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Needle biopsies of lung lesions: Options, indications and complications

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Abstract
Background This article aims to comprehensively describe indications, contraindications, technical aspects, diagnostic accuracy and complications of percutaneous lung biopsy.
Methods and Materials: Fine-needle aspiration biopsy (FNAB) and core-needle biopsy (CNB) currently is the predominant method for obtaining tissue specimens in patients with lung lesions. In many cases treatment protocols are based on histological information. In 85 of all 97 patients included in ours study FNAB biopsy is performed and in 12 patients (CNB), when technically feasible, or in cases where other techniques (such as bronchoscopy with lavage) are inconclusive. The 19-22G disposable needles were used.
Results In all 97 patients, aged 19-69 years with pulmonary lesions with dimensions of 2.0 cm or less FNB under CT control are performed. In 15 cases FNA under US control are performed due to the superficial localization of the lesions. Cytological and histhological evaluation of FNAB samples were performed in all patients. Diagnostic sensitivity and accuracy are calculated. Assess the nusmber and type of complications that occurred. Fine-needle aspiration biopsy (FNAB) and core-needle biopsy (CNB), with the latter demonstrated to have a slightly higher overall sensitivity, specificity and accuracy.
Conclusion Percutaneous fine-needle aspiration biopsy (FNAB) and core-needle biopsy (CNB) are safe procedures even though a few complications are possible: pneumothorax, pulmonary haemorrhage and haemoptysis witch are common, while air embolism and seeding are rare, but with severe consequences.

Keywords: lung lesion. Fine-needle aspiration biopsy (FNAB). Core-needle biopsy (CNB). Complication. Diagnostic accuracy

Introduction

Chest tumours, in particular lung cancer, remain one of the most common causes of death worldwide. With the aplication of MD spiral CT, an increasing number of lung and mediastinal lesions is detected and histological diagnosis is often necessary to determine the most appropriate management of these lesions(1). Various imaging techniques including computed tomography (CT) fluoroscopy and ultrasound (US) can be used to guide chest biopsies. CT is the most frequently used methods because of its high spatial and contrast resolution.

Indications of imaging-guided chest biopsy have significantly changed as a result of technical advances in needle types, imaging modalities, pathological analysis and immunohistological techniques. At present, the growing list of indications includes histological diagnosis of undetermined and otherwise not characteristical pulmonary, mediastinal and chest wall lesions as well as biopsy or re-biopsy of known malignant lesions to obtain histological material for targeted therapy (Fig. 1).

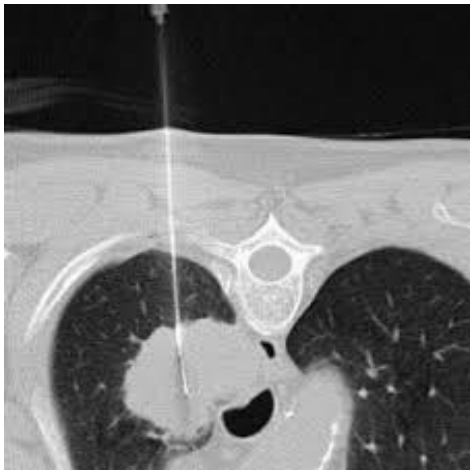

Fig 1: Axial image from computed tomography–guided biopsy in lung windows with a patient in prone position shows the biopsy needle in the center of the large irregular right lung mass having histology consistent with undifferentiated small cell lung cancer.

On the last decade the use of MDCT has increased with the detection of small pulmonary nodules.

In many cases pulmonary nodules are incidentally detected in general population [3] in patients without clinical manifestation. If a nodule is initially identified at conventional chest radiography, CT investigation is necessary to characterise the lesion, estimate the malignancy [4] and identify lymphadenopathies or other accessible sites for biopsy - extra-thoracic metastases [5]. PET-CT examination may also be helpful in the investigation of pulmonary nodules, reducing the need of puncture of non-enhancing solid nodules [6]. It must be taken in consideration that active inflammation (i.e. active tuberculosis, histoplasmosis, rheumatoid nodules) may cause false positives on PET-CT scans because of their high glucose metabolism [7]. Although low-grade malignant tumours, such as carcinoid [8] or low-grade adenocarcinoma [9], may produce falsenegative results because of their low glucose metabolism. In these cases follow-up with CT must be performed to demonstrate regression of the nodule after therapy or to biopsy if increase in size are evident [10].

Mediastinal masses are most frequently located in the anterior mediastinum and include a variety of different entities, such as thymic malignancy, lymphomas, endocrine tumours and malignant germ cell tumours. In the absence of typical clinical and imaging features, histological diagnosis is necessary.

Imaging guidance techniques

MDCT and US we used to guide chest biopsies. Parameters affecting the selection of the most appropriate imaging technique are the size and visibility of the lesion as well as its relationship with critical anatomical structures. Whenever possible, chest biopsies should be performed under US guidance (Fig. 2) to use the advantages of real-time monitoring without radiation to patients and operators [11];

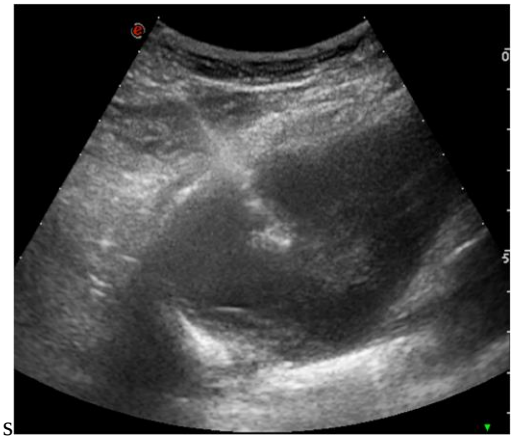

Fig 2: Ultrasound-guided FNB biopsy of a pulmonary nodule in the left lower lobe

US guidance is limited to superficial lesions adjacent to the chest wall or to lesions delineated by pleural effusion sufficient to create a suitable interface for ultrasound penetration. In the significant majority of cases, MDCT (Figs. 3) is the preferred guidance method for chest biopsies due to its optimal spatial and contrast resolution. Furthermore an intravenous contrast agent can be used to differentiate target lesions from atelectasis, necrosis and vascular structures.

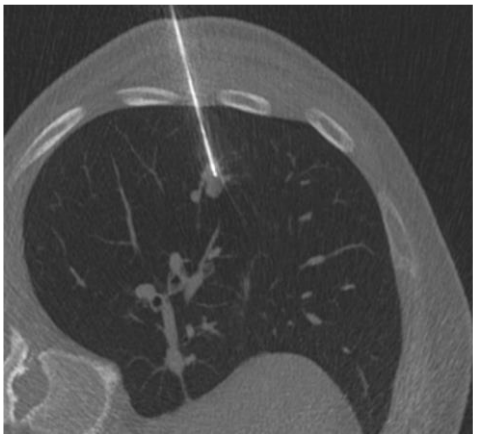

Fig 3: CT-guided chest biopsy of a pulmonary nodule in the left lower lobe.

Biopsy procedure

Patient positioning and instruction

The patient should be positioned prone, supine or lying on the side, based on the previously planned access site. Whenever possible, the needle access site should be cephalic to the ribs to avoid intercostal vessel and nerves puncture (Fig. 4). The skin in the access site should be sterilised with standardised antiseptic solution and subcutaneous tissues should be infiltrated with lidocaine.

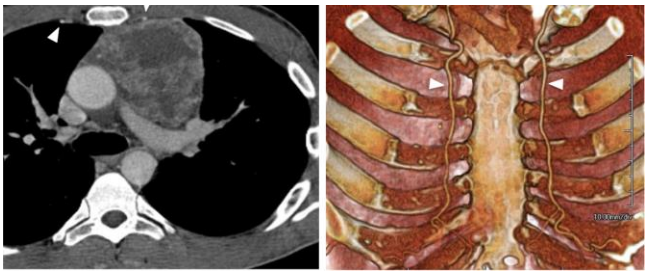

Fig 4: (a) Axial CT image and (b) 3D reconstruction showing internal mammary arteries (arrowheads), which must be avoided during the procedure

Breath-hold capabilities are extremely different from patient to patient. Therefore, it is easier to target larger tumours (>2/3 cm) instructing the patient to breath freely with shallow respiration. In the remaining cases, the patient can be instructed to maintain an inspiratory or expiratory apnoea to allow easier access to target lesions under CT or US control (Fig. 5 and Fig. 6).

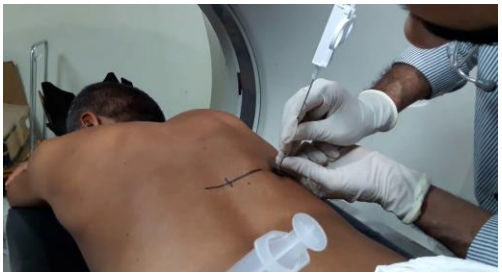

Fig 5: CT scan Lung Biopsy

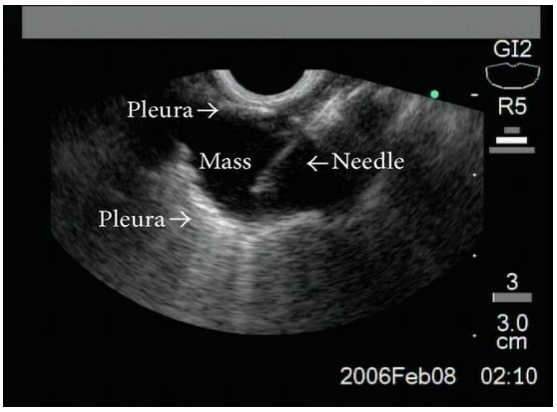

Fig 6: US-FNA of the lung mass identified in the subcostal region was performed

Needle types

Needle choice is based on the size and location of the lesion, planned needle path way, status of the lung parenchyma and operator preference. Some of the used fine-needle aspiration devices include Chiba, Westcott, Greene (Cook) and Turner (Cook) needles, which have circumferentially sharpened tips allowing for sampling (Fig.7).

Fig 7 a: Cook Franseen Lung Biopsy Needle 18G x 15cm and b) Pave Preps First-of-its-Kind Lung Biopsy Device

Core biopsy needles are designed to collect a small piece of tissue intended for surgical pathology analysis and can be designed as end-cutting or side-cutting devices.

The most commonly used core biopsy needle is the Tru-Cut, which consists of an outer cutting cannula and an inner slotted stylet. The presence of an on-site pathologist may reduce the number of biopsies needed.

Diagnostic accuracy

We prefer MDTC for guidance of FNB due to the better biopsy needle path control and the visibility of small-sized and deeply located lung lesions. We have a wide variation in diagnostic accuracies of fine-needle aspiration biopsy (FNAB) ranging from 64% to 97%. Core biopsy has been shown to have slightly higher overall sensitivity, specificity and accuracy, with values of 89%, 97% and 93%. The test of genetic mutations is important to plan targeted therapies in patient with lung cancers. Therefore, it is necessary to obtain a sufficient amount of tissue sample.

In our studie the effects of lesion location on the diagnostic accuracy of imaging-guided biopsy in chest tumours were evaluated. In a paper from Layfield *et al*., the sensitivity in diagnosing lung tumours decreased from 100% in peripheral lesions to 82% in central lesions; however, this study was Conducted in 1996 with basic CT equipment, as demonstrated by the striking differences

In sefnsitivity between fluoroscopy guidance (97%) and CT guidance (80%). Yamagamy *et al*. demonstrated that some peripherally located lesions are not accessible at all with conventional CT guidance because oftheir relationship with rib arcs, thus requiring needle positioning under CT-fluoroscopy guidance. Finally, Wang *et al*. [11] recently compared the rates of complications and diagnostic accuracy of CT-guided biopsy in peripheral versus paramediastinal lesions, demonstrating how this technique may be safe and reliable even for deeply located tumours; in particular, their paper reports diagnostic accuracy of 95.4% in paramediastinal lesions and 94.7% in peripheral lesions, with a sensitivity of 95.6% and 94.2% respectively.

Post-procedural care and complications

Once the biopsy has been performed, a CTscan of the chest is obtained to identify any immediate post-procedural complications. According to some authors, the patients should be rolled over onto the punctured side to reduce the risk of delayed PNX; anyway, this is a controversial opinion, since other authors have reported no benefits of putting patients in the Biopsy down position. Following measures include observation and monitoring of vital signs for at least 4 h. Chest films are usually acquired after 4 h to detect possible asymptomatic PNX. If the clinical suspicion of a PNX arises, chest radiography must be obtained immediately. In low-risk patients, many interventional radiology services reasonably perform lung biopsies on an outpatient basis, with discharge at 4 h and readmission only if symptoms develop [12].

Pneumothorax

PNX is the most common complication after imaging-guided chest biopsy; it is most frequently detected after lung biopsy but can also occur even after biopsies of mediastinal, pleural and chest wall lesions. Usually PNX occurs during or immediately after the procedure and it is detected on postprocedural control scans. The incidence of PNX has been reported to be up to 61% with an average risk of 20% [13]. Risk factors for PNX can be related to patient or lesions features, but also to the biopsy technique. In particular, the rate of PNX increases with the patient age and severity of underlying lung disease (e.g. emphysema or chronic obstructive disease) as well as in smaller and deeper lesions [14]. Technical risk factors include the type and size of biopsy needle, longer procedure duration, biopsies in the middle or lower lobe, transgression of a fissure and multiple needle repositioning or pleural passes. A PNX developed during the procedure can be immediately aspirated through the introducer needle or a separate needle inserted into the pleural space, preventing further enlargement; however some authors suggest placing a chest tube if aspirated air is greater than 670 ml. PNXs developed after the procedure (Fig. 8) are often small and asymptomatic and can be managed conservatively by monitoring vital signs and performing serial chest films (at 1 and 4 h. Nevertheless, in a minority of cases (1–14%), PNX can be significant (>30% of lung volume), increase over time or become symptomatic. In these cases small-calibre, 6- to 9-French catheters can be safely and easily placed under CT guidance [16].

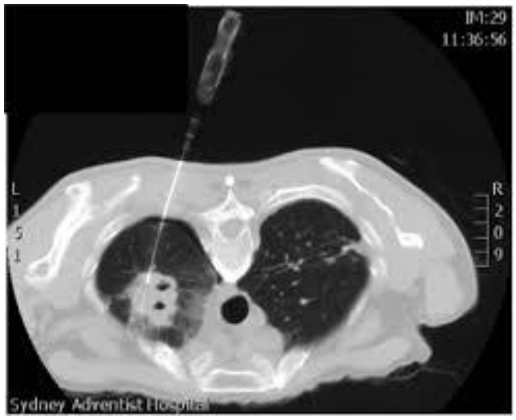

Fig 8: Pneumothorax after transthoracic needle biopsy of lung lesions.

Pulmonary Haemorrhage and Haemoptysis

Haemorrhage represents the second most common complication after imaging-guided biopsy. PH may occur with or without haemoptysis and can be easily detected on screening post-biopsy CT scan as a perilesional or needle tract ground-glass opacity (Fig. 9). The occurrence rates of PH are estimated to be from 4 to 27% (with an average incidence of 11%), while haemoptysis risk is up to 5%. Usually this complication does not need any treatment and the only recommendations is to place the patient in a lateral position, with the biopsy side down, to avoid aspiration of blood into the unaffected lung. Occasionally a larger, higher-grade PH occurs and oxygen as well as pro-coagulative therapy may be needed. Risk factors for higher-grade PH include older age, female sex, emphysema, pulmonary hypertension, coaxial technique, subsolid lesions, nonsubpleural location and lesion size smaller than 3 cm [18]. Avoiding PH is important to manage patients with abnormal coagulation profiles and to correct the diathesis before the procedure. In such patients, more invasive biopsy techniques that imply the use of the core needle and coaxial technique should be avoided as should prolonged procedures with extended needle paths. Finally, haemothorax is an extremely rare and more severe complication, usually due to puncture of an intercostal or less commonly a large thoracic vessel, or mammary vessels in the case of an anterior parasternal biopsy.

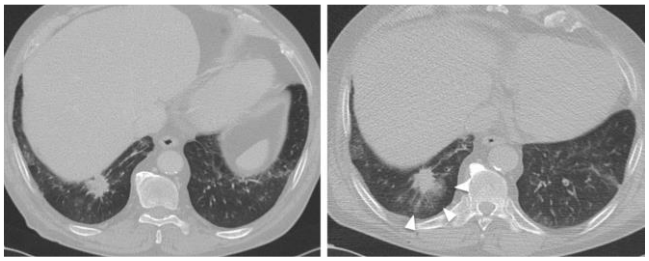

Fig 9: CT-guided chest biopsy of a pulmonary nodule. (a) Axial CT image before the procedure showing a pulmonary nodule in the right lower lobe. (b) Postprocedural axial CT image demonstrates perilesional haemorrhage as ground-glass opacity around the nodule (arrows)

Air Embolism

The occurrence of systemic air embolism (SAE) in the left atrium, left ventricle or systemic circulation is a rare (incidences between 0.01% and 0.21%), but potentially fatal (bybrain or cardiac infarct) event. There are three mechanisms in particular responsible for SAE during biopsy: placement of the needle tip in a pulmonary vein, formation of a bronchial-venous or alveolar-venous fistula and opening the outer cannula of a coaxial biopsy needle to the atmosphere. In the meta-analysis from Tomiyama *et al*. [20], the incidence of SAE ranges from 0.001% to 0.003%, being influenced by the depth of needle penetration into the lesion, endotracheal anaesthesia, location of the lesion above the level of the left atrium and prone position of the patients.

Tumour Seeding

Tumour seeding through the needle tract represents a very rare complication with a prevalence reported in the literature between 0.012 and 0.061%. The real clinical relevance is still discussed, but it is obvious that tumour seeding along the needle tract can significantly change patient management and life expectancy and should be strictly avoided. Tumour seeding is reported to be more frequently observed after imaging-guided core needle biopsy of pleural mesothelioma [22].

Complications by imaging guidance technique

In the meta-analysis from Di Bardino *et al*. US-guided biopsy was generally very well tolerated and safe, with a pooled incidence of PNX of 4.4% (22/503) in the reported papers. This looks favourable compared to CT-guided biopsy, but is also obviously correlated to a statistical bias in lesion position since the targets of USguided biopsies are usually adjacent to or infiltrating the pleural surface, with a very low risk of PNX. Compared with the conventional step-and-shoot approach for CT-guided biopsy, CT fluoroscopy is faster and requiresfewer needle passes, resulting in a decrease of procedure duration and fewer complications.

Conclusions

In conclusion, imaging-guided chest biopsy is an interventional procedure of pivotal importance for several clinical conditions of pneumological, oncological and surgical interest. This procedure may appear very simple, but radiologists approaching it for the first time must consider several clinical and technical variables significantly affecting the final results, in terms of both diagnostic accuracy and patients' safety.

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