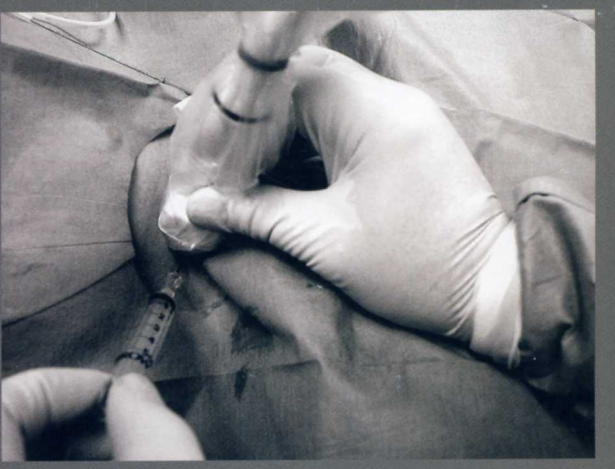

The Handbook of *Ultrasound* in Trauma and Critical Illness

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CHAPTER 10

VENOUS CANNULATION

INTRODUCTION

Percutaneous central venous cannulation is associated with significant risks, such as arterial puncture, pneumothorax, and hemothorax. The complications associated with these procedures have not gone unnoticed. The Department of Health in its 2001 Agency for Healthcare Research and Quality (AHRQ) report recommended that central venous cannulation be done under ultrasound-guidance to minimize complications.[1] The use of ultrasound-guidance, when correctly employed, can significantly reduce the incidence of these complications by allowing direct visualization of the needle going into the vein.[2-17]

PROCEDURAL TECHNIQUES

General concepts

In order to become proficient at ultrasound-guided procedures, one must have a thorough knowledge of the anatomy as well as significant practice training with phantoms or homemade models developing the hand-eye coordination needed prior to attempting the procedure on a live patient. Lack of familiarity with ultrasound and the orientation of the image on the screen can lead to complications even in the hands of a physician skilled at blind, percutaneous central venous cannulation.

One-vs-two operators

Ultrasound-guided central venous cannulation can be done with the physician holding both the needle and the transducer or with an assistant holding the transducer (Freehand technique). For many it is a personal decision. Some skilled interventionalists like utilizing the freehand technique while others prefer holding both the

needle and transducer. The hand-eye coordination and neural feedback obtained by a single operator is much more accurate than the verbal communication between two operators and it is the opinion of the author that the freehand technique not be utilized in the ED.

The interventionalist in the radiology suite will have a skilled sonographer assisting him or her. In the ED, the person holding the transducer will frequently be unfamiliar with ultrasound and the correct way to hold the transducer. Also, they will most likely be unfamiliar with image interpretation and will not be able to keep the vessel centered. For these reasons, it is the author's preference to hold both the needle and transducer.

Mechanical guides

Mechanical guides that attach to a transducer are useful for keeping the needle in the plane of the ultrasound beam and many beginners find this technique easier. The major disadvantage of using mechanical guides is that the angle of entry will be limited. One of the main advantages of ultrasound is that the sonologist has complete control over transducer placement and angle of entry. It is the author's preference to not use mechanical guides unless performing endocavitary punctures (this will be discussed in the peritonsillar abscess section).

Entry approach

The location for needle entry will be based on anatomic considerations. The goal of using ultrasound is to determine an entry point that requires the shortest distance for needle passage in an area where there is no structure between the skin and vessel that will cause the patient harm if punctured (i.e. artery or lung). The principles utilized in central venous cannulation can be used in joint aspirations, biopsies, abscess drainage, etc.

Venous cannulation can be done with the transducer either long-axis to the vessel, short-axis to the vessel, or oblique to the vessel. The decision about which method to perform is usually a personal one. Most physicians tend to use a short-axis approach based on their training but some physicians, such as the radiology group at Children's Hospital of Columbus, Ohio have had great success utilizing a long-axis approach in pediatric patients (personal communication).

Venous cannulation in a transducer plane that is long-axis to the vessel is accomplished by utilizing a needle entry point on the short-axis of the transducer (Figure 131). The needle entry point must be in-line with the marker on the short-axis of the transducer. It is essential to remember that the US beam is very thin, so the sonologist does not have a lot of latitude in terms of alignment of the needle and the beam (Figures 132A and 132B).

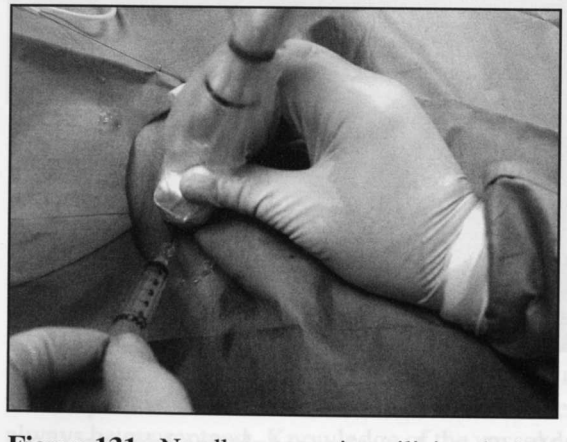

Figure 131. Needle entry point utilizing the long-axis approach.

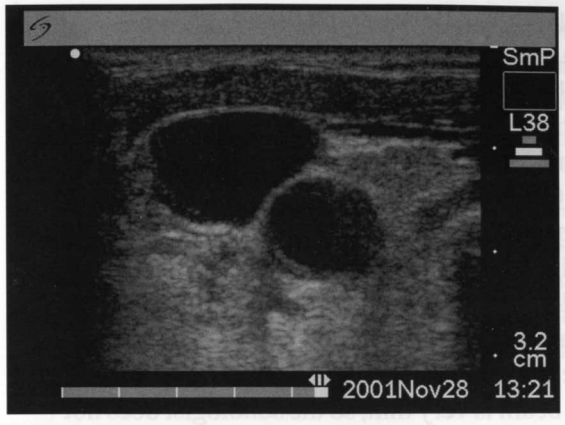

Figure 132A.

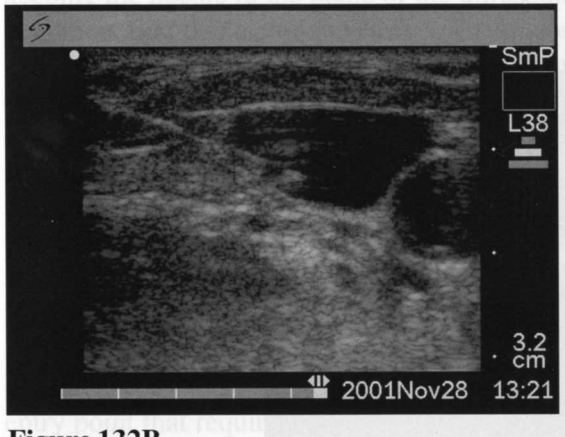

Figure 132B.

Figures 132A and 132B. These depict images obtained during RIJ cannulation. The needle was not moved but note the absence of needle visualization (A) and the presence of needle visualization on (B). The difference between Figures 132A and 132B is proper alignment of the needle and sound beam.

Using the long-axis or oblique approach to the vessel will allow the needle to be visualized in its entirety (Figure 133). This is a major advantage of the long-axis technique in that the sonologist is confident as to where the tip of the needle is. The needle will appear sonographically as a linear group of echoes with or without comet-tail artifacts (depends on the incident angle) (Figure 133). Visualizing the needle tip will minimize the chance of a double wall puncture.

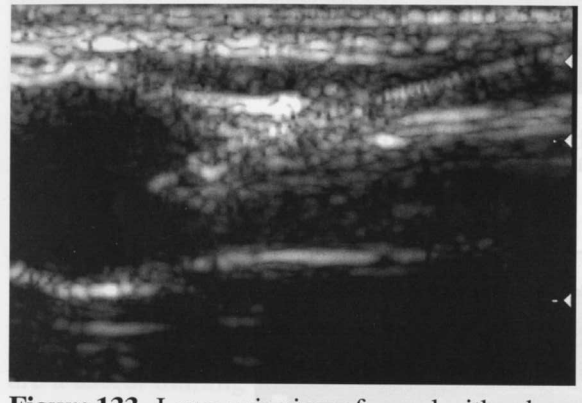

Figure 133. Long-axis view of vessel with echogenic needle noted within the lumen (Courtesy of B Coley, MD).

A short-axis or transverse approach to the vessel is accomplished by using a needle-entry point in the middle of the long-axis of the transducer (Figure 134). The transducer is centered over the vessel so the middle of the long-axis of the transducer will correspond with the center of the vessel (Figure 135). The sonologist must note the depth for entry into the vessel since the location of the needle-tip cannot always be guaranteed. Knowledge of the vessel depth is also helpful since this will help the sonologist decide the angle of needle insertion. It is the author's preference to angle the transducer so that the needle can be localized in the subcutaneous tissue and then followed by directing the beam posteriorly as the needle is advanced (Figure 136). The use of Doppler is not helpful in visualizing the needle tip since flash artifact will occur due to needle movement.

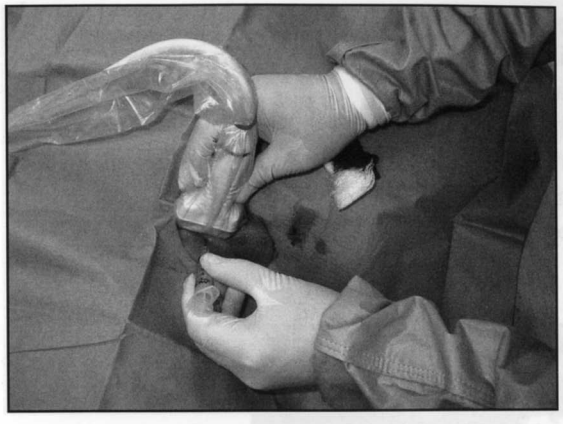

Figure 134. Correct technique for short-axis or transverse approach to venous cannulation.

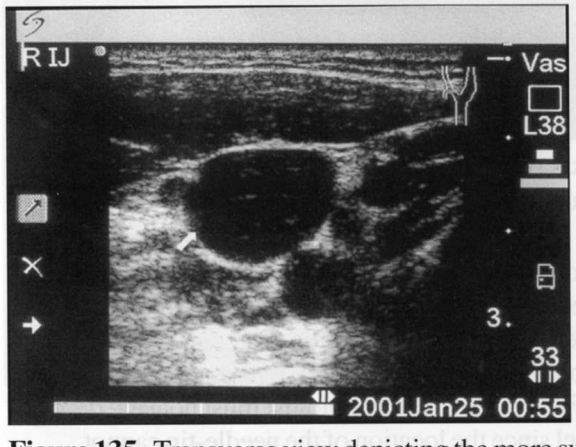

Figure 135. Transverse view depicting the more superficial internal jugular vein (arrow) and the deeper carotid artery.

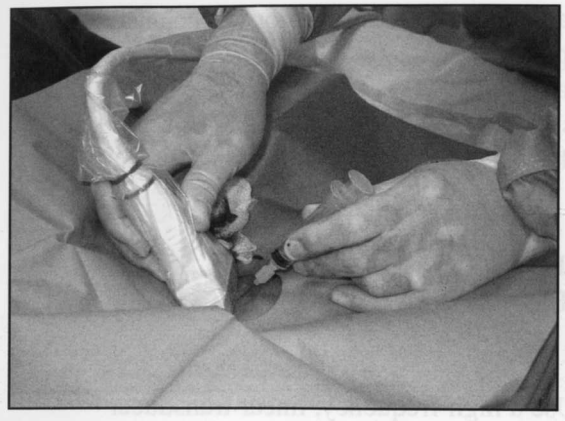

Figure 136. Transducer is angled toward the needle in order to locate the needle in the subcutaneous tissue.

TRAINING

Specific evidence-based training guidelines are unfortunately not available. Use of commercially made breast phantoms are a useful training tool. It is essential to feel comfortable with needle localization and developing the spatial orientation required to perform the procedure. It is helpful to practice aspirating the lesions in the phantom from different entry-points and at different angles and specifically practice following the needle in short-axis down to the lesion of interest.

A training method the author has found very helpful is cannulation of plastic tubing in a turkey leg. The tubing is fed through the turkey leg underwater in order to prevent introducing air into the soft tissue. The turkey leg can be scanned in both long and short-axis to the tubing. In short-axis, attempt to follow the needle down to the tubing by angling the transducer. If you have tactile confirmation of tube contact but no visual confirmation, then adjust the transducer until you visualize the tube and critically analyze your angle of entry and needle localization. In long-axis, you can get tactile feedback if you are not centered over the vessel since you will slide off the side after contact.

Once you feel comfortable with needle localization and contacting the hard plastic tube, then practice cannulating straws filled with colored-fluid and clamped off at both ends. The straws do not provide tactile resistance and serve as good models for venous cannulation. If double-wall puncture occurs, then critically analyze your entry angle and needle localization.

STEPS FOR PERFORMING AN ULTRASOUND-GUIDED VENOUS CANNULATION

General

1. Transducer- Use a high-frequency, linear transducer (5-10MHz).
2. Anatomy screening- The desired vessel should be scanned and assessed for size, location, and compressibility. The ideal vein should be in an easily accessible location, of normal caliber, and with no evidence of thrombosis. Doppler is not required since all you are looking for is an echo-free lumen and compressibility (Figures 137A, 137B and 137C). Scan the opposite vein since there may be a difference between the two sides (Figures 138A and 138B).

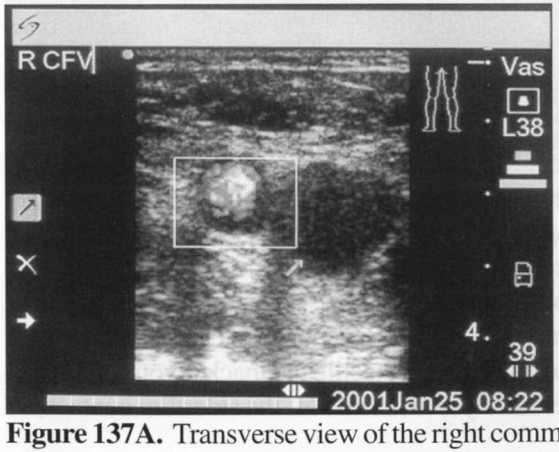

Figure 137A. Transverse view of the right common femoral vein (arrow) and artery. Note Doppler box on the common femoral artery.

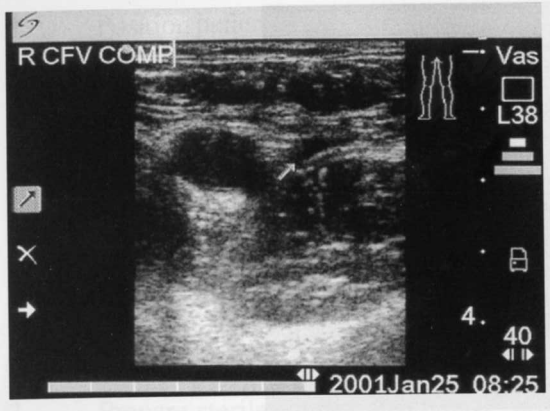

Figure 137B. Transverse view of the right common femoral vein depicting collapse of the common femoral vein with transsducer pressure (arrow).

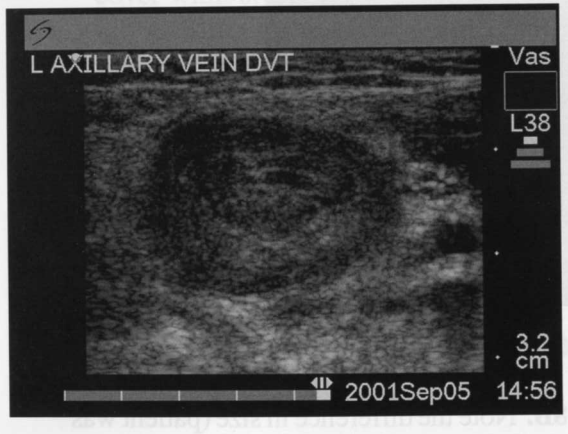

Figure 137C. Transverse view of left axillary vein with echoes noted within lumen and lack of compressibility consistent with deep venous thrombosis (DVT).

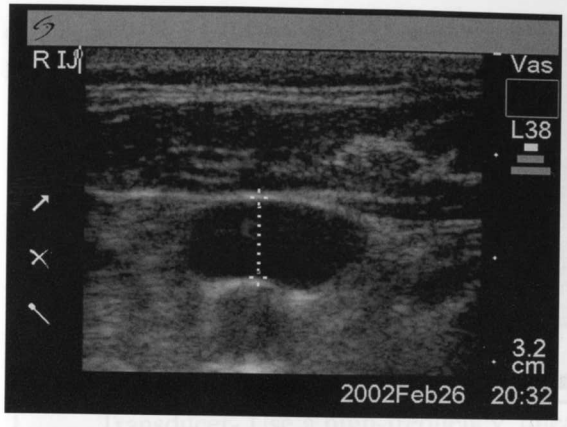

Figure 138A. Right internal jugular vein.

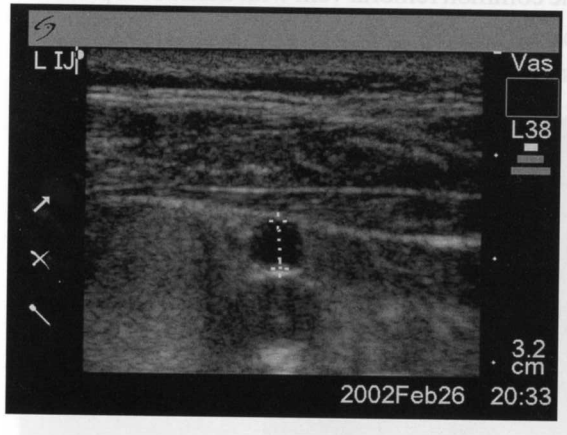

Figure 138B. Left internal jugular vein.

Figures 138A and 138B. Note the difference in size (patient was performing valsalva manever in both images) of the left and right internal jugular veins in a patient being assessed for central venous cannulation. The physician's original preference was the left internal jugular vein but it can be seen from the images that the right internal jugular would be preferred. Key Point: Asymmetry is a common occurrence.

2. Position patient- The patient should be positioned in the appropriate position for the vessel selected for cannulation (i.e. head turning for internal jugular vein cannulation and frog leg position for femoral vein cannulation). Assess the effect of Trendelenburg positioning for internal jugular cannulation or reverse Trendelenburg positioning for femoral vein cannulation. Avoid extreme turning of the head since this will frequently put the carotid artery directly behind the vein (Figures 138A and 138B). Since a double-wall puncture is a reality with the short-axis approach you do not want the artery sitting directly behind.

3. Prepare sterile field- Put on mask, gown, and gloves. Drape and prep the patient. Hold the sterile transducer cover and have an assistant put about 10cc of non-sterile US gel into the cover without contaminating the outside. Then have the assistant insert the transducer inside the cover without contaminating the outside. Slide the sterile rubber bands over the transducer cover. Avoid using sterile gloves if at all possible since they are much shorter in length and do not cover the transducer cord which will frequently enter the sterile field.

4. Place sterile US gel from the sterile transducer on the patient's neck or groin and identify the vessel. Do not apply pressure since this will collapse the vein.

5. Follow the specific instructions below based on approach.

Internal jugular- posterior approach

1. Hold the transducer in an oblique orientation on the neck (just above the clavicle) and image the internal jugular vein (Figure 139). Mentally note the depth of the vessel and assess the entry point. The posterior approach will utilize an oblique orientation to the short-axis of the vessel but will visualize the needle in long-axis (Figure 140). The needle is to enter in line with the marker on the short-axis of the transducer just lateral to the sternocleidomastoid muscle (Figure 141).

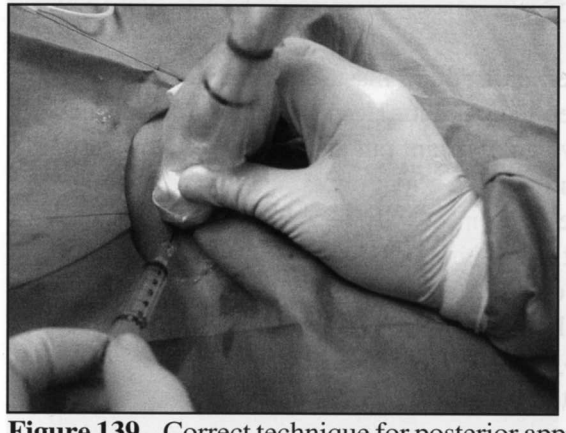

Figure 139. Correct technique for posterior approach to internal jugular vein.

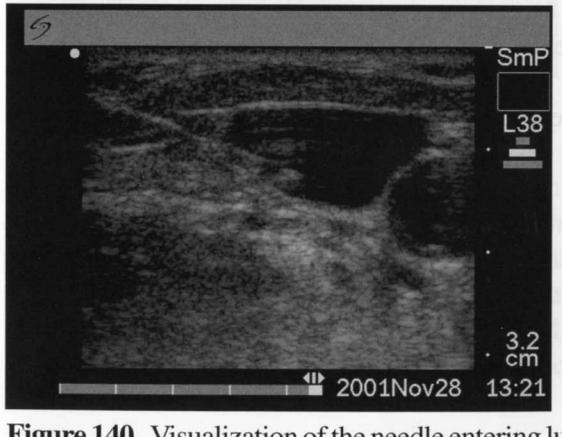

Figure 140. Visualization of the needle entering lumen utilizing posterior approach. Note the lateral approach of the needle entry, avoiding sternocleidomastoid muscle puncture.

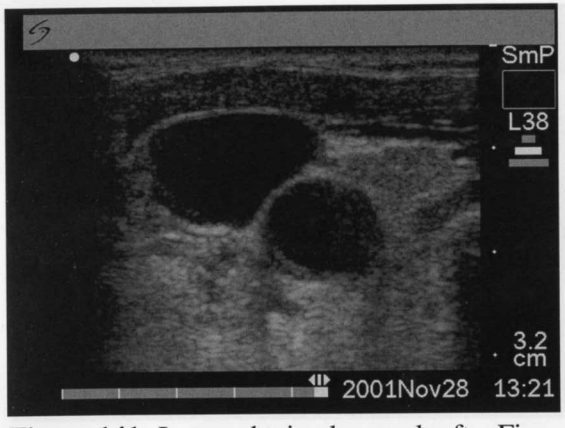

Figure 141. Image obtained seconds after Figure 140 by gently angling the transducer. Note loss of the needle.

2. After noting needle tip in the vessel lumen, put the transducer in the sterile field and aspirate.

3. If venous blood is easily aspirated, then complete the cannulation in the traditional fashion.

Internal jugular-middle approach

1. Hold the transducer in a low cervical position perpendicular to the vessel in its short-axis (Figure 142) and image the vessel. Note the depth of the vessel. The use of a vessel long-axis approach may be difficult using this approach unless a small-footprinted transducer is utilized. Use light pressure in order to avoid venous compression. Make sure that the carotid artery does not sit directly posterior to the vein.

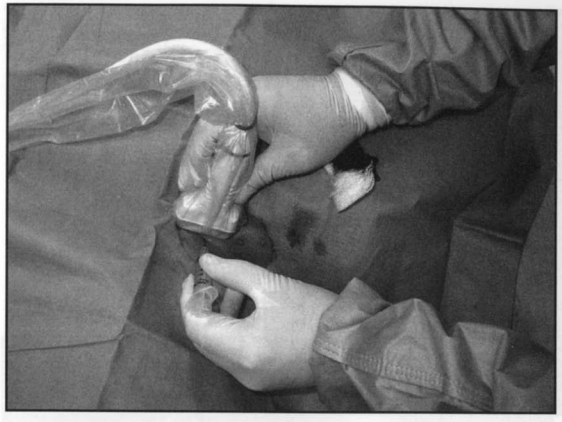

Figure 142. Correct technique for middle approach.

2. Center the vessel in the image so the middle of the long-axis of the transducer will correspond to the middle of the vessel. Identify the heads of the sternocleidomastoid muscle and verify that the needle puncture will be made between the sternocleidomastoid muscle bellies.

3. Gently angle the transducer toward the needle entry point (cephalad to the transducer) and follow the vessel as it transverses the subcutaneous tissue.

4. When tenting of the anterior wall of the vessel is noted from the needle, then enter the vessel with a short jabbing motion (Figure 143).

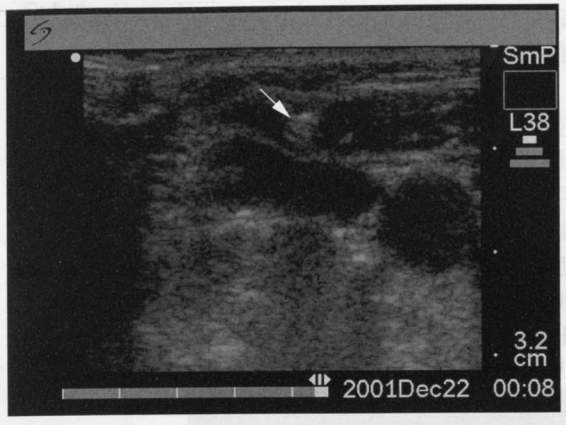

Figure 143. Tenting of the right internal jugular vein noted with reverberation echoes (arrow) from needle noted anterior to lumen.

5. If the needle tip is visualized in the vessel lumen, then aspirate for venous blood (Figure 144).

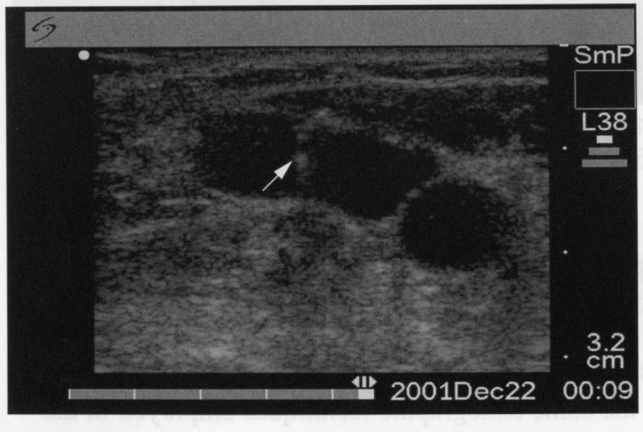

Figure 144. Reverberation echoes (arrow) from needle noted within the vessel lumen.

6. If venous blood is not obtained and the needle tip is not visualized, then gently withdraw the needle while aspirating. If blood is obtained, then this means you went through the posterior wall of the vessel. If blood is still not obtained, then further attempts using ultrasound-guidance are required.

7. Upon obtaining venous blood, then complete the procedure in the traditional fashion.

Femoral vein cannulation

1. Have the patient lie in a frog-leg position (Figure 145).

2. Hold the transducer perpendicular to the vessel in the short-axis similar to the internal jugular vein-middle approach and image the vessel. Note the depth of the vessel, assess the appearance of the vein and the entry point.

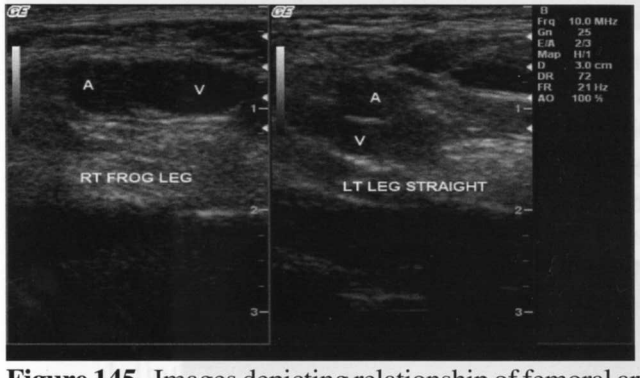

Figure 145. Images depicting relationship of femoral artery(A) and vein (V) in the frog leg and straight leg positions.

3. When performing the procedure on an infant/child, remember to decrease your field of depth in order to avoid minimizing the appearance of the vessel.

4. Utilize the same sonographic techniques employed in the internal jugular-middle approach section.

Subclavian vein cannulation-intraclavicular approach

1. Place the patient in the Trendelenberg position.

2. Place the linear, high-frequency (5-10mHz) transducer just inferior to the clavicle. By keeping the transducer parallel to the clavicle, the axillary vein and artery will be visualized in short-axis. Remember that the axillary vein becomes the subclavian vein as it passes under the clavicle (Figure 146).

3. Turn the transducer 90 degrees and center the beam over the axillary-subclavian vein so that the vessel is imaged in long-axis (Figure 147). The medial aspect of the transducer can be placed against the clavicle.

4. The vein can be accessed utilizing a venous cannulation long-axis approach (previously described).

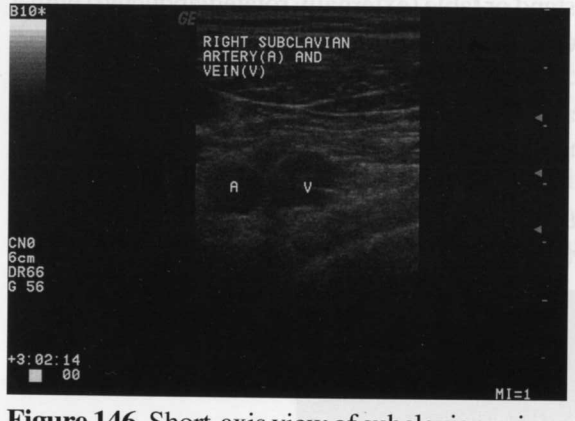

Figure 146. Short-axis view of subclavian vein and artery.

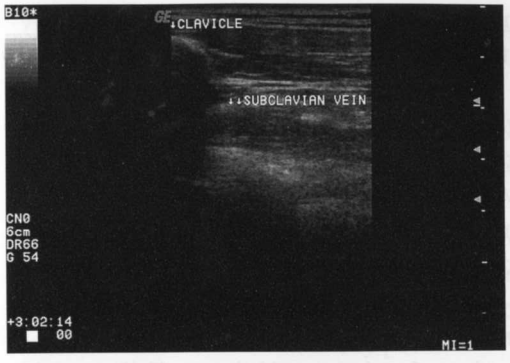

Figure 147. Long-axis view of subclavian vein.

Upper extremity venous cannulation

1. The cephalic, deep brachial, and basilic veins can be accessed when superficial venous catheters cannot be placed (Figure 148).

2. Place arm on stand or table (externally rotated/abducted) with a tourniquet placed proximally.

3. The basilic vein is the author's preferred vessel since it is larger in diameter and is more superficial.

4. The vessels can be accessed using the previously described long and short-axis approaches.

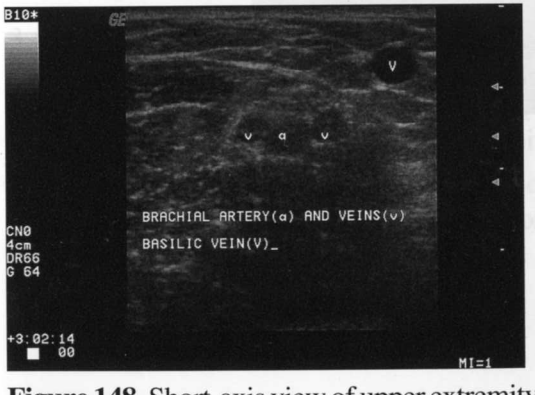

Figure 148. Short-axis view of upper extremity showing the basilic vein and the brachial artery and veins.

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