

ULTRASOUND GUIDED PHRENIC NERVE BLOCK FOR PERCUTANEOUS COMPUTER TOMOGRAPHY GUIDED LUNG BIOPSY

Andrei Neagu¹, Corina Adelina Zah¹, Alexandru Bucur¹, George Manucu¹, Cătalina Neagu², Cezar Iulian Bețianu³

¹Radiology Department, "Dr.Carol Davila" Central Military Emergency Hospital Bucharest

²Oncology Department, Elias University Clinical Hospital Bucharest

³Angiography Department, "Dr.Carol Davila" Central Military Emergency Hospital Bucharest

Corresponding author: Corina Adelina Zah

"Dr.Carol Davila" Central Military Emergency Hospital Bucharest

88 Mircea Vulcănescu, Bucharest, District 1, Postal Code 010825

Phone: +4021 312 1458

E-mail: corinazah@icloud.com

Abstract

The aim of this paper is to present the technique of the ultrasound (US) guided phrenic nerve block (PNB). This is an important adjuvant technique for percutaneous computer-tomography (CT) lung biopsy of nodules situated in the lower lobes, in proximity of the diaphragm, with a diameter of less than 2 cm. These types of nodules have a high location variability during respiration, which makes them hard to be approached for a successful biopsy.

US visualization of the nerve is possible after identifying specific landmarks as the sternocleidomastoid and scalene muscle, interval jugular vein and brachial plexus. The phrenic nerve is seen as an oval hypoechogenic structure with no Doppler signal, superficial to the anterior scalene muscle. Ropivacaine can be used as a local anesthetic to induce the PNB.

Results: Success of the phrenic nerve block can be assessed by CT scanogram, which shows the ipsilateral hemidiaphragm elevated, and by subsequent lung scans that show little to no location variability of the target lesion.

Conclusion. *US-guided PNB is a safe and efficient procedure that can help during percutaneous CT-guided lung biopsy of small basal nodules.*

Keywords: *phrenic nerve, nerve block, percutaneous lung biopsy, CT guided biopsy.*

Rezumat

Obiectivul acestei lucrări este de a prezenta tehnica blocului de nerv frenic (BNF) sub ghidaj ultrasonografic (US). Aceasta este o tehnică cu importanță în biopsiile pulmonare percutanate sub ghidaj computer tomografic (CT) pentru nodulii situați în lobii inferiori, în proximitatea diafragmului, cu un diametru sub 2 cm. Acest tip de noduli prezintă o variabilitate mare a localizării în timpul respirației ceea ce poate reprezenta o dificultate în cazul biopsiei.



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Vizualizarea US a nervului frenic se poate face utilizând ca repere mușchii sternocleido-mastoidian și scaleni, vena jugulară internă și plexul brahial. Nervul frenic are o structură ovală hipoecogă, fără semnal Doppler, superficial de mușchiul scalen anterior. Ropivacaina poate fi utilizată ca anestezic local pentru a realiza BNF.

Succesul BNF poate fi obiectivat cu ajutorul topogramei CT, unde se poate observa ascensiunea hemidiafragmului ipsilateral și prin scanările pulmonare successive care arată poziția fixă a leziunii țintă.

Concluzie: BNF sub ghidaj US este o procedură sigură și eficientă care poate facilita biopsia pulmonară percutanată sub ghidaj CT a nodulilor bazali de dimensiuni mici.

Cuvinte cheie: nerv frenic, bloc de nerv, biopsie pulmonară percutanată, biopsie sub ghidaj CT.

Introduction

Lung cancer is the most frequent encountered cancer in men and women combined, globally⁽¹⁾. In Romania, lung cancer is the most common cause of cancer death⁽²⁾. Chest Computed tomography (CT) is the standard procedure to assess lung pathology, some of which may need biopsy for tissue confirmation⁽³⁾. Most of the cases that require biopsy are lung nodules with a high chance of malignancy, as either a primary tumor or metastasis⁽³⁾. To establish the correct diagnosis, CT or ultrasound (US)-guided percutaneous biopsy of the tumor is required. It is a known fact in the radiological community that lesions in the lower lobes,

especially those in proximity of diaphragm have a larger location variability caused by respiratory movements⁽³⁾. This is a greater concern when the lesions are small (<2 cm) and located more central (no contact with any parietal pleural surface). CT-guided biopsy does not provide real-time feedback, so needle advancement is laborious.

When feasible, a phrenic nerve block, on the lesion side, is performed under US guidance in order to diminish the respiratory movements and tumor location variability.

Anatomy of the phrenic nerve

The phrenic nerves are formed from sympathetic, motor, and sensory fibers that

innervate the two hemidiaphragms ipsilaterally⁽⁴⁾.

The phrenic nerve emerges primarily from fourth cervical ventral ramus, but also from the third and fifth. It originates at the upper lateral border of the anterior scalene and descends slightly oblique over its anterior surface under the prevertebral fascia⁽⁴⁾. It descends obliquely from its origin, posterolateral to the sternocleidomastoid muscle, internal jugular vein, transverse cervical, ascending cervical, and suprascapular arteries, and antero-medial to the brachial plexus⁽⁴⁾. On the left, the thoracic duct is also located anterior from the inferior cervical course of phrenic nerve.

It arises between the anterior scalene muscle's ventral surface and the prevertebral fascia that covers the muscle. The prevertebral fascia covers the scalene muscles and the brachial plexus that emerges between the anterior and middle scalene. In the cervical region, the path of the right and left phrenic nerves differs just slightly. The thoracic anatomy of the phrenic nerves is not relevant to the purpose of this paper⁽⁵⁾.

At the root of the neck, it runs anterior to the second part of the subclavian artery, from which it is separated by scalenus anterior (first part of the subclavian artery on the left), and posterior to the subclavian vein⁽⁵⁾.

Technique description

US guided phrenic nerve block is performed with the patient in the supine position. A high-frequency probe (9 to 12 MHz) is needed to identify the superficial placed nerve. We use the in-plane approach with the needle inserted parallel to the long side of the transducer, in long-axis so the full needle is visualized. This permits the tip of the needle to be visualized at all times.

When performing a nerve block the goal is to deposit the local anesthetic (LA) close to the nerve, avoiding intraneural injection that may cause direct trauma or toxicity to the nerve.

After aseptic skin preparation, anatomic structures at the site are identified using an US probe in a sterile plastic sheath with sterile gel. These structures include the target nerve and other nearby nerves, blood vessels, and bony and soft tissue structures.

For the US identification of the phrenic nerve, several anatomical landmarks can be used⁽⁶⁾. This includes the anterior scalene muscle, which is found behind the sternocleidomastoid muscle, lateral to the IVJ and medial to the brachial plexus (figure 1)⁽⁶⁾. Another useful landmark is the transverse cervical artery, which is being crossed by the phrenic nerve at the ventral surface of the anterior scalene muscle⁽⁶⁾. On US, the nerve presents as an oval hypoechoic structure superficial to the anterior scalene muscle with no Doppler signal⁽⁶⁾.

When the optimal US view is achieved (by rotating, tilting, or moving the probe), the probe is held immobile; the block needle is then advanced, with movement only when the needle tip is seen (figure 2). If the tip disappears from view, it may be located using hydro-localization (injecting small increments of saline or LA). The puncture is performed from antero-medial to posterolateral, to avoid any major vascular branches in the needle path. Special attention needs to be paid in order to avoid puncture of the jugular vein. A 1:1 dilution of 100-200 mg ropivacaine is injected in the vicinity of the nerve, under the prevertebral fascia that surrounds the anterior scalene. Avoid direct trauma to the nerve. To prevent intravascular injection, careful aspiration before injection is recommended.



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US imaging permits direct visualization of needle location relative to target nerves, blood vessels, and related structures, as well as observation of the LA during and after the injection (figure 3). The nerve remains visible by US following LA injection, allowing the block to be repeated if necessary.

Successful phrenic nerve block can be assessed using CT scan when performing core needle biopsy. Signs of nerve block include:

- CT scanogram shows ipsilateral hemidiaphragm elevated (more than the preprocedural scan) (figure 4)
- Subsequent lung scans from the planning of the CT guided biopsy should show little to no location variability of the target lesion

Indications and contraindications for phrenic nerve block

We prefer to perform a phrenic nerve block prior to the lung biopsy when there is a small target lesion (<2 cm) in the lower lobes, usually at the lung base. The most common reason for doing it is to shorten the procedure and minimize the side effects and complications from the biopsy, notably pneumothorax.

Reducing the respiratory motions of one lung may be detrimental for certain people. In some cases, lung function may be insufficient and risk/benefit ratio is higher than normal.

Severe emphysema and interstitial lung disease are two examples of such conditions.

Complications of phrenic nerve block

Anesthetic toxicity can occur whenever LA is administered, and it can occur with any LA and any route of administration. It can cause seizures, as well as arrhythmias and cardiac arrest⁽⁷⁾. It makes sense to use ropivacaine when a long-acting local anesthetic is necessary as well as when high doses of local anesthetic are being used since it is less toxic and clears the bloodstream more quickly⁽⁸⁾.

Allergic reaction to LA include anaphylaxis and urticaria (uncommon), but also contact dermatitis and delayed swelling at the site of administration.

As for nerve injuries, intraneural injection is considered to be the cause of the nerve damage. The danger is considered to be minimized by continuous US viewing of the needle⁽⁹⁾.

Brachial plexus nerve block can occur as both the brachial plexus and phrenic nerve are located deep within the prevertebral fascia in the neck. As the anaesthetic is injected under the fascia it frequently affects both⁽¹⁰⁾.

Discussion and conclusion

Ipsilateral phrenic nerve block managed by US-guidance can be used as an adjuvant



Figure 1. White circle- phrenic nerve; yellow star- sternocleidomastoidian muscle; yellow dotted circle- anterior scalene muscle; blue star- inferior jugular vein; red star- common carotid artery; orange circle- brachial plexus nerve branches

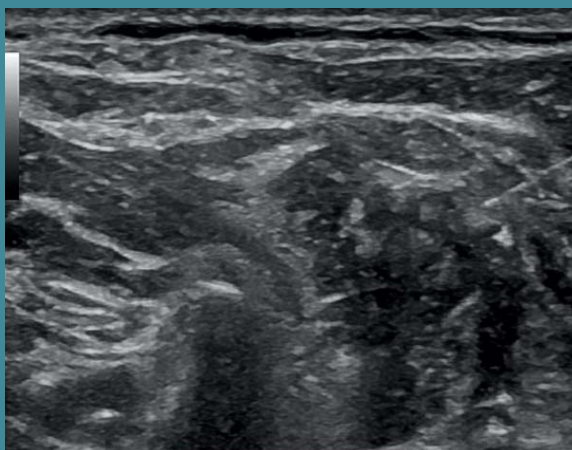


Figure 2. White circle- phrenic nerve; white arrow- puncture needle

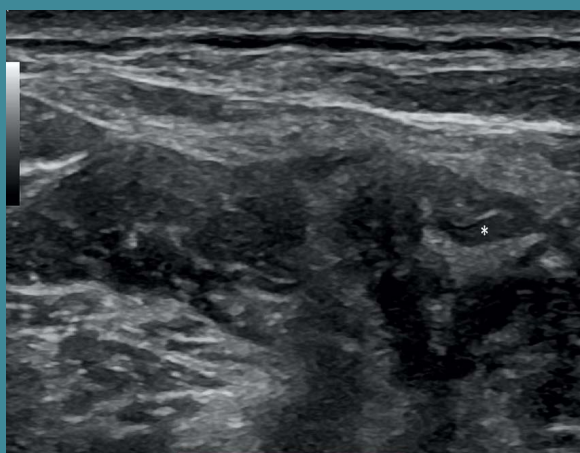
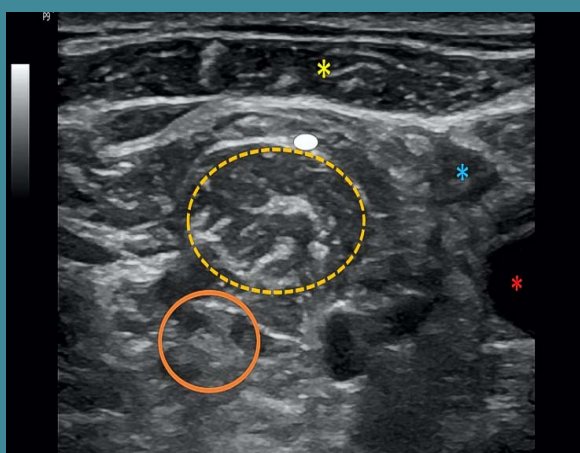


Figure 3. White star- local anesthetic

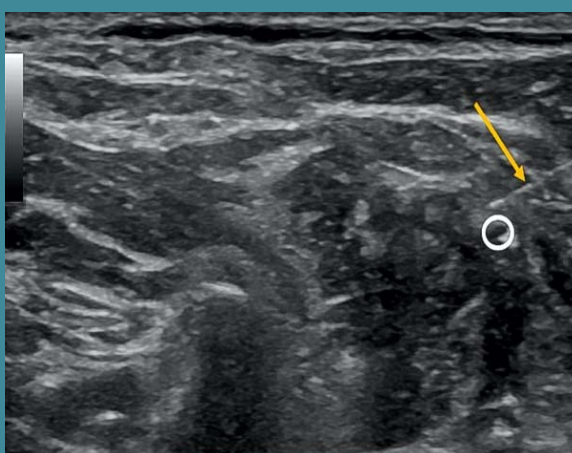


Figure 4. Scanogram showing high left diaphragm elevation after ipsilateral phrenic nerve block



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technique for patients with small lung lesions that need to be biopsied or ablated. Diaphragm movements are diminished to completely abolished. This is of a great advantage especially for lesions in the lower lungs, close to the diaphragm or in proximity of pulmonary bronchi or vessels. From our observations, the only characteristic that could lower the success rate of the phrenic nerve block was existence of adipose tissue around it as it prevents the LA to act properly on the nerve. The existence of an accessory phrenic nerve has been described in the literature, with its origin varying from ansa cervicalis to the subclavian nerve. Despite it being present at approximately one third of patients, it has not been demonstrated to have a major contribution to the innervation of the diaphragm⁽¹¹⁾.

As a conclusion, US guided phrenic nerve block is a safe procedure to be carried out that can help maximize the success rate of lung biopsy with minimal discomfort for the patient.

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