Percutaneous Needle Biopsy

Seishi Nakatsuka
Department of Diagnostic Radiology, School of Medicine, Keio University, Japan

1. Introduction

Image-guided percutaneous needle biopsy (PNB) under computed tomography (CT), CT fluoroscopy (CTF) or ultrasonography (US) is an indispensable tool in the evaluation of neoplasm or parenchymal abnormalities (lung, liver, kidney, bone, lymph nodes and so on) because of its high diagnostic accuracy, sensitivity, and specificity. Image-guided PNB, mainly focusing on lung PNB, will be introduced in this chapter.

2. Indications and Contraindications [1]

a) Indications for PNB

- To establish the benign or malignant nature of a lesion.
- To obtain material for microbiologic analysis in patients with infections.
- To stage malignancy when local spread or metastasis is suspected.
- To determine the nature and extent of certain diffuse parenchymal diseases (eg, hepatic cirrhosis, transplant rejection, glomerulonephritis).
- To check genetic mutations (EGFR gene mutation including T790M and ALK fusion gene) and/or PDL1 expression [2].

b) Contraindications

There are no absolute contraindications for PNB but relative contraindications exist.

- Significant coagulopathy that cannot be adequately corrected.

  According to the SIR guideline [3], biopsy procedures for most organs are recognized as procedures with moderate risk of bleeding, while those for superficial lymph nodes and thyroids are recognized as procedures with low risk, and those for kidney with high risk. High PT-INR, low platelet counts should be corrected.

Risk of bleeding		SIR recommendation					
		PT-INR	APTT	Platelets	Plavix	Aspirin	Heparin
Low	Superficial	< 2.0		> 50,000			quit last dose
Moderate	Most organs	< 1.5	< 1.5 x contr.	>50,000	quit 5 d		quit last dose
High	Kidney	< 1.5	< 1.5 x contr.	>50,000	quit 5 d	quit 5 d	quit for a day

- Severely compromised cardiopulmonary function or hemodynamic instability.
- Lack of a safe pathway to the lesion.
- Inability of the patient to cooperate with, or to be positioned for, the procedure.
- Pregnancy in cases when CT, CTF or fluoroscopy is used for image guidance.

3. Technique

a) Biopsy Needles

PNB includes two basic techniques for sample acquisition, fine needle aspiration (FNA) biopsy and core needle biopsy. Needle choice is based on the size of the lesion, intended needle trajectory, required information from the sample, and operator preference. FNA is the use of a thin, hollow needle (22G or thinner) inserted into a region of interest to extract cells for cytologic evaluation. Core needle biopsy is the use of a hollow needle (20G and thicker) specially adapted with a cutting mechanism that is inserted into an organ or region of interest to extract a piece of tissue for histologic evaluation.

FNA devices including Chiba needles are designed for cytologic evaluation, while Mashima needle is designed especially for pathologic diagnosis of hepatic masses.
Core biopsy needles are designed to obtain a small piece of tissue intended for pathology analysis. The needles consist of an outer cutting cannula and an inner slotted stylet. Full-automated end-cutting needles produce a full cylindrical core specimen. Semiautomatic core needles are more popular among interventional radiologists because the position of the sampling slot on the inner stylet can be adjusted under real-time image-guidance. The size of the core needles varies 14G to 20G. The 18G core needles are usually enough not only for usual pathologic diagnosis but evaluation of genetic mutations and/or PDL1 expression.

A coaxial technique is preferred at some institutions to decrease the number of pleural passes. However, one study showed no difference in rates of pneumothorax and pulmonary hemorrhage [4]. Following adequate sedation and standard sterile precautions, the coaxial needle is advanced into the subcutaneous tissues of the chest wall incrementally to assure proper needle angulation and direction prior to pleural puncture.

b) Image-guidance

US, CT and CTF are popular modalities for image guidance during biopsy procedures of a tumor or diffuse parenchymal disease, while MRI is much less popular. Fluoroscopic guidance with/without cone beam CT (CBCT) including isocenter puncture method [5] can be used especially for biopsy of vertebral bodies.

US guidance should first be considered because it is real-time and free from radiation exposure to both patients and radiologists. In addition, deep cranio-caudal/ caudo-cranial puncture is achievable. However, interposition of gas (bowel, free air or lung) or calcification (bone) often makes it difficult to visualize the target organs and masses. Deep location of a target sometimes makes puncture challenging because of

attenuation of ultrasound in muscles and fat. In such cases, biopsy under CT guidance should be considered.

Recent advances in CTF provide successive 3 or 4 images. CTF is faster and requires fewer needle passes, resulting in shorter procedure times [6], and is associated with fewer complications after lung biopsy compared with conventional CT guidance [6, 7]. However, CTF results in increased radiation doses to the radiologists [6-8]. Radiation doses can be minimized by using intermittent "quick check" method of CT fluoroscopy [9].

4. Lung biopsy under CT guidance [10]

a) Indications and contraindications specific to lung biopsy

Bronchoscopy is preferred especially for central lesions, whereas surgical biopsy is usually performed for suspected interstitial lung disease. Percutaneous biopsy should be performed to establish a malignant diagnosis, establish a benign diagnosis, or obtain material for culture. In addition, these days, PNB of the lung is performed to obtain tissue for genetic testing [2].

Relative contraindications specific to percutaneous lung biopsy include positive pressure ventilation, severe respiratory compromise, pulmonary artery hypertension, severe interstitial lung disease, and central lesions adjacent to large vessels or heart.

b) Procedure

First, a safe pathway should be planned. The important factors in choosing an access route include avoiding chest wall vessels. Subclavian, internal thoracic, lateral thoracic, and intrapulmonary vessels are visible even on non-contrast CT. However, it is very hard to tell the exact position of intercostal arteries. It is said that the puncture route just below ribs should be avoided if we puncture from the patient's back.

After local anesthesia, pleura should be penetrated carefully checking the direction of the needle. If repositioning is necessary after penetrating pleura, the direction of the needle should be adjusted without exiting the lung. The center of the target lesion should be penetrated with the inner stylet of the core needle. The appropriate position of the sampling slot is the key for the diagnostic specimens.

Coughing should be discouraged to minimize increase of intrathoracic pressure that could result in a pneumothorax or air embolism. The patient should be monitored in a hospital ward for 2-3 hours. An upright chest radiograph 2-3 hours after biopsy is obtained to evaluate for pneumothorax.

c) Diagnostic value

Core biopsy has been shown to have a high sensitivity, specificity, and accuracy of malignancy (94.2%, 99.1%, and 95.2%) [11]. The significant independent risk factors for diagnostic failure includes lesions in the lower lobe, and lesions measuring $\leqq$1.0 cm and > 3.0 cm that likely demonstrate necrosis [11]. When performing a biopsy on such large lesions, it is important to have a pre-procedural contrast-enhanced CT or Positron Emission Tomography (PET) to determine the non-necrotic portion.

d) Complications

Complications after PNB include pneumothorax, bleeding (pulmonary hemorrhage, hemothorax and chest wall hematoma), air embolism and tumor seeding. Pneumothorax is the most common complication of PNB, while massive hemothorax and air embolism are the risk of post-procedural mortality. Tumor seeding which develops years later is a complication to be avoided, especially in patients whose pulmonary malignancy can be completely resected.

The incidences of pneumothorax and that requiring chest tube placement are about 20% and 2-7%, respectively [12]. The rate of pneumothorax is increased by patient's factors and/or procedural factors. Patient's factors include age, gender, existence of chronic obstructive pulmonary disease [13] and prior surgery to the ipsilateral lung, while procedural factors such as increased number of pleural punctures and needle insertion at an angle other than perpendicular to the pleural surface [14]. If a non-negligible pneumothorax occurs during or immediately after the procedure, aspiration of the pneumothorax minimizes the rate of chest tube insertion [12]. Chest tube insertion should be considered for symptomatic or enlarging pneumothoraces.

Pulmonary hemorrhage is also common complication but self-limiting, and rarely life threatening. If the hemoptysis is significant, the patient position with the biopsy side down will minimize hemoptysis.

Air embolism is a rare, life-threatening complication [15]. Air embolism occurs when the needle traverses a pulmonary vein and a negative pressure gradient between air space and the vein exists. If air embolism is suspected, the patient's head should immediately be lowered.

Tumor seeding to pleura, or chest wall is also rare [15]. A report from our university indicated the pleural seeding was not significantly increased after PNB in lung cancer patients who underwent surgery [16].

5. Liver biopsy

Liver biopsies are performed for both focal and non-focal hepatic lesions under US or CT guidance. Percutaneous liver biopsies for diagnosing focal hepatic masses are performed usually under US and rarely under CT or CTF. Majority of biopsies are for parenchymal liver disease with use of percutaneous maneuver. Transjugular liver biopsy (TJLB) performed under fluoroscopic guidance is an alternative for patients with contraindications to standard percutaneous biopsy (uncontrollable ascites or uncorrectable coagulopathy).

Major complications are generally rare. The potential risks of the biopsy include intraperitoneal hemorrhage from liver surface or abdominal wall, and tumor seeding.

6. Bone biopsy

Image-guided PNB of bone and soft tissue lesions (including paraaortic lymph nodes) provides comparable diagnostic accuracy to surgical biopsies with lower complication rates [17].

Choice of image-guidance for bone biopsy includes CT, CTF, US (for osteolytic lesions), and fluoroscopy with/without CBCT. Selection of appropriate bone biopsy system, core biopsy needle or thick aspiration needle (12-16G), depends upon the presence of an intact cortical bone. CT or CTF provides the best images guidance for bone biopsy, while fluoroscopy with use of isocenter puncture method [5] also enables safe bone biopsy sessions.

Potential complications of PNB of bone or soft tissue lesions, such as bleeding, infection, pneumothorax, neurological injury, and pathologic fractures, are mainly related to the anatomic location of the lesion and needle type used.

Referrence

1) Gupta S, et al.J Vasc Interv Radiol 2010; 21:969-975.
2) Tan DSW, et al. J Thoracic Oncol 2016; 11: 946-963
3) Malloy PC, et al. J Vasc Interv Radiol 2012; 23: 727-736
4) Küçük CU, et al. Respirology. 2004; 9: 392–396
5) Sakaino S, et al. Radiation Medicine 2008; 26: 70-75.
6) Kim GR. et al. Eur Radiol. 2011; 21:232–239.
7) Heck S L, et al. Eur Radiol. 2006; 16: 1387–1392.
8) Prosch H, et al. Eur J Radiol. 2012; 81: 1029–1033.
9) Paulson E K, et al. Radiology. 2001; 220: 161–167.
10) Winokur RS, et al. Semin Intervent Radiol. 2013; 30: 121–127.
11) Hiraki T, et al. Chest. 2009; 136: 1612-1617.
12) Yamagami T, et al. Acta Radiologica 2009; 50: 1126–1133.
13) Fish GD, et al. Am J Roentgenol. 1988; 150: 71–74.
14) Ko JP, et al. Radiology. 2001; 218: 491–496.
15) Tomiyama N, et al. Eur J Radiol. 2006; 59: 60–64.
16) Asakura K, Nakatsuka S, et al. PLoS One. 2012; 7(8): e42043
17) Kattapuram SV, Rosenthal DI. Am J Roentgenol 1991; 157: 935-942.