Consensus

The Society for Translational Medicine: indications and methods of percutaneous transthoracic needle biopsy for diagnosis of lung cancer

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Introduction

In 1883, Leyden successfully performed percutaneous transthoracic needle biopsy (PTNB) of the lung in three patients with pneumonia according the records (1); three years later, Menetrier was the first recorded to employ this technique for the diagnosis of lung cancer (2). So far, PTNB has a history of more than 100 years (3-5). In recent years, PTNB has increasingly been applied in clinical settings along with innovations in imaging devices (6,7), improvement of puncture needles, and advances in cellular pathology (8,9). Currently, PTNB is often performed under the guidance of ultrasound or computed tomography (CT) (10,11).

Indications

The indications for PTNB of unidentified lung lesions with high suspicion of lung cancer include:

(I) Unidentified peripheral pulmonary nodules or masses especially if localized close to the chest wall, whose pathological nature cannot be identified even after repeated sputum cytology and bronchoscopy (12-22);
(II) Radiologic imaging suggestive of neoplastic lung lesions with no surgical indication (e.g., lymphomas) or currently non-resectable lung cancer amenable to neoadjuvant chemo-radiotherapy (15);
(III) Unidentified mediastinal mass or pleural lesion with high suspicion of cancer (10,12-14);
(IV) Patients who cannot tolerate bronchoscopy but require pathological or cytological characterization of an unidentified lung lesion (10);
(V) Staging of histologically proven malignancies that have spread to the pulmonary hilum, mediastinum, chest wall, or to more distant sites (14).

Contraindications

Contraindications for PTNB of lung lesions include:

(I) Isolated pulmonary lesions that are highly suspected to be malignant and are potentially surgically resectable in order to minimize potential risks of PNB-related cancer seeding and dissemination (23);
(II) High risk of bleeding (e.g., patients undergoing anticoagulant therapy or with conditions such as von Willebrand disease or severe thrombocytopenia) (24);
(III) Radiologic imaging suggestive of vascular lesions such as arterial or venous malformations, arteriovenous fistula, and aneurysms (22,25);
(IV) Severe diffuse or bullous emphysema, severe pulmonary fibrosis;
(V) Severe pulmonary hypertension; cor pulmonale and/or myocardial infarction; severe cardiopulmonary insufficiency (21);
(VI) Radiologic imaging suggestive of pulmonary Hydatid disease;
(VII) Poor general clinical status making PTNB intolerable (24).

Pre-PTNB work-up

Before performing PTNB a rapid work-up must be conducted, including:

(I) Baseline blood tests, including coagulation profiles, hepatitis/HIV/syphilis status, and urine testing (26);
(II) ECG and complete pulmonary function tests including transfer factor;
(III) Chest computed tomography (CT). Enhanced CT is preferred if the lesion is close to the mediastinum and/or major vessel (27-29).

Types of PTNB needles

Percutaneous puncture needles are divided into three classes: aspiration needle, cutting or core needle, and bone-drilling needle.

(I) Aspiration needles (30-31). These needles are used to obtain cytological specimens. Model sizes range between 16–24 G with an external diameter of

0.6–1.6 mm. They are characterised by a small external diameter and thin walls and thus will cause lesser injury to the tissues with fewer complications. The types of aspiration needles commercially available include Chiba needles, Turner needle, and Greene needles;

(II) Cutting needles (32-34). These needles are used to obtain tissues samples for histological examinations. They have a relatively large diameter, and are associated with more severe injuries to the tissues and more frequent complications. The types of cutting needles commercially available include Vin-Silverman needles, Trucut needles, and Rotex needles. In recent years, the spring-loaded automatic biopsy needle (also known as biopsy gun) has replaced the conventional cutting needle in many centers. This new device reduces operative time, has higher high success rate, is more convenient in sampling, and reduces the risk of needle track implantation;

(III) Bone-drilling needles (35). Bone-drilling needles are employed for the biopsy of bone lesions. Their tips have sharp cutting teeth, which enable them to pass through hard bone/cartilage tissues to harvest histological specimens. If appropriate, the Ackermann needles can be used.

PTNB-guiding devices

Percutaneous lung puncture biopsy can be performed under the guidance of fluoroscopy, ultrasound, CT, or magnetic resonance imaging (MRI). Currently, CT-guided PTNB is the most commonly used approach (10,36-37). The addition of spiral CT-based real-time fluoroscopy can make the procedure safer, quicker, and more accurate. For lesions close to the chest wall and if sufficiently large, ultrasound-guided PTNB may be more appropriate (38). MRI-guided biopsy can be performed in multiple axial planes and at any angle, which helps to increase the success rate (39); however, specially designed puncture instruments that can be used in a magnetic field are required.

Technical details of PTNB

Technical details of PTNB can be summarized in a few main steps:

(I) The patient will be asked to lie in supine, prone, or lateral position based on the location of the lesion. The chest wall side close to the lesion should be placed upward to facilitate the procedure (13);

(II) A catheter position-ruler is attached to the site to be punctured, which is then scanned at slice thickness of 5 mm and slice interval of 5 mm (the slice thickness and slice interval can be 2–3 mm for small lesions);

(III) The optimal puncture level and site are decided, and the angle and depth of the needle insertion are measured (4,40-43);

(IV) The lesion center is selected as the target puncture level. At this step it is important to avoid skeletal structures, heart/great vessels or pulmonary emphysematous bullae if present (40);

(V) After the body surface puncture site is marked, disinfection and draping should be routinely performed with the puncture site at the center. Subsequently, the chest wall is anesthetized layer by layer using 2% lidocaine (4,44,45);

(VI) The patient is asked to take a relaxed breath, and then the needle is inserted via the pre-set needling angle. After the needle approaches the pleura, the patient is asked to hold breath before the needle is quickly advanced to the target site; CT scan is performed immediately at the target level to ensure that the needle tip has reached the target site, after which aspiration biopsy or sampling using an automatic biopsy gun can then be performed (10);

(VII) The content of the aspiration biopsy needle is gently expelled onto a glass slide, evenly smeared, and then fixed using 95% ethanol. After the tissue needle is withdrawn, the tissue specimen strip is fixed in 10% formalin. Multiple slides are prepared for histological analysis (44,45);

(VIII) Routine CT scan is performed after puncture to promptly identify any possible complications such as pneumothorax or significant bleeding visible as pleural effusion (40);

(IX) At the completion of the procedure, the patient is observed for 2–4 hours. Chest X-ray in posterior-anterior and lateral views are performed after 24 hours.

Complications

Percutaneous needle biopsy of lung lesions can cause a variety of complications (31,46-66), which can become even life-threatening complications requiring prompt diagnosis and adequate treatment. While no special treatment is needed for mild complications, active management and surgical consultation/rescue may be required for severe conditions. After the procedure, the patient has bed rest and avoid vigorous physical activity for the first 24 hours.

The most frequently reported complications include:

(I) Pneumothorax (5,46-59): pneumothorax is the most common complication. A small pneumothorax may spontaneously resolve without any treatment. Conversely, patients with large pneumothoraces greater than 30% of the lung volume on chest X-ray or becomes symptomatic should have a chest tube inserted;

(II) Hemorrhage (46-62): localized hematoma in lungs may resolve without treatment. In a similar manner no special treatment is required if small amount of hemoptysis (e.g., phlegm with blood) occurs. Hemostatic drugs may be administered in presence of major or massive hemoptysis. Massive hemothorax is often caused by the injury of intercostal arteries or the pulmonary artery, for which an open or video-assisted thoracoscopic surgery may be required to achieve hemostasis;

(III) Air embolism (43,55,64,65): air embolism is an extremely rare complication but may cause cerebral or spinal cord infarction, myocardial infarction, arrhythmia, heart failure, or even death. Once air embolism occurs, the patient should be immediately placed left lateral decubitus or Trendelenburg's position to prevent residual air in left atrium to pass into the systemic circulation; concurrently, 100% oxygen must be administered to the patient to promote the absorption of the air embolus. The patient can also be transferred for hyperbaric oxygen treatment;

(IV) Needle-tract seeding of tumor cells (17,64,65): needle-tract seeding is a relatively common complication of percutaneous lung puncture biopsy, particularly in biopsies performed for sub-pleural lung lesions. Despite its frequency, its risk is often underestimated in the clinical setting. To minimize this risk, negative pressure should be maintained during needle withdrawal while the needle core be protected with a cannula. Repeated use of puncture needle or cutting needle should be avoided;

(V) Vasovagal pleural irritation (12,66): pleural irritation, characterized by constant cough, dizziness, sweating, paleness, palpitations, weak pulse, cold extremities, decreased blood pressure, a feeling of chest oppression, prostration, and even consciousness disorders, occurs more frequently in young adults and in women. Once pleural irritation symptoms do occur, chest puncture should be stopped immediately; the patient is then made supine and the hemodynamic parameters be closely monitored. Mild symptoms can resolve spontaneously after rest or psychological counseling. In patients with excessive sweating and/or hypotension, administration of oxygen through a Venturi mask and of intravenous supplementation of fluid boluses of 500 mL of 10% glucose can be given to provide energy while supplementing body fluids. If necessary, 0.3–0.5 mL of adrenaline (1:1,000) should be injected subcutaneously to prevent shock according to the usual clinical experience;

(VI) Reactive cardiopulmonary arrest (64): reactive cardiopulmonary arrest is an extremely rare and life-threatening complication. Once it occurs, the patient must be immediately rescued according to the standard cardiopulmonary resuscitation care.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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