic lung biopsy should be considered in the following:

- New or enlarging solitary nodule or mass on the chest radiograph which is not amenable to diagnosis by bronchoscopy or CT shows it is unlikely to be accessible by bronchoscopy.
- Multiple nodules in a patient not known to have malignancy or who has had a prolonged remission or more than one primary malignancy.
- Persistent focal infiltrates, either single or multiple, for which no diagnosis has been made by sputum or blood culture, serology, or bronchoscopy.
- Hilar mass.

3. Contraindications to lung biopsy

There are relative contraindications to PTLB and the balance of benefit against risk for the procedure should be assessed at a multidisciplinary meeting.

4. Preoperative investigations: coagulation indices

Prothrombin time (PT), activated partial thromboplastin time (APTT), and platelet count should be checked before percutaneous lung biopsy.

Oral anticoagulants should be stopped before a percutaneous lung biopsy in accordance with the published guidelines on perioperative anticoagulation.
Relative contraindications include:

- Platelet count <100,000/ml
- APPT ratio or PT ratio >1.4
- In these situations a decision to proceed to biopsy should be made following discussion with a haematologist.

5. Preoperative investigations: pulmonary function

The balance of benefit against risk for PTLB should be assessed by a multidisciplinary team with a respiratory physician and radiologist as a minimum.

All patients should have recent pulmonary function tests (spirometry) before needle biopsy.

Patients with FEV$_1$ <35% predicted should not undergo needle biopsy without further assessment by the multidisciplinary team.

6. Preoperative investigations: chest radiography and CT scanning

PT, APTT, platelet count, and pulmonary function tests are desirable before needle biopsy. In patients with risk factors for bleeding, PT, APTT and platelet count are required.

Recent chest radiographs and CT scans and all previous radiological investigations should be reviewed to decide if a biopsy is appropriate and must be available to the radiologist at the time of the biopsy.

CT should preferably be performed before bronchoscopy.

Repeat imaging should be performed if there has been significant change in the patient's clinical condition, if there has been significant delay before the biopsy is performed, or if the localising CT scan at the time of the biopsy shows significant change.

7. Biopsy procedure

All patients should have a diagnostic CT scan of the chest and liver before a biopsy procedure.

Specific recommendations for the choice of biopsy imaging depend on the operator but, when possible, ultrasound should be used.

The decision on the type of needle used will be made by the operator and will be dependent on operator experience, available cytological support, and the position of the lesion.
Sufficient passes should be made to obtain diagnostic material (see later).

8. Sedation

Biopsies should be performed without sedation whenever possible.

9. Informed consent

Written information should be given to all patients before the procedure.

Informed consent should be obtained in a written form from all patients.

10. Staffing issues

Staffing should be adequate to enable the patient to be monitored for signs of distress during and after the procedure.

11. Expected accuracy of sampling

False positives should be less than 1%.
Adequacy of sample should be over 90%.
Sensitivity for malignancy should be within the range of 85-90% in lesions over 2 cm.
Standards should be set and outcomes audited.

12. Post biopsy observation

An erect chest radiograph should be performed 1 hour after the biopsy and is sufficient to detect the majority of post biopsy pneumothoraces.

Patients should be informed of the risks of delayed pneumothoraces.

No specific observations are necessary after the biopsy procedure, but patients should remain in a place where staff can be alerted if new symptoms develop in the first hour.

The chest radiograph should be reviewed by a suitably qualified member of staff.

If a pneumothorax has developed, the clinical condition of the patient and their home circumstances should be considered before deciding on further management.

13. Management of acute complications
The operator should be able to identify and appropriately manage the complications of lung biopsy procedures. Resuscitation facilities and chest drain equipment should be immediately available.

When a complication has occurred, the pulse, blood pressure and oxygen saturations should be monitored and recorded in a severely unwell patient.

14. Outpatient and day case biopsies

Percutaneous lung biopsies can be performed safely on an outpatient basis.

"High risk” patients should not have a biopsy performed as a day case procedure.

A post biopsy erect chest radiograph should be performed at least 1 hour after the procedure and a decision should be made at that time regarding further management if a pneumothorax is present.

Patients should be warned of delayed complications and given verbal and written instructions to return if symptomatic.

When biopsies are performed on an outpatient basis, patients should live within 30 minutes of a hospital, have adequate home support, and have access to a telephone.

Discussion

CT-guided biopsy is playing an increasing role in the diagnosis of benign disease, cellular differentiation, somatic mutation analysis, and molecular fingerprint analysis due to an accurate and safe needle advancement and a less radiation exposure.

After appropriate patient positioning, a radiopaque marker or grid is placed on the patient’s skin over the area of interest to focus the optimal access point. A short spiral CT scan of the region of interest is obtained, and from these images, an appropriate table position and needle trajectory are chosen. The shortest straight pathway from the skin to the lesion is preferred over a longer oblique pathway.

Pneumothorax and pulmonary haemorrhage, quite easily treatable and usually non-associated with long-term sequelae, are frequent complications. However, most potential catastrophic complications as massive hemithorax, air embolism, pneumomediastinum, tumour seeding, and infection are extremely rare and difficult to recognize.
Conclusions

1. CT-guided percutaneous chest biopsy has become an indispensable tool in the diagnosis of thoracic lesions as it yields tissue samples for detection, staging, and differentiation of primary cancer from metastases or inflammatory diseases.

2. Radiologists should be familiar with percutaneous transthoracic lung biopsy complications to be able to quickly discover and provide required acute care. Pneumothorax and pulmonary haemorrhage are the most common complications of percutaneous chest biopsy, whereas massive Hemothorax, air embolism, pneumomediastinum, tumour seeding, and infection are extremely rare.

3. Standing protocols for chest biopsy performance, diagnostic workup, and complications management should be in place prior to performing biopsy to obtain diagnostic specimens while reducing preventable complications.
Personal information

This work comes from the Radiology Department of:

Hospital General Universitari Vall d'Hebron
Passeig de la Vall d'Hebron 119-129
08035. Barcelona, Spain.

e-mail address of the first author:

carmenparrafarinas@gmail.com

Carmen Parra-Fariñas
References


