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Ultrasound-guided percutaneous pleural and lung biopsy

Biopsia pleurală şi pulmonară percutană ghidată prin ecografie toracică

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Abstract

Pleural biopsy, or lung biopsy, is recommended for the diagnosis of pleural and subpleural lung abnormalities (primary or secondary malignant tumor, tuberculosis, collagen disease, pachipleuritis, sarcoidosis etc.). There are several biopsy techniques: closed needle pleural biopsy, image-guided (thoracic ultrasound or computerized tomography) needle biopsy, and biopsy by thoracoscopy or open lung surgery. The continuous development in the recent years of the use of thoracic ultrasound (TUS) has improved the technique and the results of the pleural and lung biopsy. Ultrasound-guided pleural, or lung needle biopsy (USPLB), is a safe and minimal invasive real-time technique with less complications than CT-guided biopsy. USPLB may provide adequate tissue sampling of lesions for cytology/ histology/ immunohistochemistry or bacteriology. At the same time, USPLB has a high diagnostic yield and is much more accessible and comfortable for patients and the physician than thoracoscopy. This review aims to summarize the key technical elements of ultrasound-guided pleural and lung biopsies, in order to promote the development of these techniques in Romania.

Keywords: ***pleural biopsy, pleural diseases, pleural ecography***

Rezumat

Biopsia pleurală este recomandată pentru stabilirea diagnosticului pozitiv și pentru efectuarea diagnosticului diferențial în afecțiunile pleurale și unele leziuni pulmonare subpleurale (tumori primitive și secundare, tuberculoză, boli de colagen, pahipleurite, sarcoidoză etc.). Există mai multe tehnici de biopsie: biopsia pleurală percutană pe ac, biopsia pe ac ghidată imagistic în timp real (prin ecografie toracică sau tomografie computerizată), biopsia prin toracoscopie sau toracotomie chirurgicală. Dezvoltarea continuă în ultimii ani a utilizării ecografiei toracice ca mijloc de ghidare pentru proceduri diagnostice sau terapeutice a îmbunătățit tehnica și rezultatele biopsiei pleurale și pulmonare. Biopsia pleurală sau pulmonară ecoghidată (BPPEG) este o tehnică biopsică minim invazivă, ce asigură evaluarea pleurei în timp real, fiind sigură, cu mai puține complicații față de biopsia ghidată prin CT toracic. BPPEG permite obținerea de fragmente biopsice adecvate din leziuni pentru examinarea citologică, histopatologică, imunohistochimică sau bacteriologică. BPPEG are un randament ridicat de diagnostic pozitiv și este mult mai accesibilă și mai confortabilă pentru pacient și medic față de toracoscopie. Am revizuit recomandările ghidurilor din literatură și am selectat aici elementele tehnice cele mai importante pentru pregătirea medicilor tineri în efectuarea BPPEG și promovarea acestor tehnici și în România.

Cuvinte-cheie: ***biopsie pleurală, afecțiuni pleurale, ecografie pleurală***

Introduction

Lung and pleural biopsies are essential procedures for the diagnosis of a large number of chest conditions. Modern medicine requires histological confirmations. For example, no patient with suspected lung cancer should have oncological treatment in the absence of a biopsy. Moreover, tissue sampling is also essential for inflammatory conditions of the lung and the pleura, and also for microbiological diagnosis.

Lung lesions, however, can be difficult to target. Radiology-guided procedures to help targeting lung lesions have been used in pneumological practice for a long time. All image-guiding modalities, such as fluoroscopy, CT, MRI or ultrasonography, have advantages and disadvantages, with positive yields that are also significantly influenced by the operator's experience. The development of powerful, accurate, and relatively inexpensive ultrasound machines has made possible the expansion of ultrasound-guided procedures outside specialized radiological departments.

This review aims to summarize the key technical elements of ultrasound-guided pleural and lung biopsies, in order to promote the development of these techniques in Romania.

Common indications and contraindications of ultrasound-guided pleural/peripheral lung biopsy (USPLB)

A pleural biopsy should be considered in all non-diagnostic chronic or recurrent pleural effusions. The indication depends on the pre-test probability (Table 1)[(1)]. The British Thoracic Society algorithm for pleural effusion (ref) indicates the need of a pleural biopsy before a thoracoscopic examination, but thoracoscopy remains the gold standard for the diagnosis of pleural pathology[(2)].

A lung biopsy can be performed with ultrasound guidance only if the lesion is in direct contact with the pleura (thoracic ultrasound; TUS). These lesions usually appear like hypoechoic masses with posterior acoustic enhancement[(2,3)].

All specific contraindications for a pleural or lung biopsy are similar for ultrasound-guided biopsies[(4-8)] (Table 2). If the patient is anti-coagulated, the oral anti-coagulation should be switched to a low molecular heparin, which should then be stopped 12 hours before the procedure. The procedures are usually safe. A study of 605 patients who underwent pleural/peritoneal aspiration and had mild coagulopathy (INR<1.5, platelets

Table 1 Indications for ultrasound-guided pleural biopsy[4-8]

1. Malignancy: mesothelioma, metastasis of lung/extrarespiratory tumors, lymphoma, leukemia (specific tumoral cells).
2. Pleural TB (specific caseating granuloma, Ziehl-Neelsen positive acid fast bacilli – Koch bacilli) or mycobacteriosis due to atypical mycobacteria.
3. Systemic lupus erythematous (direct immunofluorescence staining positive – IgG, C3).
4. Sarcoidosis (non-necrotizing epitheloid granuloma).
5. Pleural plaques/pachipleuritis (hyaline fibrous tissue).
6. Asbestosis (ferruginous bodies and marked fibrosis at hematoxylin and eosin stain).

Table 2 Contraindication of the pleural biopsy[2]

1. Lack of patient's agreement and uncooperative patients.
2. Uncorrectable bleeding disorders (hemophilia, coagulation factor deficit, thrombocytopenia) or anticoagulant treatment.
3. Respiratory failure.
4. Empyema.
5. Cutaneous lesions (Herpes Zoster, pyoderma).
6. A dry tap (the absence of the pleural fluid determine the risk for pneumothorax).
7. Severe hepatic or renal failure.

between 50,000 and 99,000 elements/mcl) did not show a supplementary risk of bleeding and did not need platelet correction[9].

Technical aspects

As in most interventional pulmonology procedures, it is important for the operator in charge of the service to establish a check list approach (also known as "procedural protocol", or "SOP – **S**tandard **O**peration **P**rocedure") of the technique. The check list can be inspired by international guidelines, by step-by-step protocols from other services or departments, but should be adapted to the local needs and local practices. The role of a SOP is to standardize the practice, the quality of the procedure, and also to help disseminating the knowledge and the expertise. It is also a tool in clinical auditing practices which are similar. A random ("artist's") approach to these procedures is not only irresponsible, but is also likely to generate risks for the patient and the doctor, complaints and malpractice disputes.

We present here the key elements of a SOP for ultrasound-guided biopsies, but it will be the local operator's responsibility to design and audit a local SOP if the procedure is introduced in a local department. The elements of the SOP for an ultrasound-guided pleural or lung biopsy can be grouped within the following stages:

1. Prepare the patient and yourself

1. Before any interventional procedure, it is important to have obtained the patient's informed consent. This should be done on a standardized form approved by the local institution and should include consent for any image acquisition as well. We recommend caution in disseminating interesting images on social media, even if the patient consented to image acquisition for educational purposes. This is because one will lose control of the image once it is uploaded on social media and the patient can still be recognized, even if his name is not in clear.

The informed consent should explain the purpose and advantages of the procedure, the painless technique but the inherent possible incidents or complications[2] and should allow the patient to ask questions and think about the opportunity of signing the form. It should not be rushed.

Figure 1. *Thoracic ultrasound in a patient with pleural mesothelioma and pleural effusion*

2. Check the indications.

3. Perform a clinical examination. The doctor performing the procedure should do a general consult and check the hemorrhagic risk (hepatic failure, renal failure, anticoagulant treatment, active hemorrhages?).

4. Check the recent chest X-ray and CT scans and performe TUS (Figure 1).

5. Prepare the procedure area. USPB should be performed in a sterile environment, but can be done either on the wards, or in outpatient settings. The best is to perform the procedure in a room dedicated for interventional pulmonology procedures.

6. The procedure is usually done with the patient in a sitting position. Explain the position to the patient.

7. Premedication is not always necessary. However, mild sedation is recommended for anxious patients and to reduce the pain associated with pleural biopsy (anxiolytics: 0.5 mg - 1 mg midazolam i.v.)[2].

8. Equipment. All equipment should be in the room and checked before procedure starts.

In general, these procedures require:

- Procedure tray
- Skin marker
- Sterile fields and skin disinfectants
- Sterile gloves for the operator
- Sterile cover for the ultrasound probes
- Syringes, needles and local anesthetic
- Biopsy needles
- Scalpel for skin incision
- Gauze
- Specimen samples
- Sutures.

Several needles can be used for ultrasound-guided pleural and lung biopsies.

Needles for US guided "close" pleural biopsy:

- Abrams needle = "guillotine" for pleural biopsy (Figure 2).
- Cope needle. In Romania, it is still in use the "Prof. Dr. Stoicescu" needle (a modified Cope needle (Figure 3).
- TruCut needle.

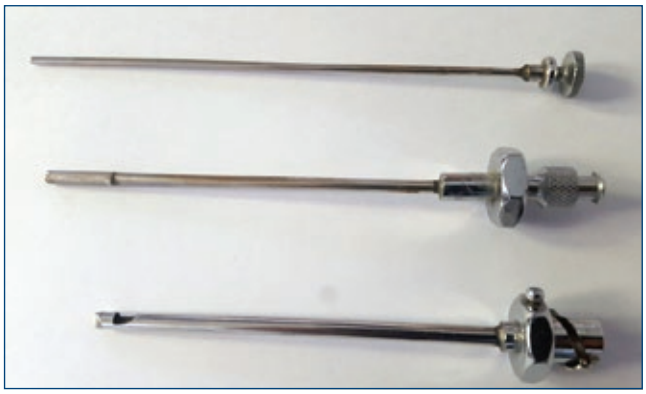

Figure 2. *Abrams needle for pleural biopsy (collection of the Pneumology Clinic from Târgu Mureş)*

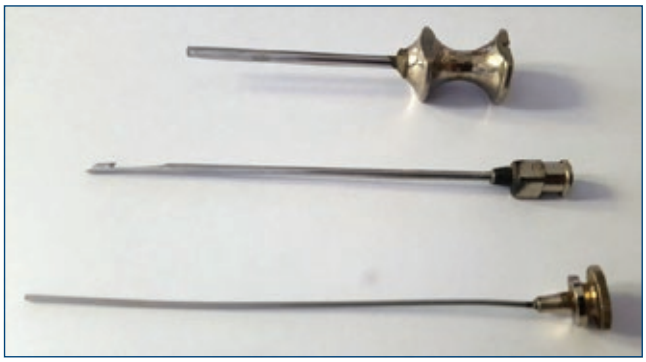

Figure 3. *"Prof. Dr. Stoicescu" Needle (modified cope pleural biopsy needle – collection of the Pneumology Clinic from Târgu Mureş)*

Needles for lung masses biopsy:

- TruCut needles.
- Transthoracic Fine-Needle Aspirations TTFNA for pleural lesion and for lung masses in contact to the thoracic wall.

2. Plan the biopsy

Before cleaning the skin and move to the sterile step of the procedure, it is necessary to do a "planning & mapping" chest ultrasonography.

The area of interest, as identified from other images (CT, radiographs), is scanned, initially in the longitudinal plane, and then in the transversal plane - to localize the lesion, understand the local pathology and plan the biopsy.

Usually, the abdominal ultrasound probe is used, with abdominal settings. Once the lesion is identified, depending on the quality of the image, for the procedures itself one can use the linear probe, which gives a higher definition of the image. A skin marker is used to mark the skin for local anesthetic.

3. Local anesthetic

Correctly applied local anesthetic is essential for a painless, quick and successful procedure. With an organge (intradermic) needle, a skin bleb is produced

with 2-3 ml of intra-epidermal insertion of 1% lignocaine. With a green needle, more local anesthetic (2-4 mls) is injected along the proposed tract of the biopsy needle, with most of the anesthetic injected at the pleural and costal level (not in the subcutaneous fat). The first amount of fluid serves for bacteriology, cytology and biochemistry analysis[8].

4. Ultrasound guiding the biopsy needle

There are two ways of ultrasound guiding a needle to the pleura and/or to a lung lesion.

In plane ultrasound guiding: the probe is placed above the lesion and the needle is inserted from the lateral end of the probe. This method has the advantage to show the tip of the needle all the time of the insertion, but requires good probe - needle synchronization, so that the needle stays in the scanning plane. Probe - needle synchronization can be helped by a special needle attachment which can keep the needle in the scanning plane[11].

Out of plane ultrasound guiding: the probe is also placed above the lesion, but the needle is inserted at the middle of the probe from out of scanning plane, in the direction of the lesion. This method does not require probe - needle synchronization, but does only visualize the tip of the needle when reaching the lesion.

For both methods, color Doppler can be used to show the tip of the needle. It would be best if the procedure is done with two operators. One is the "cameraman", the person who holds the probe fixed on the chest to visualize the lesion and the needle, and the other operator is the "biopsier", the person who performs the biopsy. This team approach is particularly helpful for pleural biopsies, as Abrams and Cope needles require both hands to operate them.

5. Performing the biopsy

Here we describe the pleural biopsy with the "Prof. Dr. Paul Stoicescu" patented needle (a modified Cope needle), which is the most common pleural needle used in Romania; the biopsy is easy to perform without complications[12].

- The entire system (guiding trocar, inner needle, and mandrel) is introduced on the same route of the local anesthetic trajectory, under the guidance of a real-time TUS, as described above.
- At the introduction, the hook of the needle is completely inserted inside the trocar.
- The trocar is angled perpendicularly on the chest wall on the lower edge of the intercostal space, grazing the top edge of the lower coast (to prevent the damage of the neurovascular bundle).
- When the tip of the needle reaches the fluid level on the ultrasound image, the mandrel is withdrawn, to check for fluid aspiration – which confirms the position in the pleural space.
- The trocar is withdrawn still under US guidance. Then the needle is withdrawn until it hooks on the parietal pleura.
- The tissue is sectioned by the guillotine of the hook, and after that the needle is removed. The sample will be flushed into a histology pot.
- During the procedure the needle is seen as a whitish spot in the "black" anechoic image of the fluid.
- Aspiration biopsy will be performed by attaching a syringe to the needle holder or attaching and aspirator[13].
- 4-6 specimens are required for a satisfactory result of the examination[11-14] (unfortunately, the etiology of pleural effusion remains unclear in nearly 20% of cases)[8].

Lung biopsy is performed in a similar way, but most often with a TruCut needle. The mass needs to be in contact with the chest wall, otherwise the lesion is not visible by ultrasonography.

The operator should be familiar with the TruCut and with positioning it in order to reach the lesion. The needle has two parts[10]:

1. The outer guide has a sharp cutting edge in the front. The depth of the pleura is assessed as the point at which fluid is aspirated when the needle is advanced into the pleural space.

2. The inner needle (18 G) with a cutting sheath that shaves off the tissue specimen; an 18 mm-long "specimen tray", which will collect the tissue, and a 5 mm-long "stylet" tip (Figure 3).

6. After the biopsy and finishing the procedure

The availability of ultrasound at the time of the procedure allows for immediate checks on possible complications.

The area should be scanned while the probe is still sterile. Any pneumothorax or bleeding is observed and should be treated as required.

A sterile dressing is placed at the biopsy site. Usually, there is no need for a suture. The samples are labeled and sent to the lab. The patient is observed for 1-2 hours and then discharged.

Advantages of ultrasound-guided pleural and lung biopsies

Ultrasound guidance increases the yield of positive biopsies and decreases the risk of complication. TUS can identify even small pleural nodules and allow their targeted biopsy. USPB has increased the yield of diagnostic from 60% to 77% in malignant pleurisy[13], and over 87% for all pleural pathologies[14]. In a 2014 Romanian study at the "Marius Nasta" Institute of Pneumology Bucharest, the diagnostic yield for TB pleural effusion was high – 81.25% (using the "Stoicescu" needle)[12]. The diagnostic yield of unaided closed pleural biopsy for pleural TB is generally around 80%, and may increase to 87% if at least six specimens are taken[11,15].

When several investigations are performed from biopsies obtained by TUS cutting-needle biopsy, the total diagnostic yield is up to 90%[5,6], 85% for peripheral lung tumors, 100% for mesothelioma[16]. The biopsy with Abrams needle

had a superior yield for TB than TruCut needle technique (91% vs. 78%) and without complications[7,15,16].

The Transthoracic Fine-Needle Aspiration (TTFNA) for subpleural tumors has a high yield of confirmation (82%) and a low rate of pneumothorax (1.3%)[16]. Cutting-needle biopsy was shown to be diagnostic in 76%, and the combined yield with TTFNA was 89%[7].

Complications of USP/LB

The complications of USPB include pain, vaso-vagal reactions, hematomas and hemothorax. Several studies have shown that the USPB technique may significantly increase the yield of diagnosis while decreasing the risk for complications (about 4%)[5,6,7,15,16].

USP/LB and biopsy of the peripheral lung masses are valuable and safe alternatives to CT-guided procedures in terms of accuracy and lack of complications[19]. USPB is superior than CT-guided biopsy, having several advantages: it does not irradiate, it is comfortable, accessible, and provide real-time information[17]. The sensitivity of diagnosis confirmation in peripheral pulmonary nodules (3 cm and below) is high (84%)[19], with a 96.8% sensitivity in malignancy confirmation[20], and with only 8% risk of pneumothorax[19].

Conclusions

Ultrasound-guided pleural and lung biopsies are procedures available for the chest physician and they should be performed following a standardized approach. The use of ultrasound-guided procedures requires appropriate case selection. Their complication rate is low and the utility is high. The limitations of using USGB in Romania are represented by the availability of equipment in some departments and the lack of a national specific training and competency framework for these procedures. A networking effort is necessary, and we hope that this review will motivate interested parties in working together to set up these procedures in current clinical practice. ■

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