# Ultrasound-Guided Interventions

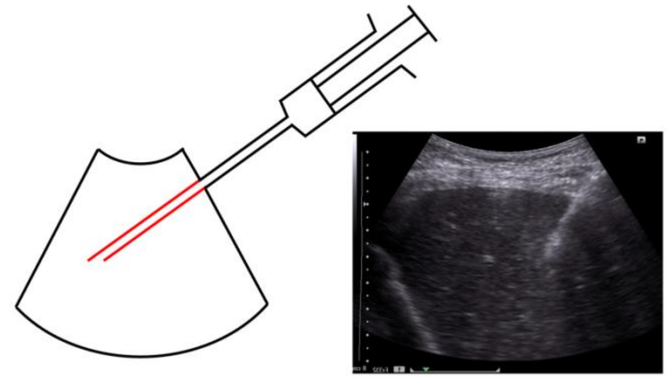
Vallery Logedi, Richard Davis

**Introduction:**

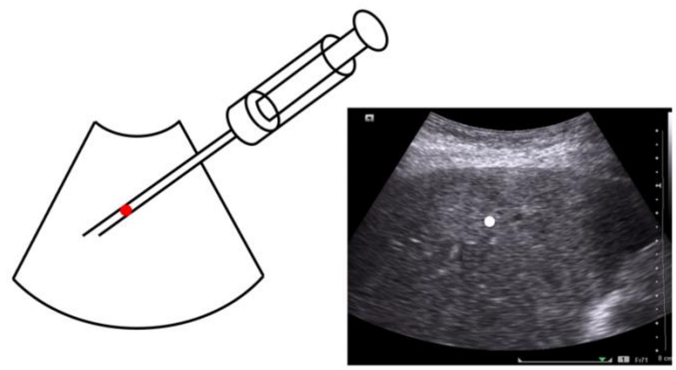
Ultrasound-guided biopsy, drainage or drain placement is the most advanced form of surgeon-performed ultrasound. The surgeon must have excellent technical understanding and skill in order to place the tip of a needle into a structure, seeing it continuously to avoid injury to surrounding structures. This is an advanced skill requiring proficiency and understanding of ultrasound. See Introduction to Ultrasonography for more details.

In general, any probe can be used for an ultrasound-guided intervention. However, the depth of the structure in question determines which probe should be used. The linear (vascular) transducer, with frequencies of 5 - 7.5mHz, shows detail at depths up to 6 cm and should be used for venous catheterization. It can also be used for breast or neck mass biopsy. The curved (abdominal) transducer, with frequencies of 2.5 - 3mHz, shows detail up to 18cm. This should be used for drainage of intra-abdominal abscess or liver biopsy.

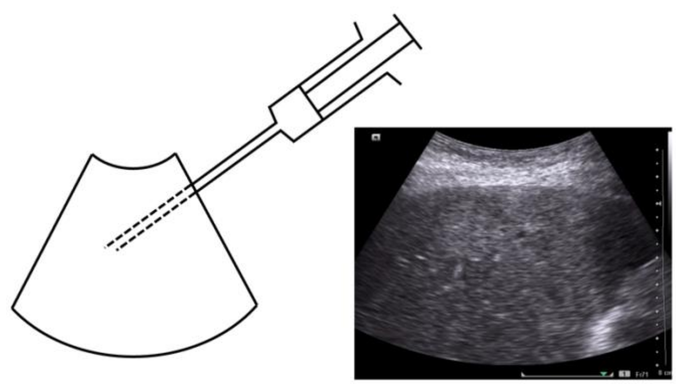
It is important to remember what an ultrasound probe shows, and what it doesn't. The image from an ultrasound probe is two-dimensional, like a "cross section" of the tissue immediately beneath the probe. If the needle is completely within the flat plane of tissue beneath the probe, all of it will be seen. If the needle merely passes through the plane of tissue in one place, it will be seen as only a dot. If the needle is parallel to, but not passing through, the plane of the tissue underneath the probe, it will not be seen at all. These last two situations should be avoided as much as possible, because the sharp tip of the needle is unseen by the operator.



*Correct technique. The needle is completely within the two-dimensional plane. It is seen by the ultrasound, including the tip which can be seen as it advances.*



*Incorrect technique: The path of the needle is not aligned with the plane of the ultrasound. Only the part of the needle that passes through the plane of the ultrasound can be seen (represented by a Red dot in the drawing and a White dot on the ultrasound image.) The tip of the needle, unseen, may be perforating another structure.*



*Incorrect technique: The needle is parallel to the plane of the ultrasound, but not within the plane. The needle cannot be seen at all; its tip may be perforating another structure. All above ultrasound images courtesy of Dr Bruno Di Muzio, from the case https://radiopaedia.org/cases/31841?lang=us*

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Ideally, for intra-abdominal interventions a CT scan is done first. The images are then used as a reference for surgical planning; probe placement can be guided by palpable landmarks such as the costal margin or the iliac crest. If CT is unavailable, the surgeon must use fixed intra-abdominal landmarks for reference while examining the anatomy with the ultrasound probe. Landmarks include the liver, the kidneys, the diaphragm, the bladder (or the Foley catheter balloon) and the retroperitoneal vessels. The bowels themselves, being compressible and mobile, are not useful as landmarks.

The most feared complication of any ultrasound-guided intervention is iatrogenic injury to surrounding structures. In the neck, the vessels of the carotid sheath as well as the trachea and esophagus are at risk. In the abdomen, the operator must avoid injury to the bowels, the great vessels, and the larger vessels within the liver. In general, the liver is a friend to the interventionist, because it is easy to visualize and relatively safe to pass a needle through. Drainage of subphrenic or para-duodenal abscesses, as well as percutaneous cholecystostomy, all involve passing a needle through the liver to get to the pathology. Coagulation must be adequate; the International Normalized Ratio (INR) should be less than 1.6.

Ultrasound-guided abscess aspiration can be performed with nothing more than an ultrasound and a long enough needle. Core needle biopsies need only an ultrasound and biopsy equipment. Interventions such as abscess drainage require some specialized equipment, at minimum a central line kit with a guidewire and a needle. Once the guidewire is placed within the structure, other interventions can be done over the wire using the Seldinger technique (described elsewhere in this Manual.)

Dedicated sterile ultrasound probe covers are available commercially in high-resource settings. We demonstrate here a technique for making your own ultrasound probe cover using a sterile surgical glove and a sterile towel.

Ultrasound-guided interventions are done in the following steps:

- Position the patient, ultrasound and surgeon
- Perform ultrasonography to plan the approach
- Anesthetize under ultrasound guidance
- Pass the needle tip into the structure of interest
- Perform the intervention (biopsy, aspiration, catheter placement)

**Steps:**

1. The first step will usually include any workup or preoperative considerations. In the case of an ultrasound-guided liver biopsy as shown below, that would include checking for a normal hemoglobin, platelet count, prothrombin time and INR.
2. Local anesthesia alone is adequate for such procedures in cooperative patients.
3. First the patient is positioned. Visualize the mass to be biopsied with ultrasound before the site is cleaned and draped. For ergonomic purposes it is important to ensure that the ultrasound machine is placed opposite the biopsy site and by extension, the surgeon.
4. The site is cleaned and draped. There is usually no need for full drapes as field sterility is adequate

*Patient positioned for an ultrasound-guided intra-abdominal mass biopsy.*

5. Local anesthesia is injected around the biopsy site. Alternatively, local anesthesia can be injected while visualizing the mass in step #3 above.
6. An extra sterile towel or small drape is laid across the field as shown in the image below. This will

be used to cover the ultrasound probe cable and ensure sterility. The probe is placed in a sterile glove containing ultrasound gel and then wrapped in the towel.

*Ultrasound probe covered with gel and placed inside a sterile glove*

*Green towel for wrapping probe cable (within the Red line)*

*Probe, manipulated by the operator holding the sterile glove, is placed on the extra towel*

*The towel is closed brought together and wrapped over the probe and wire.*

*Probe secured within the towel using gauzes. The same effect can be achieved using sterile adhesive tape, penetrating towel* *clips or hemostats to keep the towel closed over the probe and wire.*

7. After confirming the site of the mass to be biopsied, a stab incision is made over the site in the area that was anesthetized. The core biopsy needle is inserted under ultrasound guidance. Intervention such as biopsy or aspiration is performed. On completion, the site is cleaned and dressed.

*Biopsy in progress. The same operator holds both the probe and the needle. This allows both structures to be manipulated together so that the needle stays in the plane of visualization.*

*Another example of the correct technique for biopsy: The same operator holds both the needle and the ultrasound probe, allowing both to be manipulated simultaneously so that the needle stays within the plane of visualization of the probe.*

*Biopsy in progress. Note that the machine is placed opposite the patient from the surgeon, so that the ultrasound image can be seen without the surgeon having to rotate their body or neck.*

**Pitfalls**

- As stated earlier, it is important to familiarize yourself with the ultrasound machine and to ensure visualization of the needle at all times to avoid injury to other structures.
- Biopsy within the liver can lead to injury to the vascular or biliary structures, leading to an arteriovenous or arterio-biliary fistula. Proper technique and avoidance of large vessels is crucial to prevent this life-threatening complication.
- Be aware that as the patient breathes, the liver moves and your target may move out of the plane of visualization. Advance the needle with the respiratory cycle, or ask the patient to hold their breath.
- As you gradually become facile with this technique, you will be able to place the tip of the needle within increasingly smaller objects. Start with large targets.

**Guide: Gelatin Model for Practicing Ultrasound-Guided Interventions**

There are special motor skills for handling the needle and the ultrasound probe simultaneously, keeping the needle in the field of view while advancing it through tissue. It is best to acquire these skills on a realistic model rather than on a living human being. We have developed the following technique for teaching this skill, using pieces of soft fruit suspended in gelatin.

We usually have ultrasound practice sessions of 1-2 hours each, with about 3-4 stations. We obtain several ultrasound machines at once from various hospital departments, and hire people to allow their necks and abdomens to be ultrasounded. Trainees then rotate through stations practicing their ultrasound skills. This gelatin biopsy model is one of the stations.

The gelatin biopsy model must be prepared several days in advance, as it entails at least two cycles of curing the gelatin in layers, so that the "tumors" are suspended within the gelatin.

1. Obtain packets of gelatin, either plain or flavored, as available.


*An example of gelatin available in a local market.*

2. Obtain a bowl with a round shape. Line the inside of the bowl with butter or grease. This will make the gelatin and plastic wrap easier to remove from the bowl once it is cured.
3. Line the inside of the bowl with plastic wrap, which will serve as a protective "skin" over the gelatin when you are performing ultrasound.
4. Using hot water, make enough gelatin to fill the bowl halfway. Use double the strength specified by the manufacturer's instructions. Place the bowl in a refrigerator and allow it to harden overnight.
5. Once the gelatin has hardened, place pieces of fruit in the bowl. Use soft, non-round pieces such as slices of banana or mango, or sections of orange or tangerine. Round fruit like cherries or grapes will roll around on the surface of the hardened gelatin and collect all together in one side of the bowl. Hard fruit like slices of apple will be more difficult to pass a needle through.
6. Another variation includes a balloon filled with milk, to simulate an abscess to be aspirated. You can use a central line kit to practice placing a catheter within the abscess using the Seldinger technique.
7. Make enough double-strength gelatin to fill the bowl the rest of the way. Pour it over the fruit pieces, assuring that they remain in place and do not "clump" together in one corner of the mixture. Return the bowl to the refrigerator overnight.
8. Gently remove the gelatin and plastic wrap from the bowl by placing a plate over the top of the bowl and inverting it. You may need an assistant for this step, depending on the size of the bowl. The plastic wrap should easily separate from the bowl because of the butter or grease you applied. If this does not happen, pour a small amount of hot water over the outside of the bowl.
9. Apply ultrasound gel to the plastic wrap on the surface of the gelatin and practice visualizing the fruit with the ultrasound. Then, practice passing the needle into the gelatin while visualizing the needle entirely with the probe.

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*Using an ultrasound probe in one hand and a biopsy needle in the other, the operator can easily practice the skill of visualizing the entire needle and advancing it safely within the gelatin.*

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