

## 2 Image-Guided Percutaneous Biopsy

**Abstract** Image-guided percutaneous biopsy is a commonly performed interventional radiological procedure that plays an important role in patient care and management. It is a safe and effective procedure that is less invasive than surgical biopsy and can be performed using a variety of imaging modalities available to most radiologists. Increasingly, referring physicians rely on the expertise and skill of the interventional radiologist to obtain tissue specimens from organ systems within the abdomen and pelvis. Image-guided percutaneous biopsy is associated with low morbidity and mortality, and therefore it can be applied to patients who are too ill to undergo an operation. This chapter reviews the basic principles of image-guided percutaneous biopsy.

**Keywords** Fine needle aspiration • Core biopsy • Coaxial technique

### Indications

The most common indications for image-guided percutaneous biopsy are to obtain tissue to [1] establish the presence of primary or metastatic malignant disease, [2] to assess for rejection in the setting of organ transplant, [3] obtain tissue in the setting of abnormal tissue function, (i.e., random

liver biopsy for abnormal liver function tests) [4] to establish a benign diagnosis and [5] obtain tissue for culture for suspected infections [2, 3]. The decision to pursue image-guided percutaneous biopsy should be considered on an individual basis, taking into account the imaging and laboratory studies, overall medical condition as well as the potential risks of the procedure. Careful triage of biopsy requests helps to avoid unnecessary interventions.

## Contraindications

Absolute contraindications include patients with uncorrectable coagulopathies or who lack a safe percutaneous trajectory to the targeted organ. Most bleeding disorders are correctable and are related to hepatic dysfunction, thrombocytopenia, or administration of anticoagulation medications. Commonly accepted coagulation parameters include an international normal ratio (INR) of 1.5 or less and platelets levels  $\geq 50,000$ . Coagulopathies related to hepatic dysfunction or warfarin (Coumadin) can be reversed in the acute setting by transfusions of fresh frozen plasma, injections of vitamin K, or both. Similarly, transfusion of platelets at the time of biopsy is usually sufficient to correct thrombocytopenia. Other commonly used anticoagulants, such as aspirin and clopidogrel, should be held for at least 7 days prior to percutaneous biopsy whenever possible. Similarly, intravenous heparin should be held for approximately 2 h prior to biopsy.

## Equipment

A variety of needle types are available for percutaneous biopsy [4, 5]. Most are classified into two general groups: aspirating and cutting needles [6, 7]. Aspiration needles are

thinner gauge needles (typically 20–25-gauge) and are used to obtain material for cytological analysis. Because of their small gauge, these needles cause relatively little tissue disruption [8] and are associated with fewer bleeding complications. Cutting needles are larger, (typically 14–19-gauge) and are used to obtain material for histological evaluation [5, 9]. Various designs and cutting mechanisms for acquiring tissue specimens exist with these needle types [10]. All, however, serve the same goal of acquiring sufficient tissue for histological analysis.

## Patient Preparation

Patient preparation begins with an assessment of the indications for percutaneous biopsy and review of the pertinent imaging studies. Review of the imaging studies also helps to plan the biopsy route and to consider options for patient positioning. The medical records, with attention to bleeding disorders or medications that may increase bleeding risk, should be carefully reviewed.

Most image-guided percutaneous biopsies can be performed with the use of intravenous conscious sedation. Occasionally, general anesthesia may be necessary, especially in pediatric or uncooperative patients. Patients should be advised to have nothing to eat or drink for at least 8 h before the procedure. Oral medications can be taken with a sip of water on the morning of the procedure. Diabetic patients should review their insulin requirements with the physician who manages their disease and make adjustments accordingly.

Unless the indications for biopsy are to assess for possible infection, intravenous antibiotics are not routinely administered. Written and informed consent should include a discussion of the potential risks and benefits of the

procedure as well as a clear discussion regarding the indications for the procedure.

## Imaging Guidance

Image-guided percutaneous biopsy can be performed with ultrasound, computed tomography (CT) and CT fluoroscopy. The choice of imaging guidance for percutaneous biopsy depends on a number of factors, but primarily relies on user preference and equipment availability.

### *Ultrasound*

Ultrasound guidance is the preferred imaging modality for many interventionists [11–13]. Ultrasound guidance offers many benefits for image-guided biopsy. It is relatively low cost and allows real-time imaging without exposing the patient to ionizing radiation. Most biopsy needles are readily detectable by ultrasound and can be easily followed from the skin to the target organ. The relationships of the target and adjacent vasculature can be easily identified with ultrasound and thus aid in planning and guiding needle trajectory. Ultrasound also offers multiplanar imaging, further aiding in planning needle trajectory. The benefits of ultrasound, however, can be limited in patients of large body habitus in whom poor sound penetration results in poor image quality. Furthermore, lesions that are easily detected by contrast material enhanced CT or magnetic resonance imaging are not always readily detectable by ultrasound. Air from overlying or adjacent bowel or lung or lesions deep in the abdomen or pelvis may not be detected by ultrasound. High-frequency transducers (e.g., 7-MHz linear or phased-array) probes are usually sufficient for biopsy of superficial masses. Low-frequency probes, (e.g., 3.5 MHz sector probe)

are necessary for deeper lesions. Ultrasound-guided biopsy can be performed using either freehand technique or with the use of an ultrasound needle guide.

## *Computed Tomography*

CT is commonly used to perform a variety of percutaneous biopsies [7, 14–16]. CT guidance provides an alternative to US where poor image quality or identification of adjacent structures is not easily resolved. CT is especially helpful for biopsy of deep structures in large patients. While CT-guided biopsy lacks the multi-planar capabilities available with ultrasound guidance, gantry angulation can often create “windows” for safe access to the targeted structure [17]. CT fluoroscopy may allow more rapid imaging of the biopsy needle but image quality may suffer due to lower radiation dose used by this modality [18, 19]. The primary disadvantage of CT and CT fluoroscopy is that it exposes the patient and/or operator to ionizing.

## *Magnetic Resonance Imaging*

Advances in equipment design have facilitated progress in magnetic resonance (MR)-guided interventions [20–22]. While not currently in widespread use, MR-guided biopsies have the following potential advantages [23]:

- MR offers exquisite soft tissue contrast and anatomic details. This allows the detection of lesion not readily available by other imaging modalities.
- The ability to elicit various pulse sequences can help define abnormal tissue that helps to specifically target tissue or areas within abnormal tissue.

- Multiplanar capabilities allow precise needle localization
- Provides imaging guidance without the use of ionizing radiation.

MR-guided percutaneous biopsies of the liver and prostate gland have been described [21, 24].

## Technique

In general, the shortest and safest trajectory from the skin to the target lesion is preferred.

### *Fine Needle Aspirations*

Fine needle aspirations are obtained by rapid reciprocating excursions of the needle tip within the lesion. Fine needle aspirations can be performed with or without gentle suction applied to the needle with a syringe. Greater suction is generated with larger needles. A sample of the specimen should then be smeared onto a glass slide and immediately placed into the appropriate fixative solution. Minimizing air exposure prevents air-drying and helps in the preservation of the specimen. Excess tissue samples can then be placed into a receptacle with appropriate fixative material. When lymphoma is a potential diagnosis, a dedicated fine needle aspiration should be designated for flow cytometry analysis. Similarly, tissue samples obtained for suspected infection should be processed to assess for Gram stain, culture, and sensitivities.

### *Core Biopsy*

Cutting biopsy needles are designed to obtain small cylinders of tissue specimens for histological analysis.

The value of cutting needles is that they provide small cylinders of tissue that aid the pathologist in assessing tissue architecture.

Aspiration and cutting needles can be placed through coaxial introducers. This allows multiple samples, with either aspiration or cutting needles, to be obtained with a single puncture of the target organ.

## Complications

Potential complications inherent to any biopsy include bleeding, infection, and unintended organ injury. The risk of neoplastic seeding is low [25–28]. The reported bleeding risk ranges from 0.1 to 10%, depending on needle size and target organ [2, 8]. Risks of infection and/or peritonitis are less than 5% [2]. Risk of pneumothorax is <1%.

## Organ-Specific Biopsy

### *Liver Biopsy*

Image-guided percutaneous liver biopsy can be divided into two general categories: random and focal and each type is performed to assess for different conditions. Random liver biopsies are performed using large gauge cutting needles in order to obtain a sample of hepatic parenchyma for histological analysis. Fine needle aspirations with a small gauge needle are seldom necessary. Random liver biopsies are usually performed in the setting of abnormal liver function tests, but other indications include assessment for rejection in the transplant patient or assessment for hepatic iron or copper deposition in suspected cases of hemochromatosis or Wilson's disease.

Most random liver biopsies can be quickly and safely performed with ultrasound guidance. CT can also be used, but exposes the patient to unnecessary radiation. The multiplanar capabilities of ultrasound allow percutaneous access to the liver via subxiphoid, subcostal, or intercostal approaches. When an intercostal approach is used, it is important to align the transducer within and parallel to the intercostal spaces. This minimizes acoustic shadowing from the ribs and improves image quality and needle visualization. Similarly, subxiphoid approaches should point away from the heart. Subcostal approaches must clearly identify gallbladder and bowel. Keep in mind that the position of the liver may change in the time interval between preliminary scanning and the actual biopsy. This is often due to changes in depth of respiration after the patient has been sedated. Smaller respiratory excursions in sedated patients often result in the liver assuming a higher position in the right upper quadrant, such that initial subcostal or subxiphoid trajectories are lost after the patient becomes sedated. When this occurs, an intercostal approach is obligatory.

Focal liver biopsies are aimed at obtaining tissue from specific hepatic masses for cytological and histological analysis (Fig. 2.1). Focal biopsies are necessary to assess for primary or metastatic liver disease and for possible infections. Biopsy with a coaxial needle is helpful for focal biopsies, as this requires a single puncture across the capsule and into the liver. Once the coaxial needle is in the desired location within the liver, removal of the inner stylette provides a conduit that allows multiple fine needle aspirations and core specimens to be obtained. The major complications associated with liver biopsy include bleeding, though pneumothorax, hemophilia, or tract seeding have also been described. When they occur, most bleeding complications occur at the time of the biopsy but may



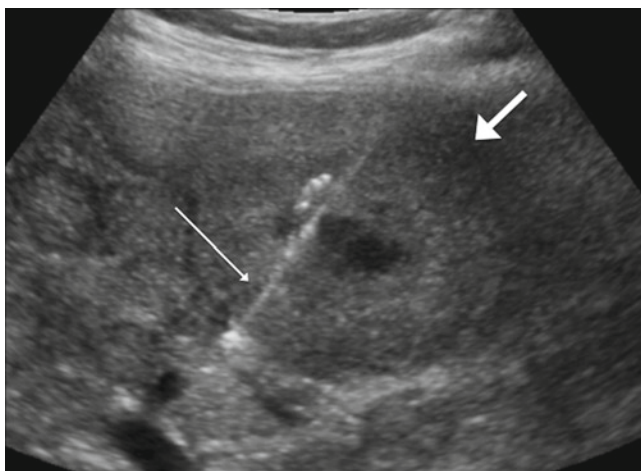


Figure 2.1. Ultrasound-guided biopsy of a focal liver lesion in the left hepatic lobe. The *thin white arrow* points to the needle. The *short white arrow* points to the liver lesion.

occasionally have a delayed manifestation. Most bleeding resolves with conservative management, but admission to the hospital and blood transfusions are occasionally necessary.

### *Spleen Biopsy*

Splenic biopsy is indicated to assess malignant from benign lesions or to diagnose suspected infections (Fig. 2.2). Despite concerns of hemorrhagic complications image-guided percutaneous biopsy is a safe procedure. Tam et al. reported high sensitivity (83.4%) and diagnostic yield (92.3%) in a series of 156 patients who underwent image-guided percutaneous biopsy with 22-gauge needles [29]. Similar reports, including reports of core biopsy of the spleen, demonstrate high sensitivity and specificity with low complication rates [30–33]. In a series of 30 patients, Muraca reported

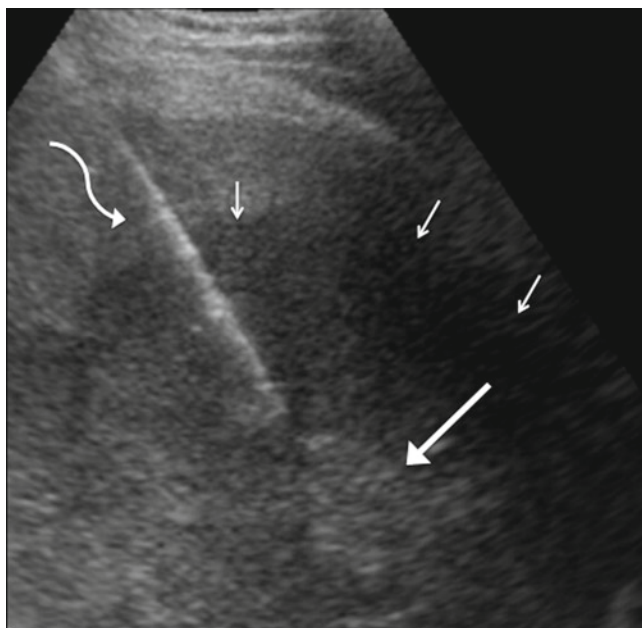


Figure 2.2. Ultrasound-guided biopsy of a splenic lesion. The *curved white arrow* points to the biopsy needle. The *long white arrow* points to an echogenic mass. The *short white arrows* outline the outer margin of the spleen.

no complications. Major complications, requiring emergency splenectomy are rare [33], and may have a higher association with tumor of highly vascular tumors [34].

Percutaneous spleen biopsies can be performed with ultrasound or CT guidance. When feasible, a coaxial needle is recommended as this reduces punctures of the splenic capsule, thus minimizing the risk of hemorrhagic complications. Traversing the least amount of parenchyma en route to the target lesion may help to minimize the bleeding risk [35]. A gelfoam suspension injected into the needle tract as the needle is withdrawn may help to minimize bleeding risk after splenic puncture [36].

## *Pancreas Biopsy*

Because of the close anatomic relationship of the pancreas to the stomach and duodenum, most pancreatic masses are easily accessible for biopsy with endoscopic ultrasound (EUS). However, tissue sampling by this method is limited to fine needles aspirations. When tissue is needed for histological evaluation, percutaneous pancreatic biopsy can be performed. When core biopsies are performed, percutaneous biopsy of the pancreas is associated with high sensitivity and specificity for malignant tumors [19, 37].

The retroperitoneal location of the pancreas often lends itself to a direct posterior approach. When a posterior approach is not feasible, solid lesions can be biopsied via a transgastric route [38] (Fig. 2.3). The risk of pancreatitis may be increased when normal pancreatic tissue is included in the biopsy specimen [39].

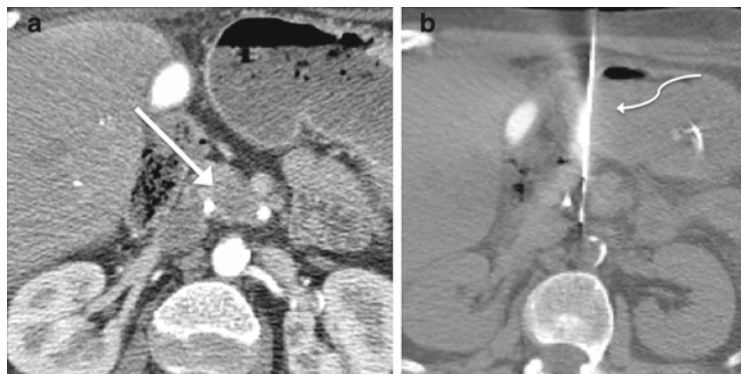


Figure 2.3. (a) Contrast material enhanced CT scan demonstrates a low attenuation lesion in the neck of the pancreas (*white arrow*). (b) *Curved white arrow* indicates the transgastric route of the biopsy needle in the pancreas neck mass.

## Adrenal Gland Biopsy

Incidentally detected adrenal tumors are a common finding in abdominal ultrasound, CT or magnetic resonance imaging. Most incidentally detected adrenal tumors are benign adenomas that can be characterized using CT or MRI. Biopsy of the adrenal glands is usually performed to confirm metastatic disease or when CT or MRI cannot adequately characterize a benign adenoma [40, 41]. The sensitivity and specificity of adrenal gland biopsy are approximately 80 and 99%, respectively [42].

Percutaneous access to the adrenal gland can be achieved via posterior, anterior, or transhepatic approaches [43] (Fig. 2.4). Because of the high retroperitoneal location of the adrenal gland, a posterior approach with the patient in a prone position can be complicated by pneumothorax. This can be overcome by placing the patient in an ipsilateral lateral decubitus position. This displaces the lung out of the



Figure 2.4. Computed tomography-guided percutaneous biopsy of a left adrenal tumor. The patient is in a lateral decubitus position. The curved white needle points to the biopsy needle and the short *straight white arrow* points to the left adrenal gland.

posterior costophrenic sulcus and often creates a safe trajectory to the adrenal gland that avoid lung altogether. When posterior or lateral decubitus positioning fail to displace lung, alternate approaches that go through lung, liver, kidney, pancreas, and spleen have been described [40, 44–47].

The possibility of a pheochromocytoma should be ruled out by biochemical testing for catecholamines or their metabolites [48, 49]. Failure to do so may result in severe hypertensive crisis [50].

### *Renal Biopsy*

Percutaneous renal biopsy is performed for the evaluation of renal failure or to assess renal neoplasms [51–54] (Fig. 2.5).



Figure 2.5. Computed tomography-guided percutaneous biopsy of a left renal cell carcinoma. The *curved white arrow* points to the biopsy needle. The *short white arrow* indicates the renal cell carcinoma. The patient is in a lateral decubitus position.

For appropriately triaged patients, percutaneous biopsy is a safe, reliable, and accurate method for assessing parenchymal disease and suspicious or indeterminate renal masses [54].

Nonfocal biopsy is typically performed in the setting of acute renal failure or to assess renal transplants in cases of suspected rejection [55]. Nonfocal renal biopsies are obtained using ultrasound guidance with a large-gauge cutting needle, typically 14- or 15-gauge (Fig. 2.6). With the patient in a prone position and using ultrasound

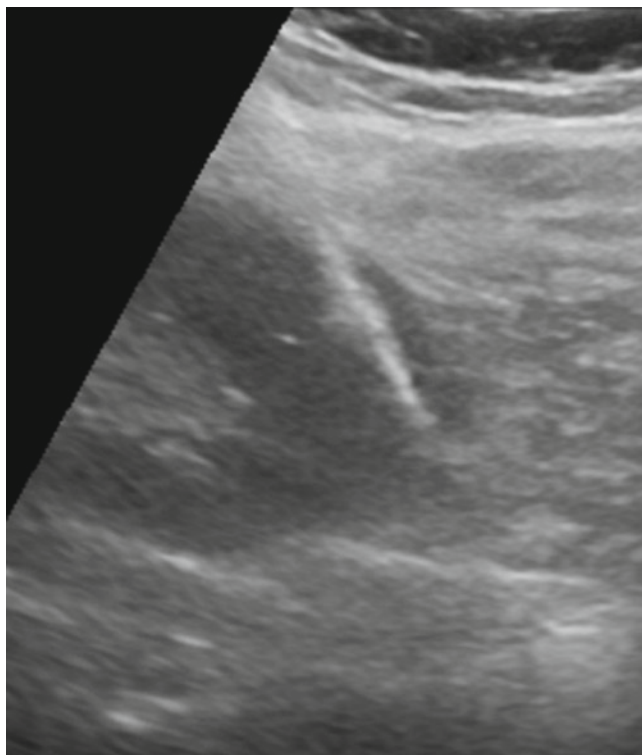


Figure 2.6. Ultrasound-guided biopsy of the left kidney. The biopsy needle should be directed toward either the upper or lower pole and away from the renal hilum so as to minimize the risk of renal hilar vascular injury.

guidance, the cutting needle should be directed toward either the upper or lower poles. It is important to obtain tissue from the renal cortex in order to maximize the yield of glomeruli in the specimen. Directing the biopsy needle away from the renal sinus helps to minimize potential bleeding complications.

Advances in tissue analysis and therapeutic options now available for the management of renal tumors have led to the value of image-guided percutaneous biopsy of focal renal masses. Published literature within the last decade demonstrates that percutaneous biopsy of renal tumors is safe. Serious complications are rare and a success rate of greater than 80% is attainable using percutaneous techniques [25, 56].

## Conclusion

Image-guided percutaneous biopsy is a minimally invasive, yet valuable procedure that provides important and useful information for patient care and management. Most organs within the abdomen and pelvis are readily accessible using imaging guidance, and percutaneous biopsy should be considered the method of choice for establishing a benign or malignant process through tissue sampling.

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