CT-Guided Percutaneous Needle Biopsy of the Chest: Preprocedural Evaluation and Technique

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Educational Objectives
1. Percutaneous needle biopsy of the lung, with its high sensitivity, specificity, and accuracy, is an important diagnostic tool in the evaluation of pulmonary abnormalities.
2. Careful case selection is necessary to increase diagnostic yield and avoid unnecessary complications.
3. Proper patient positioning, immobilization, and sedation improve access to and decrease movement of target lesions.
4. Precise needle alignment in the chest wall helps reduce manipulation of the needle within the pulmonary parenchyma.
5. Core needle biopsy can improve diagnostic yield without an increase in complication rate.

Since the first report of CT-guided percutaneous needle biopsy in 1976 [1], there has been significant improvement in CT technology and refinement of equipment available to interventional radiologists. With high diagnostic accuracy, sensitivity, and specificity for detection of malignancy [2–5] (Table 1), percutaneous needle biopsy of the lung is now an indispensable tool in the evaluation of pulmonary abnormalities. Careful preprocedural evaluation and planning and precise technique are required to achieve the highest possible success rate.

Preprocedural Evaluation
A recent CT or PET/CT is required for proper patient and lesion selection. In patients with a suspected lung neoplasm and mediastinal lymphadenopathy or liver or adrenal lesions, biopsy of possible sites of nodal or extranodal metastases rather than the pulmonary lesion can establish histology and stage the patient in a single procedure. If biopsy of the pulmonary abnormality is indicated, CT also aids in selection among different techniques of obtaining tissue, including bronchoscopic biopsy, surgical biopsy (usually by video-assisted thorascopic surgery), or percutaneous needle biopsy of the lung. Bronchoscopy is preferred for central endobronchial or peribronchial lesions. Surgical biopsy is usually performed for suspected interstitial lung disease or for small peripheral lesions, particularly those at the lung bases, which are unsuitable for or failed percutaneous needle biopsy of the lung.

Indications
Percutaneous needle biopsy of the lung is indicated for indeterminate pulmonary nodules or masses, particularly those that will likely require chemotherapy or radiation rather than surgery, and in patients with a history of extrapulmonary malignancy. Because targeted therapy has now become an important part of the armamentarium for treatment of lung cancer, percutaneous needle biopsy of the lung is also performed to obtain tissue for molecular testing. Recent studies have confirmed that epidermal growth factor receptor (EGFR) mutations seen in lung cancer patients can be detected from fine-needle aspiration specimens, thereby helping to identify patients who would benefit from EGFR tyrosine kinase inhibitors [6, 7]. Similarly, other information, such as estrogen and progesterone receptor status of breast cancer metastases, also can be ascertained by percutaneous needle biopsy of the lung. The procedure is also useful for obtaining samples for the diagnosis of focal pulmonary infection. Mediastinal, pleural, and chest wall lesions also are frequently accessible by needle biopsy.

Contraindications
Occasionally, even when the lesion is suitable for percutaneous needle biopsy of the lung, there are relative contraindications to the procedure, such as uncooperative patients (altered mental status, intractable cough), positive-pressure ventilation, severe respiratory compromise (severe emphysema, contralateral...
pneumonectomy, severe interstitial lung disease, pulmonary arterial hypertension, small lesions (< 1 cm) close to the diaphragm, and central lesions adjacent to large vessels.

Coagulation abnormalities are also relative contraindications. Platelet count, prothrombin time, international normalized ratio (INR), and activated partial thromboplastin time are routinely obtained before the procedure. According to a recently published consensus guideline, 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. Steps should be taken to correct an INR above 1.5 by administration of fresh frozen plasma or vitamin K. Platelet transfusion is recommended for platelet counts < 50,000/μL [8]. Although the guideline does not recommend withholding aspirin, if possible, nonsteroidal antiinflammatory drugs, including aspirin, should preferably be stopped for 5–7 days.

Technique

Conscious Sedation

Although percutaneous needle biopsy of the lung can be performed with only local anesthesia, conscious sedation is useful because it allows patients to breathe regularly and remain motionless. It is particularly helpful in anxious patients and elderly patients (who have arthritic complaints and cannot lie still), for biopsies of small lesions in the lower lobes near the diaphragm, or for lesions near large central vessels. We routinely use midazolam and fentanyl in almost all of our biopsy cases.

Imaging Guidance

CT is the technique of choice for guiding percutaneous needle biopsy of the lung because it allows clear visualization of pulmonary abnormalities and adjacent structures. Because of increased awareness of significant radiation exposure to the patient during CT-guided procedures [9], we have taken measures to reduce the radiation dose by decreasing the kVp and mAs during intraprocedural image acquisition, particularly after the initial scan to localize the lesion and plan the needle trajectory. Further dose reduction can be achieved by reducing the z-axis coverage to 5–7 slices at 2.5-mm intervals. CT fluoroscopy is increasingly used because of its advantage of real-time visualization during needle manipulation, particularly for difficult lesions [5]. The main disadvantage of CT fluoroscopy is radiation exposure to the operator. Ultrasound guidance can be used for peripheral lesions.

Patient Positioning

The patient is positioned in the supine or prone position to avoid crossing the interlobar fissure with the biopsy needle, thus reducing the risk of pneumothorax (Fig. 1). When possible, the prone position is preferred because the posterior ribs move less than the anterior ribs, the posterior intercostal spaces are wider, prone positioning prevents the patient from visualizing the needle during the procedure, and 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 to avoid transgression of normal pulmonary parenchyma.

Choosing an Access Route

The lesion is localized and the access route is planned using CT images of 2- or 3-mm slice thickness. Care must be taken to avoid chest wall vessels, including the internal mammary, axillary, subclavian, and intercostal vessels, as well as central vessels (Fig. 2). The intercostal vessels are sometimes difficult

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**TABLE 1: Recent Data on Diagnostic Accuracy, Sensitivity, and Specificity of Percutaneous Needle Biopsy of the Lung for Detection of Malignancy**

<table>
<thead>
<tr>
<th>Study</th>
<th>Reference No.</th>
<th>Year</th>
<th>Biopsy Method</th>
<th>Diagnostic Accuracy (%)</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yeow et al.</td>
<td>2</td>
<td>2003</td>
<td>Core</td>
<td>95</td>
<td>93</td>
<td>98</td>
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<tr>
<td>Laspas et al.</td>
<td>3</td>
<td>2008</td>
<td>FNA</td>
<td>NR</td>
<td>92</td>
<td>98</td>
</tr>
<tr>
<td>Heyer et al.</td>
<td>4</td>
<td>2008</td>
<td>Core</td>
<td>95</td>
<td>93</td>
<td>100</td>
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<tr>
<td>Hiraki et al.</td>
<td>5</td>
<td>2009</td>
<td>CT fluoroscopy, core</td>
<td>95</td>
<td>94</td>
<td>99</td>
</tr>
</tbody>
</table>

Note—FNA = fine-needle aspiration, NR = not reported.
CT-Guided Percutaneous Needle Biopsy of the Chest

Fig. 2—62-year-old man with aortopulmonary window mass. Avoid internal mammary vessels. Internal mammary vessels (arrow) were avoided during biopsy of aortopulmonary window mass by staying as close as possible to sternum.

Fig. 3—65-year-old man with left lower lobe nodule. Direct needle away from important structures. When this left lower lobe nodule adjacent to aorta was biopsied, access route was chosen with needle directed laterally rather than vertically to decrease risk of aortic injury even if needle was inadvertently advanced too far during procedure.

Fig. 4—45-year-old woman with left upper lobe cavitary lesion. Aim for wall of cavitary lesions. To increase diagnostic yield and avoid hemoptysis and air embolism, needle should be aimed at solid peripheral portion of cavitary lesions.

Performing the Biopsy Using Coaxial Technique

Coaxial technique is preferred at our institution because it allows multiple samples to be taken with a single pleural puncture. The introducer, a 19-gauge ultrathin needle that accommodates a 20-gauge core biopsy needle, is carefully aligned by advancing it in small increments in the chest wall before puncturing the pleura. Once the introducer needle is satisfactorily aligned, a single deliberate puncture is made to advance the introducer well beyond the pleura into the lung. If adjustment is necessary, the introducer can be repositioned without exiting the lung, thus limiting the number of pleural punctures to one. The introducer should be advanced into the periphery of the lesion.

Fig. 5—Angulation of gantry. A, Craniocaudal angulation of gantry avoids major fissures during biopsy of upper lobe lesions using posterior approach. B, Angulation of CT gantry allows superior needle entry point with caudal angulation of needle over major fissure to avoid major fissure while biopsying upper lobe lesion.
Core biopsies can be taken through the same introducer needle using a 20-gauge core biopsy needle with 1- or 2-cm needle throw. Studies have shown better diagnostic yield with core needle biopsy compared with fine-needle aspiration, particularly in establishing benign diagnoses such as hamartoma, granuloma, and sarcoidosis [10–13], without an excess of complications [10, 13]. Core biopsy samples are placed in formalin in most cases. In cases of suspected lymphoma, the samples are placed either in normal saline or RPMI solution (Roswell Park Memorial Institute) for flow cytometry. In cases in which infection is suspected, inflammatory cells are noted, or if a specific diagnosis is not made during rapid interpretation of cytology, a sample should be sent to microbiology.

**Postprocedural Care**

Immediately after removal of the introducer needle, the patient is swiftly rolled onto the stretcher into a biopsy side-down position and transferred to the postprocedure care area. Talking, moving, and coughing are discouraged to prevent pneumothorax. Oxygen is administered at 2 L/min by nasal cannula. The patient’s heart rate, respiratory rate, blood pressure, and oxygen saturation level are monitored during the 3-hour recovery period. Chest radiographs are usually obtained at 1 and 3 hours after the procedure to check for the presence of pneumothorax or hemorrhage.

**Conclusion**

Percutaneous needle biopsy of the lung is a safe and accurate procedure for the diagnosis of focal thoracic lesions. Careful planning and technique with knowledge of pitfalls result in low complication rates and successful outcomes.

**Acknowledgment**

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**References**


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