

# Ultrasound-Guided Percutaneous Core Needle Biopsy of Abdominal Viscera: Tips to Ensure Safe and Effective Biopsy

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Ultrasound-guided percutaneous core needle biopsy (USPCB) is used extensively in daily clinical practice for the pathologic confirmation of both focal and diffuse diseases of the abdominal viscera. As a guidance tool, US has a number of clear advantages over computerized tomography or magnetic resonance imaging: fewer false-negative biopsies, lack of ionizing radiation, portability, relatively short procedure time, real-time intra-procedural visualization of the biopsy needle, ability to guide the procedure in almost any anatomic plane, and relatively lower cost. Notably, USPCB is widely used to retrieve tissue specimens in cases of hepatic lesions. However, general radiologists, particularly beginners, find USPCB difficult to perform in abdominal organs other than the liver; indeed, a full understanding of the entire USPCB process and specific considerations for specific abdominal organs is necessary to safely obtain adequate specimens. In this review, we discuss some points and techniques that need to be borne in mind to increase the chances of successful USPCB. We believe that the tips and considerations presented in this review will help radiologists perform USPCB to successfully retrieve target tissue from different organs with minimal complications.

**Keywords:** Abdomen; Diagnostic technique; Biopsy; Ultrasonography

## INTRODUCTION

Although pathologic examinations may not be routinely performed for various diseases of the abdominal viscera, they are often necessary because an imaging diagnosis can be declared inconclusive. Ultrasound-guided percutaneous core needle biopsy (USPCB) is an accurate, safe, and widely

accepted technique for the tissue diagnosis of various lesions of the abdominal viscera (1). Among various guidance tools such as US, computed tomography (CT), and magnetic resonance (MR) imaging, US has a number of advantages for guiding percutaneous biopsy for intra-abdominal lesions, including wide availability, portability, lack of ionizing radiation, relatively short procedure time, real-time visualization of the biopsy needle and target lesion during the procedure, ability to guide the procedure in almost any anatomic plane, fewer false-negative biopsies, and relatively lower cost (2-4). These advantages make US more effective than CT and MR imaging in obtaining safe access to the target lesions without the need to traverse non-target organs and vessels. USPCB is widely used in the diagnosis of various hepatic lesions, but for abdominal organs other than the liver, it is still considered technically difficult for general radiologists, especially beginners. The success of USPCB relies on various factors such as the radiologist's experience and knowledge about the procedure.

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Among these factors, continuous real-time visualization of the whole length of the biopsy needle, anatomic knowledge of the abdomen, and specific path of approach for specific abdominal organs are all of great importance (5).

In this article, we review various aspects of USPCB, including its indications, contraindications, details on the process including useful tips, specific considerations for different abdominal organs, potential complications, and various clinical scenarios.

## Indications

Firstly, USPCB is often required to confirm and stage the malignancy of lesions within the abdominopelvic cavity, except in organs such as the stomach and colon where endoscopic approaches are possible (6). In particular, USPCB can play an important role in planning treatment strategies for patients with cancers of unknown primary origin. Secondly, USPCB enables differentiating between benign and malignant lesions, which is difficult to do with imaging studies alone, and thereby avoiding unnecessary surgery. Thirdly, USPCB is necessary to pathologically confirm diffuse parenchymal disease in the solid organs such as the liver and kidney (2, 7).

## Contraindications

Ultrasound-guided percutaneous core needle biopsy should be avoided in patients with uncorrectable coagulopathy or in the absence of a safe needle path and in uncooperative patients with uncontrolled movement or irritability (6). It is contraindicated in patients with a serum platelet count of less than  $50 \times 10^9/L$  and an international normalized ratio of more than 1.6 (8). Sometimes, before USPCB, transfusion of appropriate blood components may be useful for correcting coagulopathy when pathologic diagnosis is necessary for patients with impaired coagulation (9). For in-patients who are receiving anticoagulation therapy, such as aspirin, USPCB can be performed at least five days after the withdrawal of aspirin (10). USPCB is not recommended if the operator fails to delineate a safe path for biopsy. However, when direct routes to approach the target lesion cannot be identified during the pre-procedural US, it may be acceptable to advance the biopsy needle through major abdominal organs (11, 12). Any motion that is not anticipated by the operator while performing USPCB may cause serious injury to vital organs. Therefore, if the patient

is irritable or uncooperative or has involuntary movements, USPCB is best avoided.

## The Detailed USPCB Process

### Pre-Biopsy Preparations

Although routine screening tests for coagulation status are not universally recommended (13), many centers perform common coagulation tests before USPCB, including prothrombin time, activated partial thromboplastin time, and platelet count (9). Patients are advised to fast without taking solid or semisolid food (water permitted) for at least six hours before the procedure when the preoperative imaging shows that the planned biopsy path traverses the gastrointestinal (GI) tract or the lesion is located at a site deep in the abdominal cavity such as the pancreas, left adrenal gland, or retroperitoneum (14). It is recommended that the route for intravenous access be established before the procedure in patients with high risk of bleeding or anxiety (2).

### Selecting the Biopsy Needle

Selecting the appropriate biopsy needle is critical to the success of USPCB; the size of the needle is directly correlated with the amount of target tissue required. Needles can be classified into two types: small caliber (20-gauge or smaller) and large caliber (19-gauge or larger) (2). Although needles with small caliber are primarily used to collect cellular samples for cytologic examinations, large-caliber needles can provide sufficient tissue cylinders for thorough histological evaluations (15-17). Although fine needle aspiration (FNA) with a small-caliber needle has high diagnostic accuracy with minimal complications, its efficacy greatly depends on the on-site availability of experienced cytopathologists (18); in contrast, core biopsy does not require a cytopathologist. Further, larger tissue samples are usually obtained by core biopsies, which are more suitable for the subtype analysis of tumors (2, 6, 19). In general, USPCB can be successfully performed using an 18-gauge needle with an automated spring-loaded biopsy gun to obtain sufficient tissue samples (7, 14, 18, 20, 21).

Most biopsies are performed more than once by making multiple passes into the target lesion. Coaxial biopsy has been suggested as a useful method for obtaining multiple samples without re-puncturing the capsule of the target organ (6). Although this technique is expected to decrease the risk of bleeding and time to complete multiple biopsies,

it poses a greater risk of lacerating target organs due to longer dwell times for larger coaxial needles (6). Meanwhile, non-coaxial techniques feature less dwell time for smaller biopsy needles in the target organs. Previous studies found no significant differences in complication rates between the two techniques (6, 22).

There are two types of automated cutting needles: fully automated and semi-automated (23). In semi-automated biopsy needles, the inner trocar is advanced by hand to open the side notch, accompanied by a rapid excursion of the outer cutting cannula by a spring-loaded automated biopsy action. The manual insertion of an inner trocar may provide for more accurate targeting and added safety to minimize the risk of injury to surrounding critical structures (24). However, if the target lesion is too hard or movable, it may be difficult to introduce the trocar through the target without displacing it. Meanwhile, fully automated biopsy guns, which thrust both a central trocar and a cutting cannula in a forceful forward motion into the target, have less chance of displacing the target during the biopsy (23, 24). When using fully automated biopsy needles, it is necessary to consider both the position of the needle tip and the anticipated penetration length of the needle after the automated biopsy gun is fired. In this regard, a double-firing system may be effective in avoiding unexpected injuries to major vessels located deep in the abdomen. Firstly, operators advance the echogenic tip of the inner trocar up to the desired depth within the target with the first firing, and then the pre-set excursion of the outer cutting cannula is made by the second firing to extract a core of tissue (16).

The needle length should be chosen according to the distance of the target lesion from the skin along the expected biopsy route, considering the fact that long needles are difficult to control during biopsies. With regard to the length of the sample notch, needles with a biopsy throw between 5 mm and 30 mm should be chosen depending on the target size (3, 25, 26).

### Planning an Optimal Approach Path

Planning a safe USPCB begins with a thorough review of the CT or MR images to determine the safest needle path to the target lesions while avoiding important abdominal organs and major vessels (27). The feasibility of the anticipated biopsy route defined using CT or MR images must be confirmed by US before biopsy. If the biopsy path determined using the CT or MR images cannot be delineated by US, an alternative safe trajectory should be sought from

the US images. Naturally, the less important the vessels visualized along the biopsy path, the safer the path will be; if major vascular structures lie in the course of the planned biopsy path, the probability of major bleeding due to vascular injuries is high. Color Doppler US can be effectively used to identify important vessels around major abdominal organs and to plan the biopsy path away from them (28).

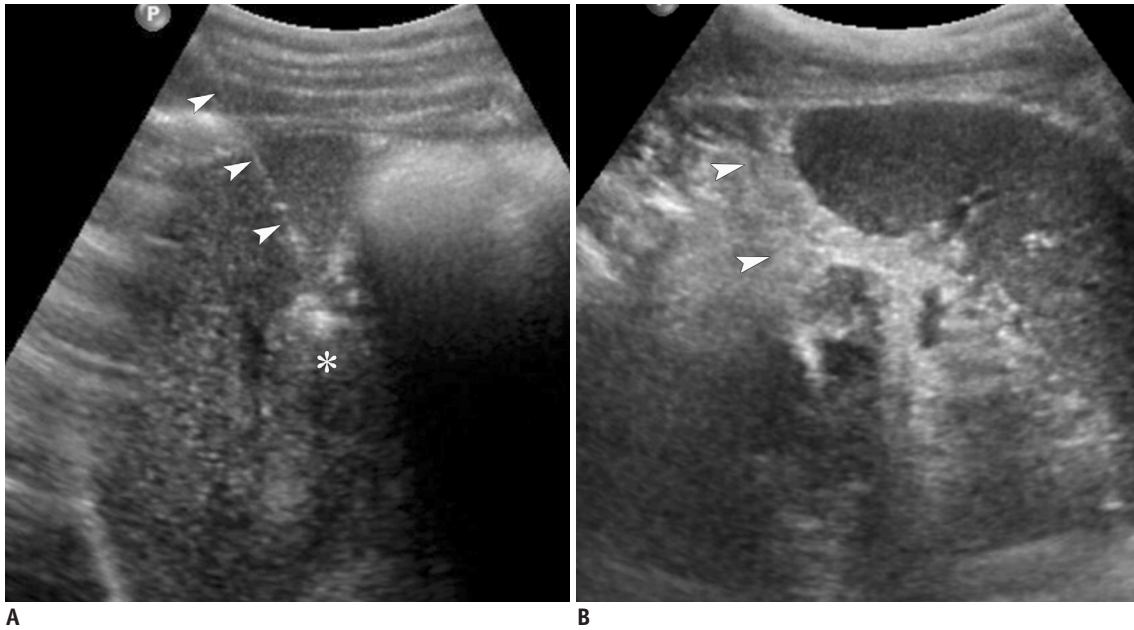
Occasionally, lesions are not detected in the US imaging because of their echogenicity or the presence of abundant abdominal fat or gases within the bowel or lung. Moreover, the locations of the target lesions and surrounding organs as defined by CT or MR imaging may vary slightly on US images because of the mobility of the abdominal organs, motions of respiration, and the patients' positions; in this scenario, the patient's position and respiration need to be changed to allow identifying the lesion.

### Technical Strategies for Clear Visualization of the Biopsy Needle

Many operators prefer a free-hand technique in which the operator holds the transducer in one hand while manipulating the biopsy needle with the other (5, 29); the advantage of this technique is that operators can freely fine-tune the needle path during the biopsy. In this technique, appropriate alignment of the needle and the transducer is indispensable for the continuous visualization of the needle tip (30). In other words, the biopsy needle should be parallel to the long axis of the transducer to ensure clear visualization of the entire needle shaft. If only part of the needle is visible on the US image, the needle should be realigned while keeping the position of the transducer unchanged.

Needle visualization is also affected by the reflectivity of the needle. Compared with highly flexible smaller needles, large-caliber needles such as 18-gauge provide greater visibility on US images (31), and sometimes, even these needles may not be visualized on US images during biopsy. In such situations, the needle's visibility may be improved by moving its tip to and fro ("pump maneuver") and by using color Doppler US (32, 33).

The echogenicity of the intervening structures also affects needle visualization during the penetration of the structures (33). Biopsy needles are easily visible within relatively hypoechoic structures such as the liver, spleen, kidney, and subcutaneous fat layers, but a gas-filled bowel or hyperechoic abdominal fat can make it difficult to visualize the needle (Fig. 1).



**Fig. 1. Influence of echogenicity of intervening traversed structures on visibility of biopsy needle.**

**A.** Echogenic shaft of biopsy needle (arrowheads) is relatively well visualized within subcutaneous fat layer, spleen, and mass (asterisk) in 50-year-old man. **B.** Biopsy needle (arrowheads) is poorly seen, especially within hyperechoic abdominal fat and bowel gas in 55-year-old man.

### How to Effectively Control the Biopsy Needle

When penetrating the abdominal organs, including the GI tract, two points are worth considering. First, pierce the surface of the solid organs and the bowel wall as orthogonally as possible; this could particularly help prevent tearing the capsule of the liver and the spleen. Second, advance the needle forcibly and quickly with no hesitation so that the flexible and mobile structures such as the bowel and gallbladder (GB) wall can be punctured (34).

When approaching the target, the needle should be readjusted to ensure proper inclination and positioning (16). For larger lesions, acquiring the specimen at the outer portion of the lesion is recommended because the inner portion is often necrotic or cystic, which is not suitable for pathologic diagnosis (6). In contrast, when a mass has a diameter less than 2 cm, a tissue specimen should be acquired from the center of the target (26).

### Post-Biopsy Management

Immediately after the core tissue is extracted, color Doppler US should be carefully performed to check for any significant post-biopsy bleeding. A linear track of color flow along the biopsy trajectory (“patent tract” sign) strongly suggests the possibility of clinically significant post-biopsy bleeding, especially if it persists even five minutes after USPCB (35).

### Organ-Specific Technical Considerations

#### Liver

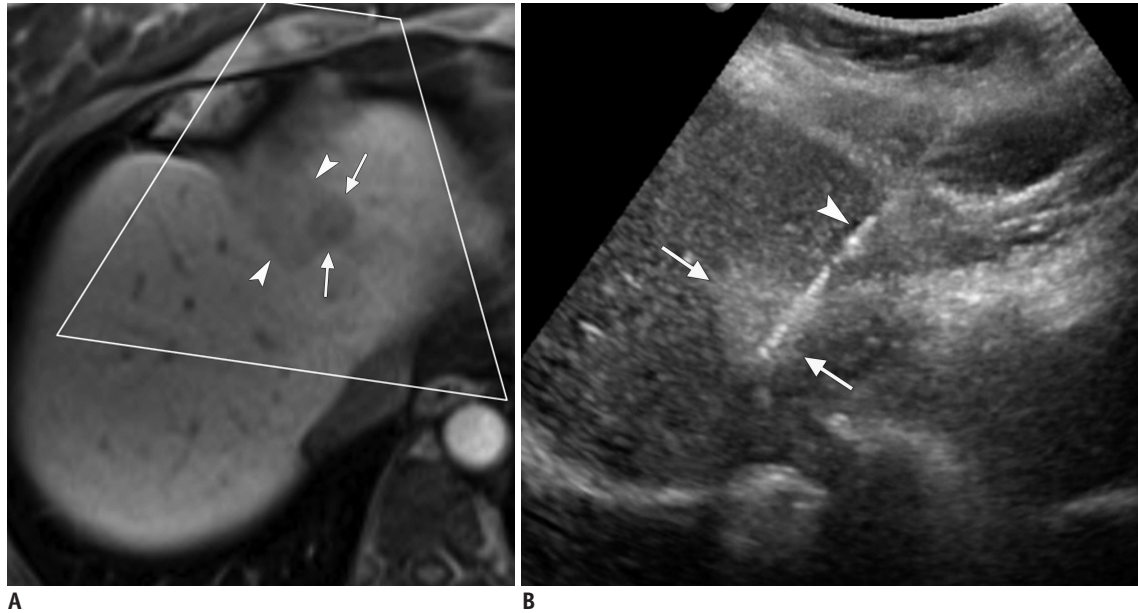
For liver biopsy, both the subcostal and intercostal approaches are used with the patients in the supine position. In diffuse liver disease, a subcostal approach to the left hepatic lobe in the midline epigastrium is usually preferred to an intercostal approach to minimize the risk of intercostal vessel injury and pain (6, 26). When a subcostal route is not available due to the small size of the left hepatic lobe, an intercostal route toward segment 5 can be alternatively used. For a focal hepatic lesion, the approach route should be determined according to the location of the lesion within the liver. If the target is located in the inferior portion of the caudate lobe or segments 4, 6, 7, or 8, an intercostal approach should be adopted, whereas a subcostal approach should be used when the target is located in the superior portion of the caudate lobe or segments 2, 3, or 5 (Fig. 2). If the lesion is located in the superior segment of the liver, close to the dome, the left posterior oblique position may be required to allow visualization of and access to the target lesion (6); the presence of ascites should not be a contraindication for liver biopsy, and drainage of ascitic fluid should be considered before the procedure only in cases with massive ascites (6). To minimize bleeding, which is the most common complication of biopsy (36), the needle trajectory should include as much normal parenchyma as



possible before the target is entered, without crossing major hepatic vessels.

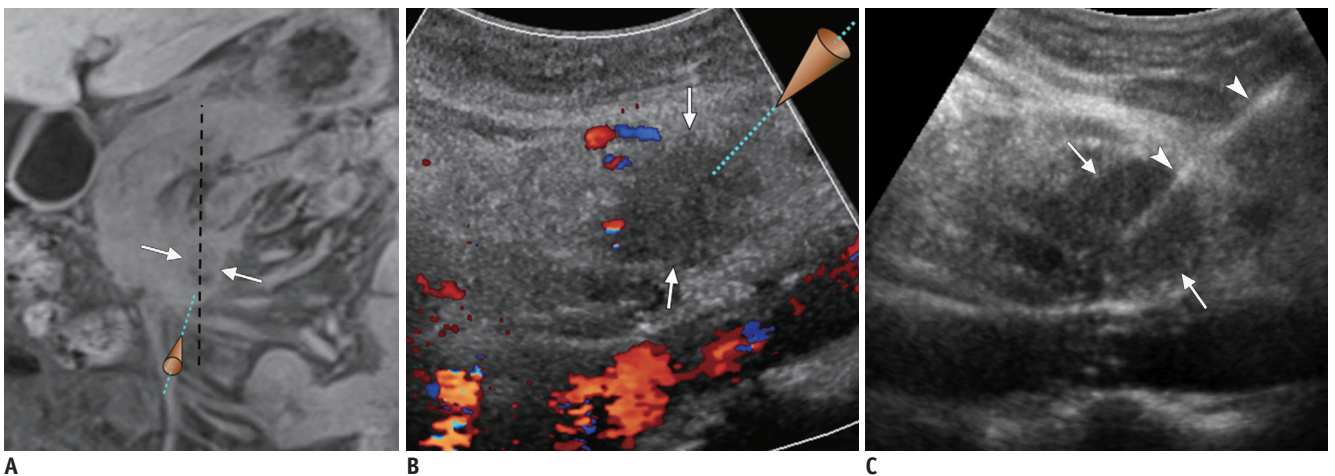
**Pancreas**

Tissue diagnosis of various pancreatic lesions can be made by FNA cytology or tissue core biopsy under endoscopic US



**Fig. 2. 57-year-old woman with dysplastic nodule in left hepatic lobe.**

**A.** Gadolinium-enhanced T1-weighted hepatocyte-phase MR image displays heterogeneously hypointense mass (arrows) measuring 2 cm with surrounding focal fat deposition (arrowheads) in left hepatic lobe. Trapezoid outline indicates US scan area (**B**). **B.** Oblique transverse subcostal US image shows hyperechoic mass (arrows) in left hepatic lobe. USPCB with 18-gauge needle (arrowhead; needle length: 11.5 cm, size of cutting notch: 1.6 cm) using subcostal approach was performed while patient was in supine position with one breath-hold; operator used two-stage biopsy action during procedure. After advancing needle tip to position 0.5 cm proximal to anterior border of target, operator pressed firing trigger to thrust inner trocar forward and confirmed that needle tip was within target, accompanied by second firing of outer cutting cannula to extract tissue specimen (stroke length: 22 mm). US = ultrasound, USPCB = ultrasound-guided percutaneous core needle biopsy



**Fig. 3. 63-year-old man with well-differentiated ductal adenocarcinoma in pancreatic uncinete process.**

**A.** Coronal enhanced T1-weighted MR image shows hypointense 2.8 cm mass (arrows) in uncinete process of pancreas. Dotted line indicates plane of sagittal US image (**B, C**). Biopsy gun model indicates planned transabdominal caudocranial approach to mass in uncinete process. **B.** Corresponding sagittal color Doppler US image planned in (**A**) shows vascular structures around mass (arrows) that should be avoided. Biopsy gun model indicates planned trans-omental caudocranial approach. Note that there is no major vessel along planned safe path. **C.** Sagittal US image shows echogenic line (arrowheads), which indicates 18-gauge needle (needle length: 11.5 cm, size of cutting notch: 1.6 cm), and hypoechoic mass (arrows) in uncinete process along planned safe path. Operator used two-stage biopsy action during procedure. After advancing needle tip to anterior border of target, operator pressed firing trigger to thrust inner trocar forward and confirmed that needle tip was within target, accompanied by advancing outer cutting cannula to extract tissue specimen (stroke length: 22 mm). US = ultrasound

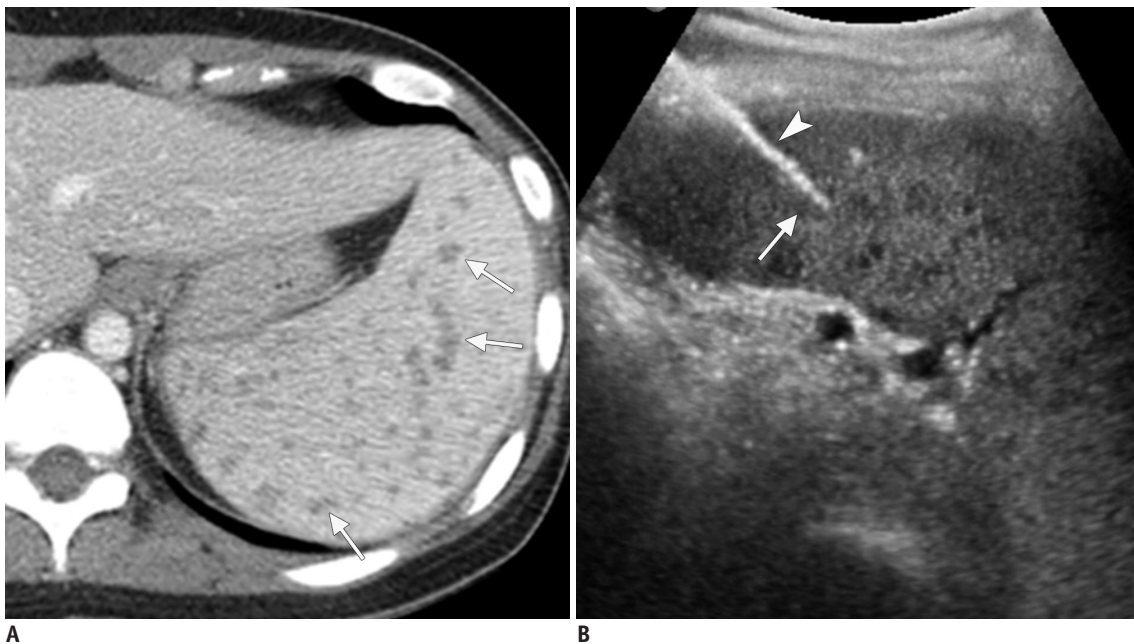
(EUS), US, or CT guidance. EUS uses a shorter needle tract, which may result in a lower likelihood of tumoral tract seeding (37). Additionally, EUS-guided FNA may be useful when CT or US cannot detect and localize small focal lesions in the pancreas (38). However, given that the diagnostic accuracy rates for EUS and the percutaneous approach are similar, ranging from 76% to 96% and from 72% to 100%, respectively (17, 18, 38, 39), percutaneous core-needle biopsy can be alternatively considered for the pathologic diagnosis of pancreatic masses through obtaining larger tissue samples if EUS-guided FNA cytology fails or is unavailable.

The pancreas is likely the most difficult organ for USPCB because it is a deep organ and it is surrounded by dense vasculature and other abdominal viscera. However, the complication rates have been reported to be low (12, 18, 40). In some cases, penetrating surrounding organs such as the stomach, small bowel, liver, and spleen cannot be avoided (12, 34). Nevertheless, USPCB through the colon is not recommended because of the potential risk of peritonitis by contaminating a sterile biopsy site (12, 41, 42). Color Doppler US is very helpful in identifying the vessels to be avoided during the procedure (Fig. 3). If the lesion is

located in the head, neck, body, or proximal tail of the pancreas, a transabdominal approach through the omentum or stomach is recommended. If the colon or abundant vasculature overlies the lesion in the pancreatic tail, it may be useful to use a left intercostal approach through the spleen or a posterolateral approach through the kidney.

**Spleen**

Ultrasound-guided percutaneous core needle biopsy of the spleen is often avoided due to concern for the associated high risk of hemorrhage after the biopsy. However, the safety and diagnostic accuracy of splenic biopsies are reported to be similar to those of liver biopsies (43). In previous research, the diagnostic accuracy rates ranged between 87.6% and 98.2%, with major complication rates of less than 3.2% (19, 43). The left intercostal approach is generally adopted with the patient in the supine position. Alternatively, the right posterior oblique or right decubitus position may be used depending on the location of the lesion within the spleen. Useful technical tips to minimize the risk of hemorrhage during splenic biopsy are as follows: 1) choose a peripherally located lesion for the biopsy rather than a deep-seated lesion if there are multiple lesions

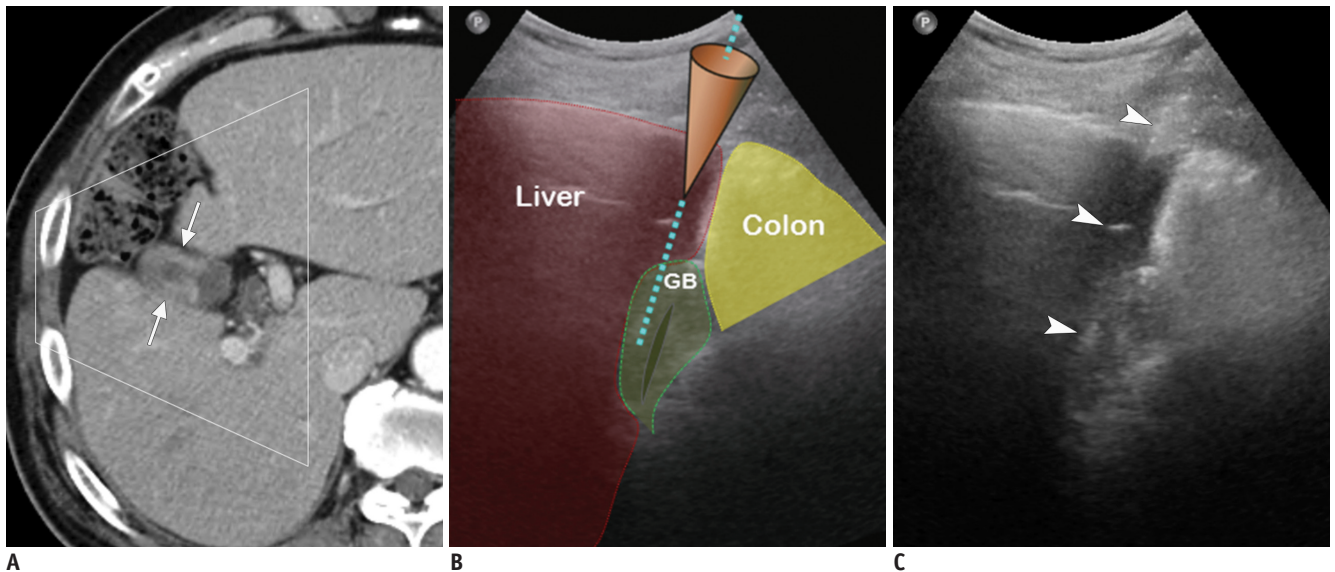


**Fig. 4. 20-year-old woman with multiple microabscesses in spleen.**

**A.** Contrast-enhanced CT image displays multiple, small lesions (arrows) in spleen with low attenuation. **B.** Longitudinal US image during biopsy with 18-gauge needle (arrowhead) shows multiple, small hypoechoic lesions within spleen. Note that peripherally located 0.8 cm lesion (arrow) was chosen for biopsy to traverse as little normal splenic parenchyma as possible. Operator used 18-gauge biopsy needle (needle length: 11.5 cm, size of cutting notch: 0.6 cm). After advancing needle tip to position 0.5 cm proximal to anterior border of target, operator pressed firing trigger to thrust inner trocar forward and confirmed that needle tip was within target, accompanied by second firing of outer cutting cannula to extract tissue specimen (stroke length: 11 mm). US = ultrasound

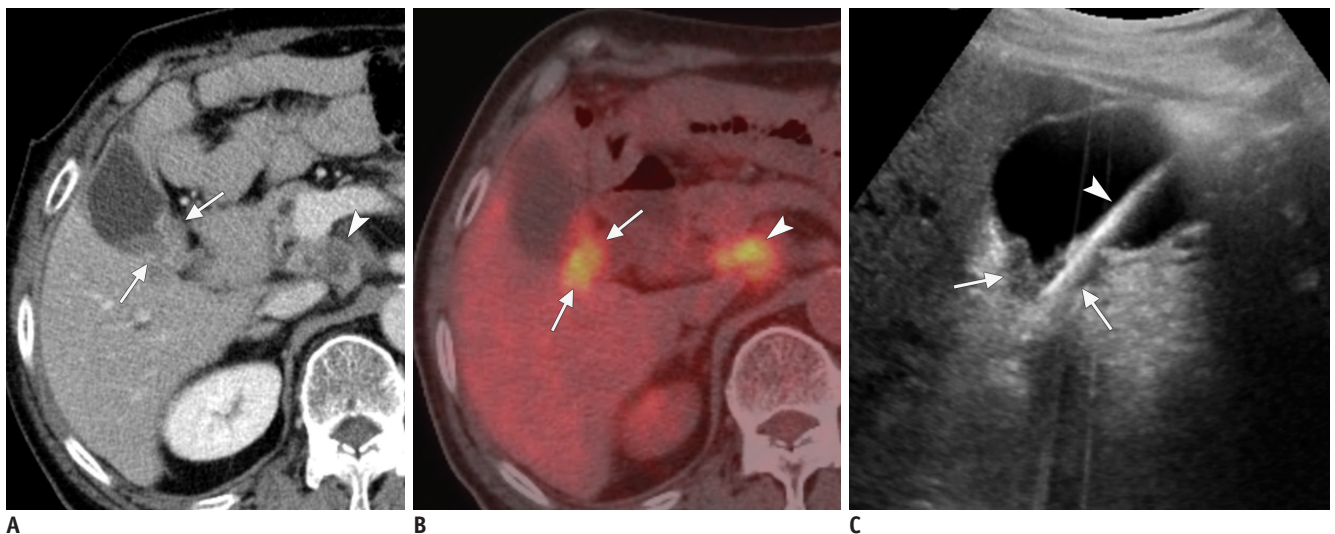
(Fig. 4); 2) choose the shortest biopsy path to traverse as little normal splenic parenchyma as possible, unlike with liver biopsy, because a more intervening normal splenic

parenchyma tends to increase bleeding risk rather than a tamponade effect (44); 3) as far as possible, finish the procedure during breath-hold or shallow respiration; and 4)



**Fig. 5.** 67-year-old man with GB cancer.

**A.** Contrast-enhanced CT image shows enhancing thickened wall (arrows) measuring 2.8 cm in GB. Trapezoid outline indicates US scan area (**C**). **B.** Illustration of transverse US image (**C**) shows target (GB) surrounded by liver and colon. Biopsy gun model indicates planned transhepatic approach to target lesion. **C.** US image during procedure with 18-gauge needle (arrowheads; needle length: 11.5 cm, size of cutting notch: 1.6 cm) via transhepatic approach shows appropriate path for adequate acquisition of specimen. After advancing needle tip to anterior border of target, operator pressed firing trigger to thrust inner trocar forward and confirmed that needle tip was within target, accompanied by second firing of outer cutting cannula to extract tissue specimen (stroke length: 22 mm). There were no symptoms from bile peritonitis after biopsy. GB = gallbladder, US = ultrasound



**Fig. 6.** 77-year-old man with GB cancer.

**A.** Contrast-enhanced CT image displays irregularly thickened enhancing wall (arrows) measuring 2.6 cm in GB neck and metastatic lymphadenopathy (arrowhead). **B.**  $^{18}\text{F}$ -FDG PET/CT image shows focal hot uptakes in GB wall (arrows) and lymphadenopathy (arrowhead) that are seen on (**A**). **C.** Longitudinal US image depicts irregularly thickened hypoechoic wall (arrows) in GB neck. US image during procedure with 18-gauge needle (arrowhead; needle length: 11.5 cm, size of cutting notch: 1.1 cm) via transabdominal approach shows needle path for adequate acquisition of specimen. After advancing needle tip to anterior border of target, operator pressed firing trigger to thrust inner trocar forward and confirmed that needle tip was within target, accompanied by second firing of outer cutting cannula to extract tissue specimen (stroke length: 16 mm). There were no signs or symptoms of bile peritonitis after biopsy. FDG = fludeoxyglucose, GB = gallbladder, PET = positron emission tomography, US = ultrasound



limit the number of needle punctures.

### Gallbladder

Percutaneous biopsy of the GB is rarely performed due to potential complications such as bile peritonitis or hemobilia. However, USPCB for GB lesions has been shown to be accurate, safe, and cost-effective (45, 46). A mass form is more conducive to biopsy than a thickened GB wall. In most cases, the transhepatic approach is preferred to the transabdominal approach to avoid bile leak (Fig. 5). Perpendicular penetration through the GB wall is recommended to avoid GB perforation and bile leakage. If the transabdominal approach is adopted, rapid and forceful penetration is useful because of the flexibility and mobility of the GB wall (Fig. 6).

### Kidney

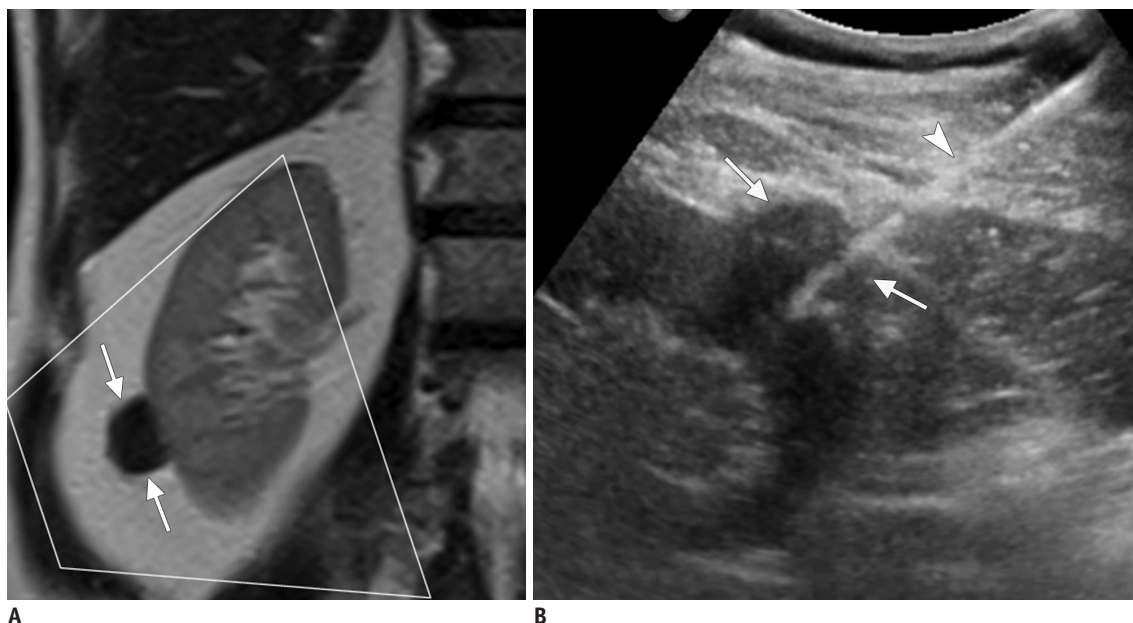
Renal biopsy is often indicated to identify the etiology of parenchymal disease and to differentiate renal cell carcinomas from other renal masses (47, 48). To acquire adequate cortical renal tissue that contains glomeruli for the diagnosis of intrinsic parenchymal disease, a posterolateral approach into the lower pole of the kidney is generally used with the patient in the prone position. The

factors to be considered in selecting safe paths for renal biopsy include the target location within the kidney, lesion size, and the patient's body habitus (26). If the lesion is located in the lateral or posterior aspect of the kidney, a posterolateral intercostal approach is recommended with the patient in the prone position (Fig. 7). However, if the lesion is in the medial or anterior aspect of the kidney, a transhepatic or trans-splenic intercostal approach is desirable with the patient in the supine position (Fig. 8).

### Adrenal Gland

For USPCB of the adrenal gland, the important factors that influence the choice of a safe path are the laterality of the lesion and the size of the target. If the lesion is located in the right adrenal gland, a transhepatic approach is recommended with the patient in the supine or left posterior oblique position; if the lesion is located in the left adrenal gland, a transabdominal or posterior approach can be adopted with the patient in the supine or prone position, respectively (Fig. 9). USPCB is more suitable for lesions in the right gland because the liver may serve as a useful sonic window.

Although USPCB is usually contraindicated in cases of pheochromocytoma (49), when performing biopsy in



**Fig. 7. 70-year-old man with angiomyolipoma in right kidney.**

**A.** Coronal T2-weighted MR image displays exophytic hypointense 2.3 cm mass (arrows) in lateral aspect of right kidney. Trapezoid outline indicates US scan area (**B**). **B.** Longitudinal US image shows exophytic isoechoic mass (arrows) in right kidney. USPCB with 18-gauge needle (arrowhead; needle length: 11.5 cm, size of cutting notch: 1.6 cm) via posterolateral approach was performed while patient was in prone position. After placing needle tip at anterior border of target, operator sequentially advanced inner trocar and outer cutting cannula to extract tissue specimen (stroke length: 22 mm). Procedure was performed as quickly as possible with patient holding his breath in order not to cause tumoral rupture. US = ultrasound, USPCB = ultrasound-guided percutaneous core needle biopsy



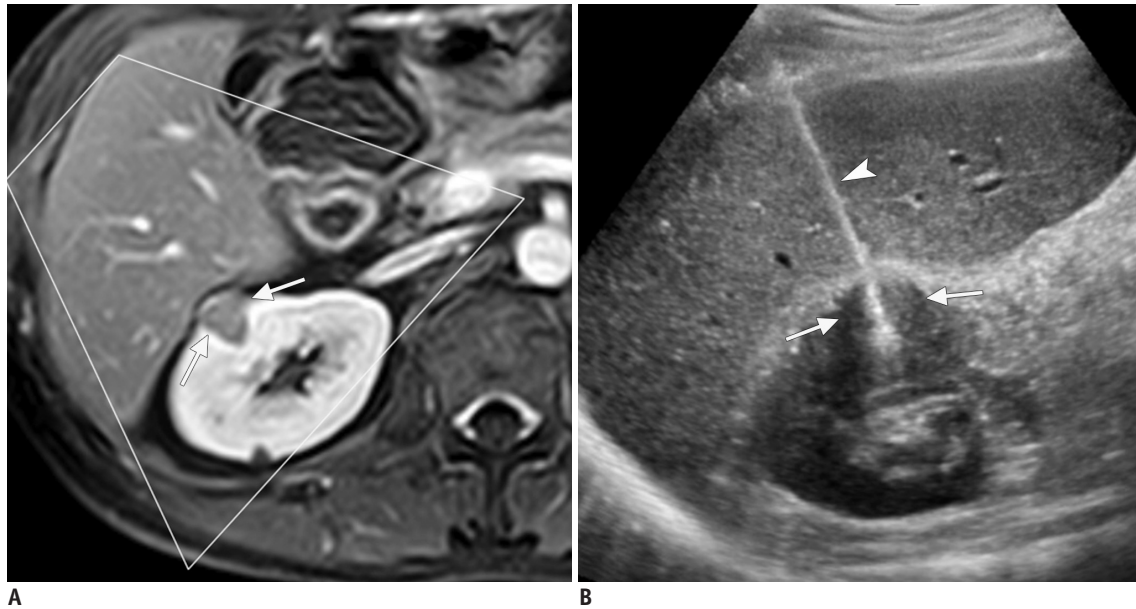
patients with suspected pheochromocytoma, pretreatment with an  $\alpha$ -adrenergic blocker is recommended to avoid hypertensive crisis and bleeding (50).

**Gastrointestinal Tract**

Biopsies for lesions in the GI tract are generally performed

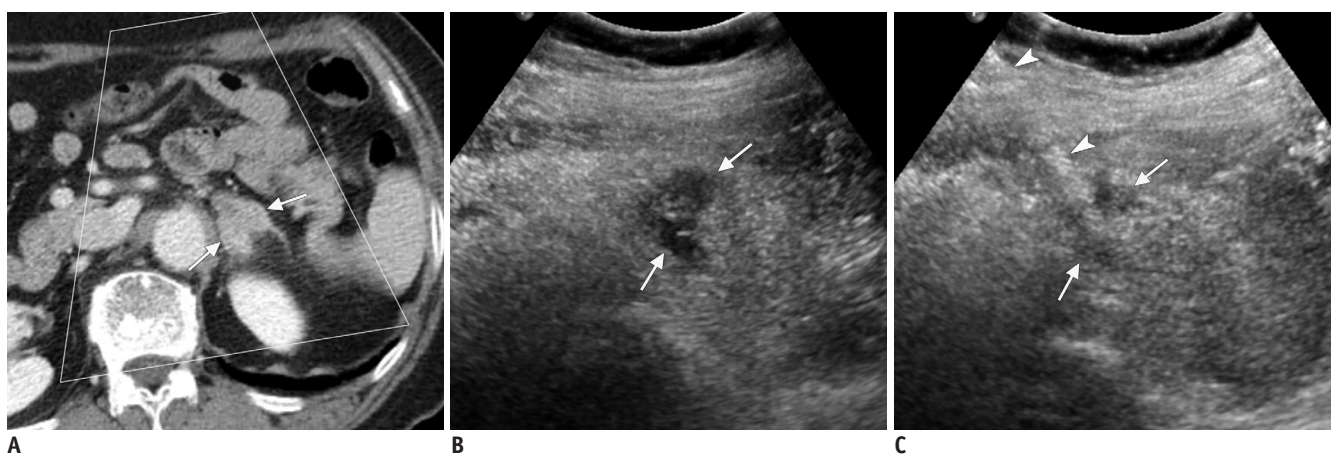
under endoscopic guidance, but percutaneous biopsy of the bowel is sometimes performed when the lesion is situated below the mucosa or in the jejunum and ileum (21, 51, 52).

A bowel mass is usually detected as a hypoechoic lesion within the hyperechoic background of the bowel (53). The location of the bowel mass as identified by US, CT, and MR



**Fig. 8.** 42-year-old man with clear cell renal cell carcinoma in right kidney.

**A.** Axial contrast-enhanced T1-weighted MR image shows exophytic poorly enhancing 1.8 cm mass (arrows) in anterior aspect of right kidney. Trapezoid outline indicates US scan area (**B**). **B.** Transverse US image shows exophytic isoechoic mass (arrows) in right kidney. USPCB with 18-gauge needle (arrowhead; needle length: 15 cm, size of cutting notch: 1.1 cm) via transhepatic approach was performed while patient was in supine position. After placing needle tip at anterior border of target, operator sequentially advanced inner trocar and outer cutting cannula to extract tissue specimen (stroke length: 16 mm). Procedure was performed as quickly as possible with patient holding his breath in order not to cause tumoral rupture. US = ultrasound, USPCB = ultrasound-guided percutaneous core needle biopsy

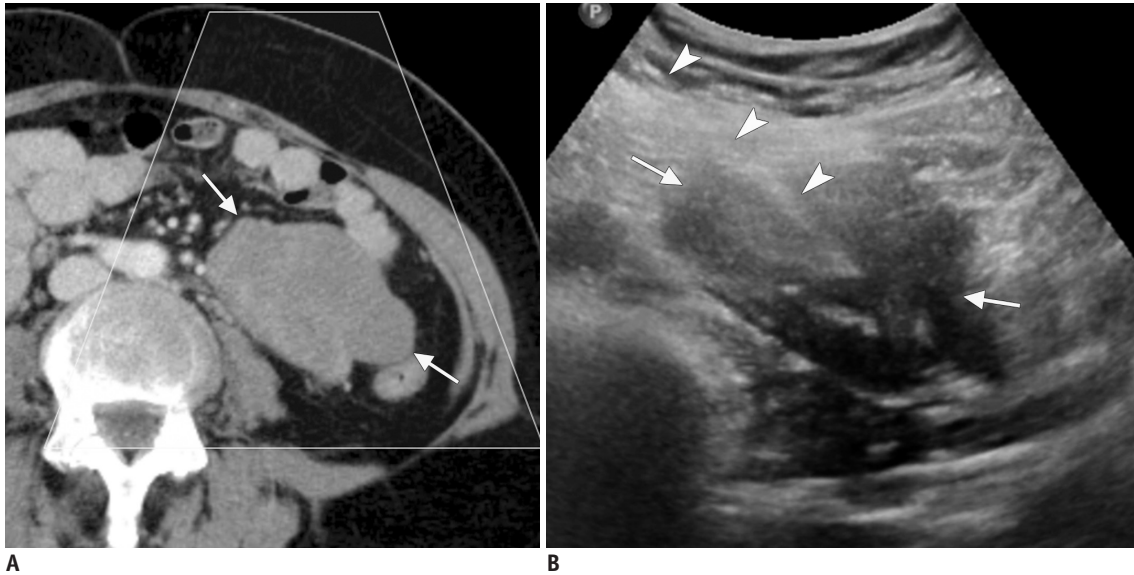


**Fig. 9.** 69-year-old woman with metastasis in left adrenal gland.

**A.** Contrast-enhanced CT image shows well-defined enhancing mass (arrows) measuring 2.5 cm in left adrenal gland. Trapezoid outline indicates US scan area (**B**). **B.** Transverse US image shows hypoechoic mass (arrows) in left adrenal gland. **C.** USPCB of left adrenal mass (arrows) with 18-gauge needle (arrowheads; needle length: 11.5 cm, size of cutting notch: 1.1 cm) via transabdominal approach was performed while patient was in supine position. After advancing needle tip to anterior border of target, operator pressed firing trigger to thrust inner trocar forward and confirmed that needle tip was within target, accompanied by second firing of outer cutting cannula to extract tissue specimen (stroke length: 16 mm). US = ultrasound, USPCB = ultrasound-guided percutaneous core needle biopsy

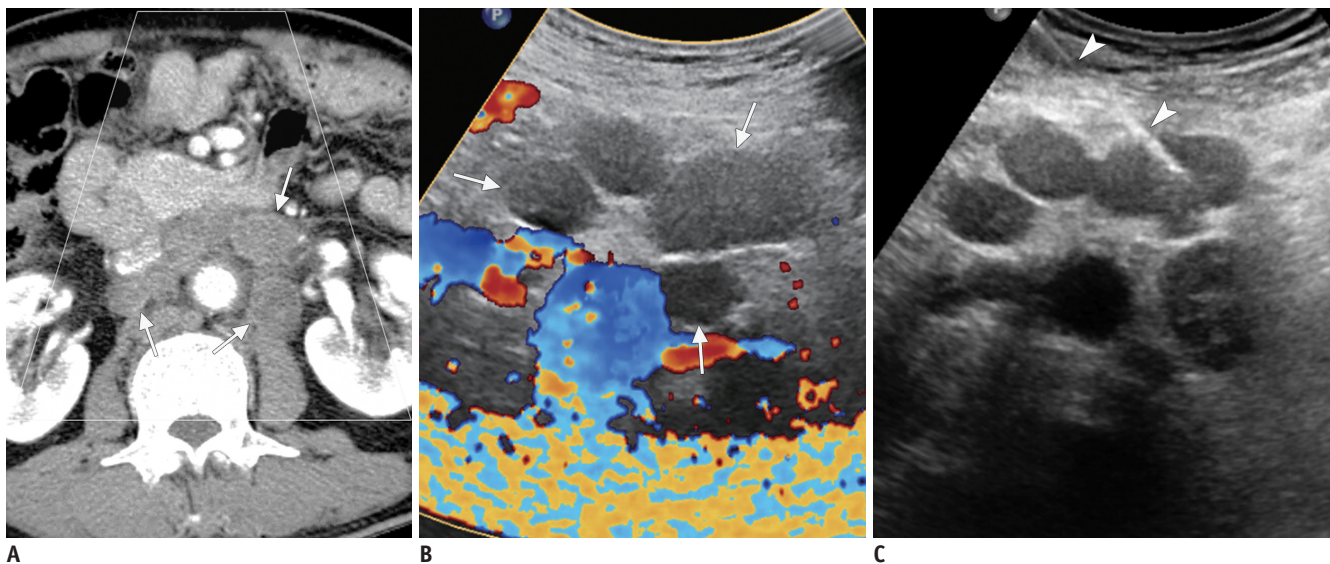
imaging studies may vary slightly because of the mobility of the bowel. Small GI tract tumors are difficult to detect not only because of the bowel's mobility but also because

of intraluminal gas and echogenic abdominal fat. When performing USPCB in the GI tract via a transabdominal approach, graded compression may be beneficial because it



**Fig. 10. 65-year-old woman with small bowel GIST.**

**A.** Contrast-enhanced CT image shows well-defined heterogeneously enhancing mass (arrows) measuring 6.8 cm in left sided mesentery. Trapezoid outline indicates US scan area (**B**). **B.** Transverse US image shows hypoechoic mass (arrows). USPCB with 18-gauge needle (arrowheads; needle length: 11.5 cm, size of cutting notch: 1.6 cm) using transabdominal approach and graded compression of abdominal wall was performed while patient was in supine position with shallow breathing. After advancing needle tip to position 1 cm distal to anterior border of target, operator pressed firing trigger to thrust inner trocar forward and confirmed that needle tip was within target, accompanied by second firing of outer cutting cannula to extract tissue specimen (stroke length: 22 mm). Note that there is no bowel between tumor and abdominal wall. GIST = gastrointestinal stromal tumor, US = ultrasound, USPCB = ultrasound-guided percutaneous core needle biopsy



**Fig. 11. 70-year-old man with metastatic retroperitoneal lymphadenopathies.**

**A.** Contrast-enhanced CT image demonstrates multiple enlarged lymphadenopathies (arrows) around abdominal aorta. Trapezoid outline indicates US scan area (**B, C**). **B.** Transverse color Doppler US image using graded compression shows aorta and both renal vessels around lymphadenopathies (arrows), which should be avoided during biopsy. **C.** USPCB with 18-gauge needle (arrowheads; needle length: 11.5 cm, size of cutting notch: 1.6 cm) via transabdominal approach and graded compression of abdominal wall in supine position was performed. After advancing needle tip to anterior border of target, operator pressed firing trigger to thrust inner trocar forward and confirmed that needle tip was within target, accompanied by second firing of outer cutting cannula to extract tissue specimen (stroke length: 22 mm). Note that there is no bowel between retroperitoneal nodes and abdominal wall. US = ultrasound, USPCB = ultrasound-guided percutaneous core needle biopsy

allows for displacing the gas-filled normal bowel loop and immobilizing the target tumor and it reduces skin-to-lesion distance (Fig. 10) (54).

### Lymph Node

Ultrasound-guided percutaneous core needle biopsy may be effectively performed for both superficial and deep lymph nodes with diameters as small as 1 cm (55, 56); before the procedure, color Doppler US is required to demarcate adjacent vessels and thereby avoid injuring them; most lymph nodes appear as hypoechoic lesions within a background of hyperechoic abdominal fat and bowel. In cases of mobile mesenteric lymph nodes, USPCB of the node is performed in a manner analogous to that used with small bowel tumors. When performing biopsy for a mobile mesenteric lymph node, slow pushing the node by needle tip and graded compression using the US probe are useful for holding the node in position to allow for accurate cutting (Fig. 11) (55). If the transabdominal approach is not possible for pelvic nodes, a transrectal approach may be useful (55).

### Omentum and Peritoneum

Ultrasound-guided percutaneous core needle biopsy of the omentum and peritoneum has been reported as a safe and feasible method of making a tissue diagnosis in patients with omental and peritoneal implants (57). The omentum and peritoneum are not visualized on US images in their normal condition (58); however, various omental and peritoneal lesions such as peritoneal metastasis and tuberculosis can be detected on US, especially in

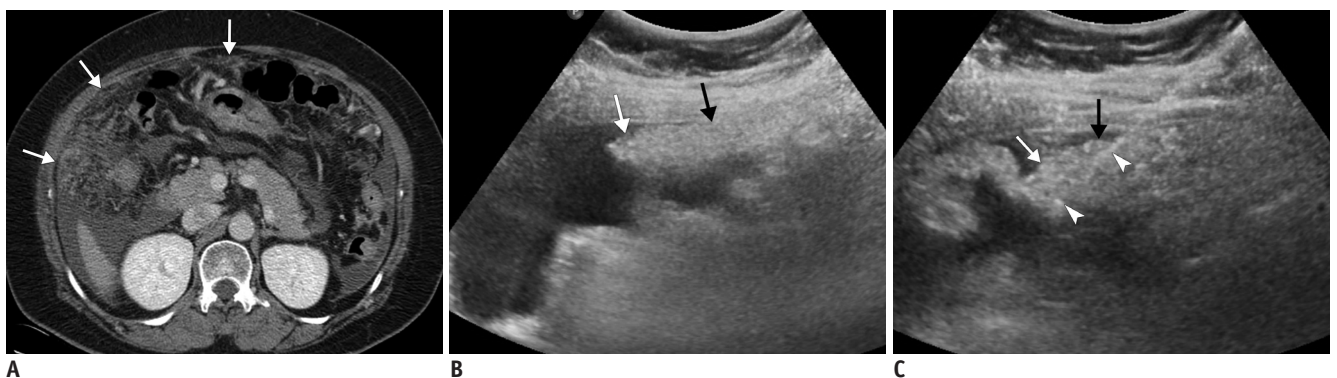
the presence of ascites. In many benign and malignant conditions, the omentum and peritoneum show irregular and nodular thickening with increased echogenicity and are often infiltrated by hypoechoic nodules (58). USPCB of the omentum and peritoneum needs to be preferentially performed at the thickest portion near the abdominal wall, without touching the adjacent intestinal wall or major vessels, which has resulted in diagnostic accuracy rates of 84% to 93.8% (Fig. 12) (57-59).

### Complications

Although USPCB of abdominal organs has been reported to be safe, complications may occur such as pain, bleeding, inadvertent organ injury, and possible tumor seeding along the needle path (2, 60).

Pain is the most common minor complication of USPCB and is successfully treated with analgesic medication, even in severe cases (40, 61, 62). Although it is rare, ranging from 0% to 3.4%, bleeding is the most common major complication (6, 19). The echogenicity of fresh blood is similar to that of surrounding solid organs, such that bleeding may be easily overlooked during the procedure (63). CT should be performed in cases with suspicious peritoneal bleeding after USPCB. Surprisingly, the risk of bleeding does not appear to be greatly affected by the needle size (64-66). If a hemorrhage occurs, especially after splenic biopsy, percutaneous embolization or even emergent splenectomy may be required depending on the severity of the bleeding.

Inadvertent organ injury is an important concern when USPCB is performed using a path that traverses non-



**Fig. 12.** 56-year-old woman with metastatic adenocarcinoma in greater omentum.

**A.** Contrast-enhanced CT image shows reticular infiltrations (arrows) in greater omentum. **B.** Transverse US image shows thickened omentum with increased echogenicity (arrows) near anterior abdominal wall. **C.** USPCB of greater omentum (arrows) with 18-gauge needle (arrowheads; needle length: 11.5 cm, size of cutting notch: 1.6 cm) via transabdominal approach was performed while patient was in supine position. After advancing needle tip to anterior border of target, operator pressed firing trigger to thrust inner trocar forward and confirmed that needle tip was within target, accompanied by second firing of outer cutting cannula to extract tissue specimen (stroke length: 22 mm). US = ultrasound, USPCB = ultrasound-guided percutaneous core needle biopsy



target abdominal organs. However, the risk of organ injury under these conditions appears to be minimal unless the penetrated organ is lacerated due to deep breathing during needle advancement (12, 56, 67).

Malignant seeding of the needle tract following USPCB is not common, ranging from 0% to 5.1% (6, 18, 60, 68). Nevertheless, the number of needle passes should be limited to as few as possible in order to minimize the risk of tumor seeding (69).

## CONCLUSION

Ultrasound-guided percutaneous core needle biopsy of abdominal organs can be effectively and safely used for retrieving sufficient high-quality tissue to facilitate pathologic diagnosis. Knowledge of proper patient preparation and technical skills for safe and effective USPCB and organ-specific considerations are keys to safe and adequate tissue acquisition. The steps outlined in this paper, if followed meticulously, can help operators collect useful information via USPCB with a high degree of patient safety.

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