Lung Needle Biopsy Made Easy: A practical approach

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Learning objectives

The learning objectives of this Educational exhibit are:

- The recognition of the main indications and limitations of this interventional procedure

- Step by step description of the basic principles of computed tomography (CT) guided lung biopsy

- Description and illustration of the procedure planning, protocol, materials used and different technical approaches.
Background

CT guided needle biopsy is one of the most commonly performed procedures in thoracic interventional radiology nowadays.

It is known that percutaneous CT-guided needle biopsy of intrathoracic lesions is a well-established technique for obtaining tissue for histopathological evaluation and molecular analysis (1).

This technique is indicated for characterization of lung nodules or masses with indeterminate origin. Despite its well-recognized safety, the complication rates of the procedure are around 28% for pneumothorax, 15% for hemoptysis and 0.3% for severe hemothorax requiring endotracheal intubation (2,3). Therefore, a close observation of best practice is essential.

According to the literature, the diagnostic accuracy and frequency of complications after lung biopsy are connected not only to the lesions’ features but mainly to the interventional procedure’s technical execution (4,5)
Imaging findings OR Procedure details

I. Diagnostic evaluation

In thoracic interventional radiology just like in all other fields of medicine, the patient is always our first concern. As such, every procedure should include careful:

- Review of the patient's clinical history with emphasis on pulmonary and cardiovascular diseases (e.g. Chronic pulmonary obstructive disease, emphysema, interstitial lung disease, pulmonary hypertension);

- Review of current medication;

- Evaluation of the clinical condition of the patient in order to access the patient's ability to tolerate the procedure (e.g. if the patient is fitted to lay on the CT table, or if the patient has persistent cough and if cough suppressants are suitable to be prescribed);

- Review of laboratory evaluation accessing coagulation factors such as platelet count, prothrombin time, activated partial thromboplastin time, international normalized ratio (INR) and hemogram;

- Access, if relevant in the clinical context, the patient's respiratory function tests in order to understand if the patient could tolerate a pneumothorax;

- Review all the previous imaging studies of the patient such as chest radiograph, Chest CT, lung positron emission tomography (PET) or chest ultrasound (US) in order to determine lesion location, location of fissures, detection of lung parenchyma abnormalities (that may determine relative contraindications) and also to depict thoracic anatomy and anatomical variants.

II. Percutaneous CT-guided needle biopsy indications, contraindications and limitations

The traditional common indications for lung needle biopsy are the diagnosis of primary malignancy versus benign disease, diagnosis of lung metastases and staging of known
malignancy. Recent advances in target therapy raised three other new indications for lung biopsy, such as to obtain tissue samples for molecular testing, detect progression of disease, predict prognosis and provide personalized therapy (6).

Some authors allege that there is no absolute contraindication for percutaneous CT guided lung biopsy when the diagnosis is primordial for the patient management; nevertheless according to our experience we advocate some absolute contraindications that are schematize on table 1. (Fig 1.)

We schematize laboratory values as a relative contra-indication due to the fact that these values might be corrected previous to the procedure.

**III. Chest wall anatomy**

The knowledge of chest wall anatomy is crucial to assure a secure interventional approach to lung lesions.

Several tissues compose chest wall. They are arranged in layers that surround the lung and line the inner aspect of the thoracic cavity. (Fig 2,3,4).

Lung is surrounded by pleura that include the visceral and the parietal layers. External to the parietal pleura is a layer of extrapleural fat, which separates the parietal pleura from the endothoracic fascia. This fatty layer is very thin in most locations but can be markedly thickened over the lateral or posterolateral ribs, resulting in extrapleural fat pads several millimeters thick (8).

The thoracic cavity is lined by the #broelastic endothoracic fascia that covers the surface of the intercostal muscles and intervening ribs, blends with the perichondrium and periosteum of the costal cartilages and sternum anteriorly, and posteriorly is continuous with the prevertebral fascia that covers the vertebral bodies and intervertebral discs (8).

External to the endothoracic fascia are the three layers of the intercostal muscles. The innermost intercostal muscle passes between the internal surfaces of adjacent ribs and is relatively thin; it is separated from the inner and external intercostal muscles by a layer of fat and the intercostal vessels and nerve (8).

Although the innermost intercostal muscles are incomplete in the anterior and posterior thorax, other muscles (the transversus thoracis and subcostalis) can occupy the same relative plane. Anteriorly, the transversus thoracis muscle consists of four or #ve slips that...
arise from the xiphoid process or lower sternum and pass superolaterally from the second to sixth costal cartilages. The internal mammary vessels lie external to the transversus thoracis. Posteriorly, the sub-costal muscles are thin, variable muscles that extend from the inner aspect of the angle of the lower ribs, crossing one or two ribs and intercostal spaces, to the inner aspect of a rib below (8).

IV. Pre-procedure steps

1. Radiologist-patient relation and information about the procedure

Communication and doctor-patient relationship is one of the most important cornerstones of all health care. Before planning the technical details of the procedure, open and understandable communicate with the patient is of utmost importance, providing all the relevant and requested information about the procedure and promote patient's confidence and trust. A brief explanation of the indications, contraindications and possible complications of the procedure, according to our experience usually result in lower level of anxiety and better collaboration during the procedure.

2. Informed Consent

Percutaneous CT-guided lung biopsy is an invasive procedure with potential complications, including death, thus obtaining informed consent with the patient and his or her family after fully explaining the procedure and its potential risks is important, due to ethical and legal issues.

3. Laboratory values review

It is important to review, before the procedure, all the recent laboratory values. Coagulation changes (INR above 1.5) should be corrected by administration of fresh frozen plasma or vitamin K. Platelet transfusion is recommended for platelet counts less than 50,000/µL (5).

4. Medication

Any anticoagulant medication is discontinued at least 4-5 days before the procedure (5,7,9). Clopidogrel (Plavix, Bristol-Myers Squibb) should be withheld for 5 days. One dose of low-molecular-weight heparin (enoxaparin, Lovenox, Sanofi Aventis, or dalteparin, Fragmin, Eisai) should be withheld before the procedure (5). Although guidelines do not recommend withholding aspirin, if possible, nonsteroidal antiinflammatory drugs, including aspirin, should preferably be stopped for 5-7 days (5).
V. Technical Procedure considerations

1. Interventional working table preparation and teamwork

The first technical step of the procedure is setup the interventional working table with all the material that will be used during the biopsy. All the material placed on the table is sterile to avoid introduction of infection agents to the lung.

All the material is illustrated on figure 5.

Cooperation and profitable teamwork between radiologists, nursing staff and radiology technicians is vital to the safety and time management of the procedure.

2. Biopsy Needles

Nowadays there are several biopsy needles available with different gauge, lengths, tip configurations, and sampling mechanisms. Needle selection depends upon lesion characteristics, type and amount of tissue required, and also with operator experience and preference. Percutaneous lung biopsy needles may be divided in two types: Fine aspiration needles for retrieval of specimens for cytologic evaluation, and cutting needles for retrieval of specimens for histologic evaluation. The latter might also be divided in manual or automated core biopsy needles.

The diagnostic accuracy of aspiration biopsy is almost as good as core biopsy for the diagnosis of malignant lesions, especially if an onsite cytopathologist is present. However, for the diagnosis of benign lesions and lymphoma, core biopsy is preferred (7). Although rates for pneumothorax are similar for aspiration needles and cutting biopsy needles, a slightly higher incidence of pulmonary bleeding is reported with cutting biopsy needles (7). According to the literature, needles larger than 18-gauge are considered a risk for causing both bleeding and pneumothorax (7,9).

The main differences between these two types of needles are schematized on the table 2. (Fig. 6)

- Fine aspiration needles

Aspiration needles are thin-walled and flexible, and are used for obtaining specimens for cytologic or microbiologic evaluation. The most commonly used of this group is the Chiba (Cook, Inc. Bloomington, IN), which has a 30-degree bevel, and is available in 18- to 25-gauge sizes (9).

According to our experience these needles require more operator precision and experience because of their flexibility, easily bending or deflecting off course. In our institution despite cytological sampling adequacy for selected cases, in order to provide
large amount of specimen and to evaluate tumor markers and tumor mutational status we commonly perform core biopsy.

- Cutting needles

These needles have a variegated tip or cutting notch on the side; two commonly used needles in this class are the Franseen (Cardinal Health, McGaw Park, IL) and Westcott (BD Worldwide Medical, Franklin Lakes, NJ) needles. These are modified aspiration needles, in that they can "cut" tissue in addition to aspirating it. Typical sizes used are between 18 to 22 gauge (9).

Automated core-biopsy needles are double-throw devices that use a spring-activated mechanism to sequentially fire first a thin-notched needle, followed by an outer cutting cannula. The length of the side-notch needle varies between devices, as does the throw-length. Some devices have fixed throw-length, whereas others are adjustable, such as the Temno Evolution1 (Cardinal Health, McGaw Park, IL) (9). (Fig 7 and 8)

3. Single needle technique and Coaxial technique

Aspiration and core biopsies may be used as single needle technique or in a coaxial technique.

In the single needle technique, a needle is directly advanced into the lesion and if multiple samples are required each time, a new pass will be made. The disadvantage of this technique is that each time we obtain a sample the needle is introduced into the lesion by image guidance, increasing of radiation dose and procedure time. Furthermore, intervening structures are traversed each time, resulting in increased risk of complications (7).

On the contrary the co-axial technique involves the initial placement of an outer guiding needle close to the target, followed by the introduction of a thinner biopsy needle through it to sample the lesion (7,9).

The main advantage of the coaxial technique is that multiple needle passes may be made into a lesion without the time-consuming process of repositioning the needle within the subcutaneous tissues for each pass. Also reduces the radiation dose given per procedure. However, differences in diagnostic accuracy and rates of pneumothorax have not been shown to be significant between the single needle technique and the co-axial needle technique (9).

When using the coaxial technique, we have to keep in mind never to leave the outer cannula inside the patient without the inner stylet, (Fig.9) in order to avoid a pneumothorax and an air embolism, which can potentially lead to myocardial infarction, stroke, or even death (1).
At our institute, we use a 18-gauge coaxial needle (TruGuide, Bard) with a length of 13 cm for most cases. Sometimes, a 17-gauge coaxial needle with a length of 17 cm is used for deep lesions. The core biopsy is routinely performed with the matching 18-gauge cutting needle (Magnum Needles, Bard) and biopsy gun (Magnum, Bard).

Some of the tips that we use to avoid air embolism are while taking out the stylet tap with the finger the outer needle or drop sterile saline solution inside to avoid air entrance.

According to our experience the limitation for coaxial technique use is related to the depth of the lesion and the size of the coaxial needle.

4. Patient positioning

Patient positioning in CT table allows the radiologist to choose the best approach to the lesion. Commonly, the patient is positioned in the supine or prone position with the arms lateral or above the head (Fig. 10, 11, 12 and 13). These positions avoid crossing the interlobar fissure with the biopsy needle, thus reducing the risk of pneumothorax (5).

Prone position is preferred due to the fact that the posterior ribs move less than the anterior ribs and the posterior intercostal spaces are wider. This positioning reduces anxiety due to preventing the patient from visualizing the needle during the procedure. Also in our experience the patient better tolerates prone positioning during procedure time. Moreover, the patient can recover in the more comfortable supine position.

The oblique and decubitus positions are less stable than supine or prone positions but can be considered as an approach into a subpleural lesion in the lateral aspect of the lungs, thus avoiding transgression of normal pulmonary parenchyma (5,7).

5. Breathing instructions

Breathing instructions depend not only on the location of the lesion but also on the preference of the operator.

Usually upper lobe lesions can be targeted during gentle breathing and no special breathing instructions are required. Nonetheless, lesions closer to the diaphragm suffer more displacement with the respiratory motion. Before each procedure, we explain to the patient the importance of breathing slowly to cause minimal motion once a needle has passed through the pleura. Deeper inspirations will cause significant needle movement with greater chances of tearing the pleural surface (7). We also explain to the patient, even if it is not easy to hold the appropriate position, it is important to have the same degree of inspiration each time during scanning or needle manipulation, so that the target lesion remains in a predictable position throughout the biopsy procedure.

6. Sedation and anaesthesia
The use of sedatives depends on the patient’s clinical and psychological condition. According to our experience and the clinical history of the patient, we advocated the use of midazolam or diazepam for conscious sedation of anxious patients, elderly patients who are unable to lay still on the CT table and sometimes for biopsies of small lesions in the lower lobes near the diaphragm. However the dose of the sedative should be carefully adjusted not to lose patient collaboration during breath hold instructions.

Regarding anesthesia, all patients in our department are injected with 1% or 2% lidocaine thru a 25-gauge hypodermic needle. First the skin and subcutaneous tissues are infiltrated and afterwards the intercostal muscles till the pleura, without penetrating it. Discomfort from lidocaine injection may be decreased by addition of sodium bicarbonate, which increases its pH (9).

7. 'Keep in mind' concepts when biopsy the lung

There are some concepts that several authors refer in the literature, which should always be present when performing lung biopsy. Some of them are intuitive, but the end-point of the procedure depends not only on big steps but also on small details.

In first instance the knowledge of anatomy in this type of biopsies helps to avoid intercostal arteries, veins and nerves that run along the inferior margin of the rib, which implies that the needle should be placed above the upper margin of the rib not to cross the neurovascular bundle. Before starting the procedure, it is important to identify all lung fissures so as to avoid their unwillingly transversal with the needle as thus reduce the risk of subsequent pneumothorax.

Respiratory motion is another important concept since some lung lesions are more affected by respiratory motion that others, like the ones sited on lower lung zones. For these lesions, before we advance the biopsy needle we should relate to the respiratory phase the previous scan was acquired and adjust the needle advancement to the patient’s breathing.

Motion artifacts are not only affected by respiratory motion but also by cardiac motion. This motion is seen most commonly in the left lingula, near the left ventricle and pulmonary trunk (9). However in these cases this detail is difficult to surpass therefore the initial procedure planning should take this in consideration and plan wider and secure margins for the procedure.

Additionally, it is important to realize the traumatic nature of the shock wave induced by firing the automatic biopsy needle gun on the normal lung parenchyma, traveling both longitudinal and sideways along the needle track. This vibration or Shock wave injuries the lung parenchyma and usually mild parenchymal hemorrhage appears (1). Regarding this concept, regions distal to the tip and lateral to the needle are named danger zones and consequently major vessels should be well away from these danger zones.
8. Scan protocol

The common scan protocol suggested is an axial scanning with 120 kVp, 30 mAs per slice, 0.5- to 1-second rotation time, and collimation of 5 mm. The window center and width are 0 and 2,800 HU, respectively, which allows simultaneous visualization of vessels, tumor, pneumothorax, bone, muscle, and fat (1). In our department we perform an additional scan with intravenous contrast injection if the patient has no prior study or contraindications, in order to depict vascular structures more accurately.

9. Plan Access route

After obtain the baseline scan, and keeping in mind all the previous concepts, an access route is planned. Chest wall vessels, including the internal mammary, axillary, subclavian, intercostal vessels, central vessels and heart are avoided. Lung parenchyma disease should also be taken into consideration, avoiding large bullae and areas of marked emphysema.

The radiologist should also evaluate the lesion before, and plan access to the region that will provide a better specimen. As an example, when performing percutaneous needle biopsy of the lung of a mixed-attenuation lesion, sampling of the solid portion is preferable; another example is when the lesion contains central necrosis or cavitation, one should aim for the wall of the lesion (1).

An important technical tip referred less often in the literature is to plan the access route with angulation of the scanner gantry. This is fairly helpful in lesions located in the inferior portion of upper lobes, that with gantry angulation will allows a superior needle entry point with caudal angulation of the needle over the major fissure. Similarly, gantry angulations allow needle entry at an intercostal space superior or inferior to a lesion (1). We use also use this technical pearl in our institution when we need to see all the needle path inside the lung.

After choosing the most suitable axial image with the most careful access route the patient is moved into the CT gantry at the same table position and this level is marked over the patient's skin with a laser light emitted from the scanner. Depending on the hospital material, to calculate the distance from the midline of the CT gantry to the anticipated skin entry site and the lesion depth, the grid superimposition technique might be used. In our institution we use 3 thin metal markers that are place on the laser line marked and adjust the position of these markers according to the next scan control (Fig. 14). With these metal markers and in cooperation with the radiology technician the distance and the angle from the skin marker to the lesion is measured.

After, the skin entry site is marked according to the laser line and the metal marker with inedible ink (Fig. 15). After cleaning the area, a sterile drape with a central hole is placed
on the region of interest (Fig. 16) and local anesthetic is injected on the cleansed skin (Fig. 17 and 18)

10. Needle entry, trajectory and manipulation

In our institution we use the anesthetic needle to start guiding our trajectory. This needle is left in placed in the soft tissue of the chest wall and all necessary adjustments are done to align the needle perfectly with the target lesion prior to piercing the pleura.

Again, with the radiology technician, the anticipated path of the needle is traced on the CT console by extrapolating the needle towards the lesion. Thereafter, the anesthetic needle is changed by a co-axial needle and again controlled the position with a scan. If the access route is maintained, we advanced the coaxial needle in one stroke through the pleura and into the lung, proximal to the lesion margin in peripherally situated lesions, or at least 1-2 cm inside the lung. Leaving at least 1-2 cm needle inside the lung parenchyma avoids slipping of the needle into the pleural space during respiratory motion and prevents needle tip laceration of pleura (7,9). After entry into lung, the needle should be left to move freely with respiration and should be touched only during the designated breath hold.

Small subpleural lesions are difficult to biopsy because a short needle length inside the lung is unstable and can be easily dislodge during respiratory motion, resulting in tearing of the pleural surface (7). Some authors prefer a tangential route rather than a right angle path for sampling the subpleural lesions, as it offers greater needle stability and easier needle correction, but the angle of entry through the pleural layers also predispose to pleural tearing and pneumothorax (7,9).

Needle angulation while inside the lung parenchyma is relatively easy to achieve due to the soft nature of the tissue. However, if large angle corrections are needed, the needle should be slightly withdrawn without exiting the lung parenchyma and again advanced after reoriented. The tissues of the chest wall can limit the extent that the needle can be reoriented, especially in large or muscular patients. Pulling on the soft tissues of the chest wall may allow gaining further room to reorient the needle with full reinsertion being needed (9).

With coaxial systems, the needle is partially withdrawn and the needle tip is redirected by pushing the hub in the desired direction while applying fulcrum-like pressure at the skin surface. Then, the needle is re-advanced towards the lesion while maintaining it in the desired angulation. While manipulating the needle in the lung, withdrawal and re-advancement of the needle tip through the pleura should be avoided (7)

11. End-point and final manipulation
The end-point of percutaneous CT-guided lung biopsy is to obtain adequate tissue for pathologic assessment and more recently for molecular testing.

Most institutions obtain at least two samples. Nevertheless, in our department, if the sample is judged to be inappropriate and if there is no bleeding, another core sample is obtained to optimise the diagnostic accuracy while taking care not to risk unnecessary complications.

A postbiopsy scan is mandatory to detect any complication provoked by the needle withdrawal.

VI. Gathering all together - Resume of the procedure step by step

1. Review patient clinical history, medication, recent laboratory values and previous imaging evaluations.
2. Explain the procedure and sign the informed consent.
3. Position the patient in the CT table.
4. Obtain a short spiral CT scan during suspended respiration and chose an appropriate table position and needle trajectory.
5. Mark with laser lines and metal markers the patient's skin over the area of interest.
6. Measure the depth from the skin entry to the pleura and to the site of the lesion. Fig xx - TC com medidas)
7. Mark the skin entry site according to the laser line and the metal marker with inedible ink. (fig 15)
8. Prepare the skin entry site with a cleaning solution like povidone-iodine.
9. Place a sterile drape with a central hole on the skin' region of interest. (Fig 16)
10. Inject with a subcutaneous needle lidocaine 1% or 2%. Infiltrate subcutaneous tissues, followed by deeper infiltration of the intercostal muscles. (Fig 17 and 18)
11. Leave the anesthetic needle with a cap (Fig 19)
12. Scan the patient to confirm appropriate access route within the correct plane and choosing the appropriate needle angle. (Fig 19)
13. Using the previous measurements, a small marker on the coaxial needle can serve as a visual aid to the amount of needle advancement intended. (Fig 20 and 24)
14. With a number 11 surgical blade, a small cut on the skin surface is created. This will facilitate needle introduction into the subcutaneous tissues. During needle insertion, one hand should hold the needle at skin level to stabilize and steer the needle. The other hand should hold the hub, and provide downward force to advance the needle. All needle movements should be performed with patient's respiration suspended. When advancing the needle, it is important to maintain the same trajectory with each movement, as even
slight deviations of the needle at the skin or within the subcutaneous tissues will produce marked deviation at a deeper level. (Fig 21)

15. Advance the needle in one motion through the pleura to the intended depth. Afterwards, the patient may be allowed shallow breathing, and the needle should be allowed to sway to-and-fro with respiratory motion; the needle should not be held or fixed during respiration, as this will cause a lacerating effect on the pleura with each breath.

16. Confirm the needle tip position before aspirating or cutting. The key to recognizing the true tip of the needle is the identification of an abrupt square tip with a black shadowing artifact arising from it (fig 22)

17. The coaxial needle tip should be placed inside the lesion (Fig 22), if its size will allow it. Placing the coaxial needle tip in this position will help stabilize it when the automatic biopsy system fires. If the needle position should be placed inside the lesion while allowing for the throw of the cutting needle to remain inside of it. This way, no normal lung parenchyma is cut as the needle open and cuts without exiting the target lesion.

18. The cutting needle throw should be adjusted if possible, so as to avoid cutting normal lung parenchyma. Cutting normal parenchyma predisposes the procedure to a pneumothorax.

19. If using a coaxial technique, several tissue samples can be obtained without replacing the coaxial needle. Rotating the cutting needle or slightly angling the coaxial needle between tissue sampling can prevent firing the needle along previous needle tracks (which will lead to inappropriate tissue sampling with hematic material) (Fig 23)

20. After firing the biopsy needle, it should be slightly retracted but without leaving the lung parenchyma. A scan can then evaluate the presence of immediate complications like a pneumothorax or hemorrhage.

21. If a pneumothorax is confirmed and it is significant, the coaxial needle still inside the thoracic cavity can be used to aspirate air. If an excess of 600ml of air is aspirated, then a pigtail catheter (8F) could be placed inside the pleural space through a Seldinger technique and water-sealed aspiration initiated. Any pneumothorax can be safely managed while inside the CT room as long as these precautionary measurements are taken.

22. If no pneumothorax is identified, the needle may be removed in a slow but unhesitant motion and the patient rescanned.

23. Hemorrhage is a frequent complication, occurring in close to 30% of cases (even though there is a large variability of published rates). These events almost always have no clinical significance but one should always keep in mind that a hemorrhagic complication after lung biopsy can be fatal and that life-saving angiographic embolization may be needed.

24. A post-biopsy imaging control should be taken 4 to 6 hours after the procedure. Although CT is often used to this effect, a chest radiogram can reliably reveal a clinical significant pneumothorax. Some pneumothoraces only present several hours after the biopsy and as such, this later imaging control is still needed, even if the immediate post-biopsy scan was uneventful.
25. Hemoptysis is almost always self-limited and usually spontaneously resolves in a matter of days, even if they appear significant. In most cases, patient reassurance is the only measurement needed. However, lung biopsy procedures can result in massive hemoptysis if the lesion is highly vascularized or in close proximity to major vessels, so care and good-sense should be always present.

VII. Post-procedure care

After the procedure, review to see how closely the procedure followed the access route plan, check if the specimen obtained is adequate for the pathologist, and to determine whether the patient developed complications.

Immediately after the biopsy the patient is placed on bed rest in contrary position to the position of the biopsy. Talking, moving, and coughing are discouraged to prevent pneumothorax. Oxygen is administered at 2 L/s by nasal cannula. The patient's heart rate, respiratory rate, blood pressure, and oxygen saturation level are monitored during the 3-hour recovery period (1).

Usually the patients after the procedure don't complain on pain, nevertheless it depends on the patient clinical and psychological condition and mild oral analgesia may be prescribed for 24-48 h following the biopsy.

In some institutions the patient is moved to a dedicated recovery unit for 4 h or directly to the ward.

In our department a routine chest x-ray is performed at 4 h to ensure no pneumothorax was created during or after the procedure.

VIII. Follow-up

It is a duty not only of the radiologist who performed the procedure but also of the other clinicians in charge with the patient to be available in the event of a late complication such as delayed pneumothorax or hemoptysis. Patients must be informed of such complications and their recognition in order to and the importance return to the hospital in case of a day case procedure.

IX. "Think out" and remember

Despite following all the steps and maintain all the rules for a secure procedure complications may occur. Therefore it is important to always keep in mind that Pneumothorax, pulmonary hemorrhage, hemothorax and chest wall hematomas are the
most commonly encountered complications of this procedure. Hence early detection of complications and timely management are important.
**Fig. 1:** Percutaneous CT-guided needle biopsy absolute and relative contraindications

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Fig. 2: Normal structures at the pleural surface

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**Fig. 3:** Normal structures of the posterior chest wall pleural surface

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**Fig. 4:** Normal structures of the anterior chest wall pleural surface

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Fig. 5: Worktable with all the material that will be used during the biopsy.

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**Fig. 6:** Percutaneous CT-guided aspiration and core biopsy needles

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Fig. 7: Two-phase automatic cutting needle device. This device allows for two firing step corresponding to the inner stylet throw and to the cutting outer cannula advancement. By allowing the advancement of the inner stylet, the extent of the cutting throw of the needle can be visualised before the final firing of the biopsy gun, as thus allowing the performing radiologist to precisely place the needle and avoid injury to adjacent structures. It should be noted that the inner stylet if relatively atraumatic to the lung parenchyma in comparison to the outer cutting cannula.

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**Fig. 8:** Automatic needle biopsy gun with a fixed 22mm throw. Once fired, the inner stylet and the outer cutting cannula cut the tissue in a single rapid movement. Care should be taken to ensure that the distal tip of the needle does not injure any vital structure once fired.

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**Fig. 9:** Coaxial needle with the inner stylet placed in order to avoid air entrance

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**Fig. 10:** Prone position in the CT table

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Fig. 11: patient lying in supine position in the CT table

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Fig. 12: patient lying in prone position in the CT table with the reference laser lines and metallic markers

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Fig. 13: patient lying in prone position in the CT table with skin mark made with inedible ink

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Fig. 14

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Fig. 15: a) Mark the skin entry site according to the laser line and the metal marker with an inedible ink b) Prepare the skin site cleaning with a cleaning solution

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Fig. 16: a) Disinfection of the marked chest skin with povidone-iodine b) sterile field placed on the region of interest

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Fig. 17: Injection of lidocaine 1% with a 10ml syringe and a 27 gauge needle

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Fig. 18: Inject with a subcutaneous needle lidocaine 1% or 2%.

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Fig. 19: Close the anesthetic needle lumen with a cap

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**Fig. 20:** Using the fingertip to prevent significant air volume to enter the coaxial needle lumen while withdrawing the inner stilet

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Fig. 21: Small angulations on the skin surface will lead to significant needle deviation in deep tissues

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**Fig. 22:** Coaxial needle placement inside the target lesion with enough space for the needle throw

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**Fig. 23:** Rotating the cutting needle and angling slightly the coaxial needle will allow for better sampling fragments to be obtained

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Fig. 24

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Conclusion

CT guided lung biopsy is a well-established technique which, in daily workflow, plays a central role in lung pathological assessment. Therefore, regarding the diagnostic benefit and the potential complications, the radiologist should be acquainted with all main aspects of the procedure, from the patients’ selection criteria to recommended follow-up protocols.
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