6 Ultrasound-Guided Central Venous Catheters

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Introduction

Ultrasound-guided (USG) central venous catheter (CVC) placement is a potentially life-saving technique that must be mastered in order to obtain central venous vascular access quickly with minimal complications. Prior to the routine use of ultrasound, CVC access was performed "blind" via landmark techniques, with failure and complication rates reported to be anywhere from 5% to 19% [1–4]. This chapter discusses the potential advantages and disadvantages of using real-time ultrasound guidance to achieve CVC access, including details relating to the performance of USG CVC placement, confirmation methods, and common pitfalls that may be encountered by clinicians wishing to utilize this technique.

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General Considerations

The use of anatomical landmarks alone to guide needle insertion during CVC placement is associated with increased risk of complications. The most common complications of the landmark-guided approach include pneumothorax, arterial cannulation, and hematoma formation. These complications are dependent on the underlying patient pathophysiology, patient anatomy, site of CVC insertion, and clinician experience [1, 2, 5, 6].

The use of ultrasound (US) guidance for CVC placement was first described in relation to the *internal jugular (IJ) vein* by Yonei et al. in 1986 [7], although the same concepts have subsequently been applied to use with the other commonly accessed central veins. In 1993, Denys et al. prospectively compared 302 patients treated with US-guided (USG) IJ vein cannulation to 302 control patients treated with the landmark-guided technique. They found that the use of ultrasound guidance in IJ venous cannulation resulted in a 100% success rate, compared to 88.1% success in the landmark-guided technique. They also demonstrated that US guidance produced fewer cannulation attempts, shorter time to cannulation, lower incidence of carotid artery puncture, lower incidence of hematoma formation, and lower incidence of brachial plexus injury [8]. Since then, additional studies from multiple medical specialties have continued to show similar safety profiles [9, 10]. In 2015, Brass et al. published a Cochrane Review including over 5000 patients that found the procedural safety of IJ venous catheters placed under ultrasound guidance to be superior as compared to landmark placement [11]. That same year, they also published data via Cochrane Review showing superiority in safety of USG catheterization of the subclavian and femoral veins as compared to traditional landmark technique [12].

Previous studies have demonstrated that the use of ultrasound guidance for CVC insertion significantly decreases morbidity and mortality in critically ill patients who require CVC placement [13–15]. Utilizing real-time ultrasound guidance, the clinician can visualize anatomic anomalies, clearly identify and visualize the target central vein, monitor progress of cannulation, and avoid ill-advised attempts to cannulate vessels with intraluminal thrombosis [13–15].

Appropriate patient positioning during IJ venous cannulation (i.e., head turned) inherently increases the risk of *carotid artery (CA)* puncture, as the IJ vein frequently overlaps this structure. In fact, at 90° head rotation away from the midline, the IJ vein overlaps 78% of the carotid artery diameter, vs 29% in a neutral position [16]. In this context, the use of USG for venipuncture is especially helpful to avoid inadvertent CA injury.

Introduction to Ultrasound

Probe/Transducer

The appropriate transducer for any vascular access procedure is a small linear array probe with a high-frequency transducer (5–15mhz) [11]. However, some linear transducers may have a range as high as 20 mhz. This provides an excellent superficial resolution, but image quality may degrade at deeper depths required for direct needle visualization during central venous cannulation [18].

Exam Type

Most commercial ultrasound systems come with preloaded exam types (i.e., vascular, cardiac, RUQ, etc.) It is important to select a "vascular," "small parts," or "needle visualization" exam type to provide you with the spatial resolution required for evaluating the anatomy and for direct needle visualization.

General Tips for Ultrasound Guidance

The reader is encouraged to become familiar with the landmark-based method for CVC insertion detailed in Chap. 5 of this book, including the relevant anatomical considerations, as much of the technique for USG CVC insertion is common with the landmark-based method.

Standard sterile technique should be followed with regard to PPE (personal protective equipment) worn by the practitioner, draping of the patient, and cleansing of the procedural area. A sterile probe cover with sufficient length to cover the probe's cord that will come into contact with the draped area is required. Either a sterile field (e.g., exterior drape or other sterile barrier) to prevent contamination by the US machine or a second person should be employed to operate the US system in case adjustments are needed during the procedure. Sterile lubricant, which usually comes prepackaged with commercially available sterile probe covers, is also needed. Lubricant will need to be applied to the probe itself, as well as on top of the sterile probe cover, to generate optimal US images. Ideal hand, probe, and needle approach positioning are demonstrated in Fig. 6.1. Note that this figure does not include sterile barriers for illustration purposes.

If local anesthesia is to be used, infiltration of 1% lidocaine solution should also be performed in conjunction with US guidance to assure that the location of the skin wheal is in appropriate proximity to the underlying vein of interest.

Cannulation of the vein occurs using either the introducer needle or appropriate angiocatheter. The needle is advanced under direct US visualization using either the out-of-plane (short axis) or in-plane (long axis) (Fig. 6.2) approach toward the target vein.

With the landmark-based approach, negative pressure is typically maintained by pulling back on the plunger of the syringe during insertion until a flash of blood is noted. One important difference with direct US visualization is that negative pressure is not required as the needle is advanced. Although a change in resistance and flash of blood into the syringe may be noted, venous cannulation will be noted via direct US visualization of the needle tip within the lumen of the vessel. Consistent with standard Seldinger technique, the guidewire is then advanced. The introducing

Fig. 6.1 Probe and needle positioning for the IJV out-of-plane (short axis) approach

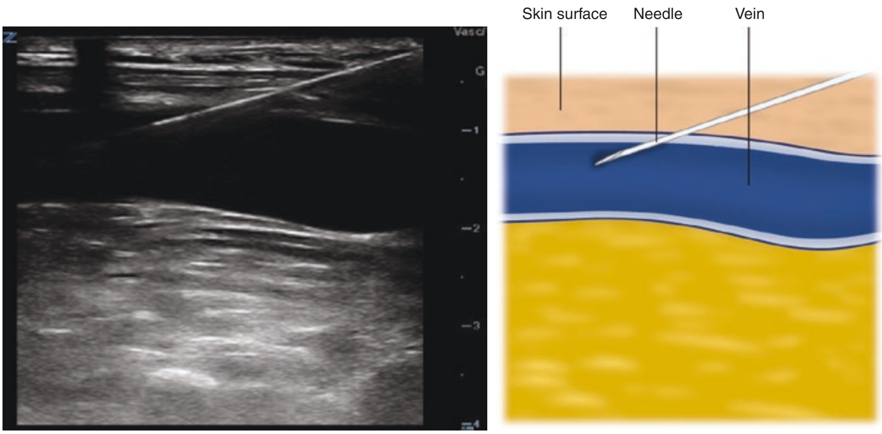


Fig. 6.2 In-plane (long axis) view of USG central venous puncture

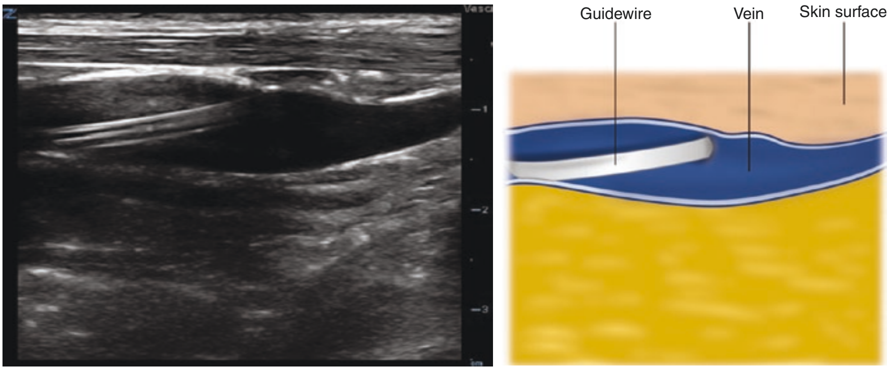
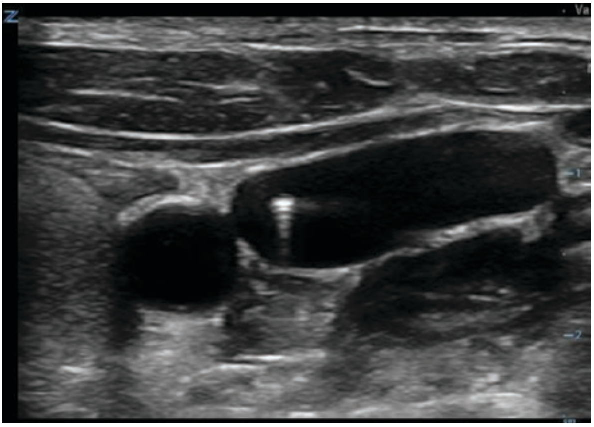


Fig. 6.3 Guidewire visualized with in-plane (long axis) view

Fig. 6.4 Guidewire visualized with out-of-plane (short axis) view



needle or angiocatheter is then removed. As described above, proper placement of the guidewire should be verified by ultrasound prior to soft tissue dilation and catheter cannulation. After cannulation, the positioning of the guidewire should once again be verified with ultrasound (as shown in Figs. 6.3 and 6.4). Note that the guidewire appears as a straight or curved line on the long-axis view, while it appears as a “dot” on the cross-sectional short-axis view. Whichever view is selected, the provider will also see *reverberation artifact lines* below the guidewire, indicating that you are viewing a dense (e.g., metal) structure. Once the guidewire has been confirmed to be in the vein and the catheter has been inserted, all lumens of the catheter should be capped, aspirated, and flushed with sterile saline to minimize the risk of luminal clotting. The catheter should then be sewn into place and secured with an appropriate occlusive dressing. The use of a BioPatch® or other antimicrobial-impregnated dressing at the site of skin insertion is recommended.

Static Versus Dynamic Techniques

Static Technique

Static technique involves using the US to evaluate the patient's anatomy and locate the target vessel but *does not include visualization of the needle as it is inserted into the patient's blood vessel*. Once the relevant anatomy is identified, the US probe is placed out of the field, and the procedure is continued using landmark methods informed by the previously visualized US images. This technique is essentially used to verify the assumptions of the landmark-based approach [12] and has been shown to improve the likelihood of successful cannulation when compared to the purely landmark-based approach [18]. The static technique does not require a sterile probe cover if this vascular survey and target localization is performed prior to sterile field preparation.

Dynamic Technique

Dynamic US guidance not only includes aspects of the static technique but *also involves direct visualization of the needle as it enters the target vein*. Although the static technique may improve the likelihood of successful cannulation, it has not been shown to decrease cost or enhance patient safety [19]. However, dynamic ultrasound guidance has been shown to reduce complication rates and decrease the risk of line-associated infection [19]. Because this additional US-guidance occurs after sterilization of the procedural field, a full-length sterile probe cover must be used for this technique [18]. Dynamic US guidance can be achieved utilizing either the "in-plane" approach or the "out-of-plane" approach.

The "In-Plane" Approach

The "in-plane" (long-axis) approach to the dynamic technique involves orienting both the path of the needle and the US beam in a coplanar path. This allows for continuous real-time visualization of the needle as it is directed toward the vein. However, given the small width of both the US beam and the needle, the margin for error is much greater. *Anchoring the operator's probe hand on the patient is of the utmost importance* to prevent loss of visualization of the needle. If the view of the needle is lost, advancement of the needle should be stalled until visualization of the needle and the needle tip in the vessel are reacquired. The primary benefit of this technique is real-time visualization of the needle in its entirety, decreasing the risk of posterior vein wall puncture [18, 20].

The "Out-of-Plane" Approach

This technique involves a *short-axis approach***,** in which the probe is oriented perpendicular to the angle of needle insertion. It allows for visualization of the vein and adjacent structures during the procedure. However, this technique is limited as the needle is only partially visualized. The tip and mid-shaft will appear the same in this orientation, and a stepwise approach of needle advancement is needed to ensure that the needle is not advanced too far, resulting in complications. This technique has been shown to be more easily mastered by emergency physicians [18, 20]. It has also been shown to be associated with an increased first-pass success for operators with varying levels of US expertise [18, 20].

Whether using the static or dynamic technique, identification of the pertinent anatomy is paramount to successful line placement. The vein of interest should be evaluated over a length of several centimeters in the anticipated direction of catheter insertion to identify venous tortuosity or changes in the surrounding anatomic structures. The target vein should be checked for patency. This can be achieved by either compression or by Doppler color flow assessment. Compression of the blood vessel may also help differentiate the vein from the adjacent artery, which must be avoided [18].

Confirming Proper Placement

Proper cannulation of the intended target vein must be confirmed prior to dilation of the tract and venotomy. This can be achieved by using US imaging to verify that the guidewire is in the correct vessel. Verification is often performed using an in-plane (long-axis) view of the guidewire within the vein of choice. (Fig. 6.3). This verification can also be obtained with the out-of-plane (short-axis) view but may be slightly more difficult to visualize (Fig. 6.4). The direct visualization of proper placement should be repeated after the advancement of the catheter to evaluate for possible malposition. This again can be achieved in both the in-plane or out-of-plane technique [21].

Another method of confirming proper venous placement of the CVC is by injecting agitated saline through the newly placed CVC while simultaneously obtaining a transthoracic or subxiphoid view of the heart. The agitated saline is generated using a three-way stopcock and two sterile saline flushes with their contents manually pushed back and forth between syringes to create tiny air bubbles in the sterile fluid. This solution is then injected through the newly placed CVC, while the provider has the phased array probe focused on the right chambers of the patient's heart. The provider monitors the ultrasound screen for a flurry of bubbles to appear in the right heart chambers. If venous placement is achieved, the agitated saline should be visualized in the right atria and ventricle, indicating proper placement and usability of the line. The benefit of this technique is it can prove appropriate line placement, prior to obtaining a confirmatory chest X-ray, and thus has utility when there is a time-sensitive need to start medications through the CVC. However, this technique involves switching between the linear and phased array probe and may be difficult to achieve when a single practitioner is present [21].

Despite the increasing utility of ultrasound imaging, standard of care at most institutions is to obtain a chest X-ray after internal jugular or subclavian central venous catheter placement to evaluate for malposition and possible complications (e.g., pneumothorax).

Needle Versus Angiocatheter

Most commercially available CVC kits contain both an introducer needle and an angiocatheter. Studies have shown that the use of the introducer needle results in fewer complications and increased first-pass success as compared to the angiocatheter [22]. If the angiocatheter is used, however, attempting to refeed the needle into the catheter while inserted into the patient should be avoided. This is due to the thin-walled nature of the angiocatheter and the possibility of the cutting needle damaging the sidewall of the catheter. The dreaded complication is embolization of the sheared tip of the angiocatheter.

Site-Specific Considerations

Internal Jugular (IJ) Vein

The *internal jugular (IJ) vein* is a confluence of the *inferior petrosal sinus* and the *sigmoid dural venous sinus* (Fig. 6.5). This vessel exits the skull through the *jugular foramen* and forms the *jugular bulb*. It descends inferiorly into the neck adjacent to the *internal carotid artery (ICA)* and the *vagus nerve* (cranial nerve X) within the *carotid sheath* before joining with the *subclavian (SC) vein* to form the

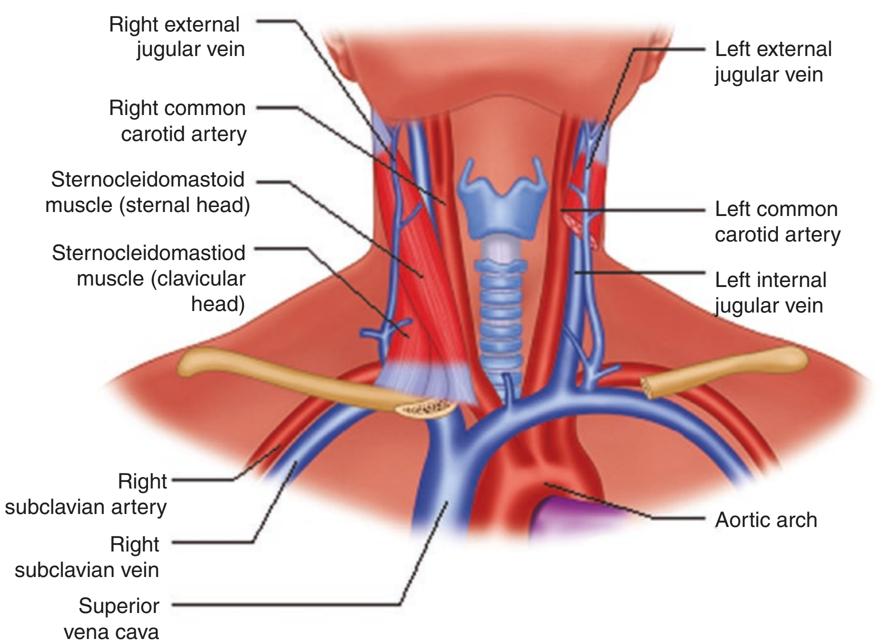


Fig. 6.5 Central vessels of the neck and upper torso

Fig. 6.6 Trendelenburg positioning

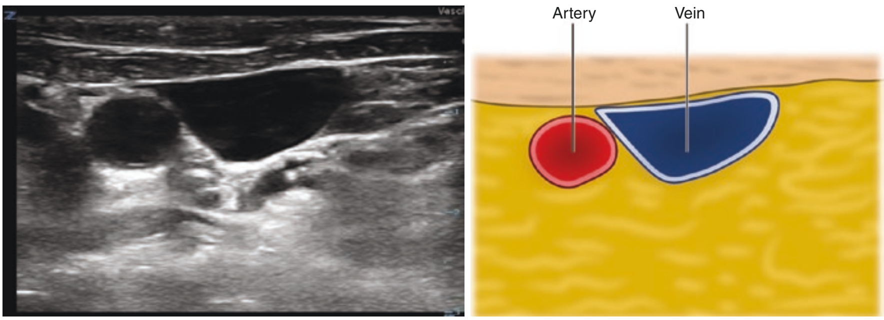


Fig. 6.7 Out-of-plane (short-axis) view of the IJ vein and the carotid artery

brachiocephalic vein. Although the IJ classically lies lateral and anterior to the ICA as it descends, this orientation can be changed with the positioning of the head [18, 23]. The left IJ is classically described as being slightly larger than the right IJ [23].

Proper positioning of the patient will maximize the likelihood of first-attempt success. Place the patient in *Trendelenburg position* (i.e., supine, bed adjusted with feet slightly higher than the head, as in Fig. 6.6) to promote increased venous filling and increase the vein's diameter [20]. This promotes easy identification of the vein and creates a larger target for cannulation. The precise degree to which the head is directed downward will depend upon multiple factors, including the patient's tolerance for this position and the capacity of the patient stretcher.

Turning the patient's head to the contralateral side will bring the IJ into a more superficial position while increasing the depth of the ICA compared to a head-neutral position [20]. This maneuver also affords improved ergonomics with regard to the angle of needle insertion for the practitioner. The IJ vein is typically identified using an out-of-plane approach. As demonstrated in Fig. 6.7, the carotid artery will appear as a thick-walled vessel that is not easily compressible, while the vein appears as a thin-walled vessel that is typically easily compressed with light pressure from the US probe.

Ergonomic positioning of the US provider relative to the patient and US screen is also important. The provider should be at the head of the bed with the US located on the ipsilateral side near the patient's hip. The screen and the point of needle insertion should be in a direct line to minimize any head movement needed by the practitioner [20].

The depth of insertion required for USG CVC insertion at the IJ vein will vary according to the side of insertion, patient gender, and other unique anatomical considerations. Although each patient is different, a good rule of thumb for the length of catheter insertion with *right-sided* IJ CVCs is [patient height in cm]/10. In one study, the average appropriate depth of right-sided IJ catheter insertion was found to be 12–13 cm in males and 11–12 cm in female subjects. The length of catheter required with left-sided IJ CVC placement is greater than that required for the right side. For *left-sided* IJ CVC placement, the required depth of insertion may be estimated by [(patient height in cm) / 10] + 4 cm, usually 13–14 cm in males and 12–13 cm in females [24, 25].

Subclavian (SC) Vein

The subclavian (SC) vein is formed by the *axillary vein* when it crosses the lateral border of the first rib, as shown in Fig. 6.8. It then arches cephalad posterior to the clavicle, where it joins with the *external jugular (EJ) vein*. It is then joined by the IJ vein to form the *brachiocephalic vein*. The SC vein accompanies the *subclavian artery*, which is usually located deep and posterior to the vein. Other structures posterior to the vein include the first rib and the lung pleura. On the left, the *thoracic duct* empties into the beginning of the brachiocephalic vein. The right lymphatic trunk empties into the same position on the contralateral side [27].

Infraclavicular Approach

As with IJ vein cannulation, the patient should be placed in Trendelenburg position (Fig. 6.6) to increase venous filling and provide a more easily identifiable structure and larger target vein [20]. Placing a towel beneath the patient in between the scapulae is also recommended, as this promotes anterior projection of the chest wall with the shoulders drawn back, bringing the SC vein into a more superficial position and reducing obstruction to access by the upper extremities. If the infraclavicular approach is sought, position the patient so that the shoulders are in a "shrugged" position, displacing the clavicle cephalad and opening an acoustic window to facilitate US visualization of the subclavian vein [28]. In neutral position, the clavicle lies over the proximal aspect of the SC vein. Shrugging the shoulder moves the clavicle superiorly, which opens a window that allows the SC vein to be seen on US without obstruction by the clavicle (Fig. 6.9).

The US screen is best placed on the contralateral side of the patient (i.e., opposite the side of the target vessel) for both the supraclavicular and infraclavicular SC approach. The needle insertion site and the US screen should be within a straight line of sight to reduce the amount of movement needed by the practitioner during the procedure [20].

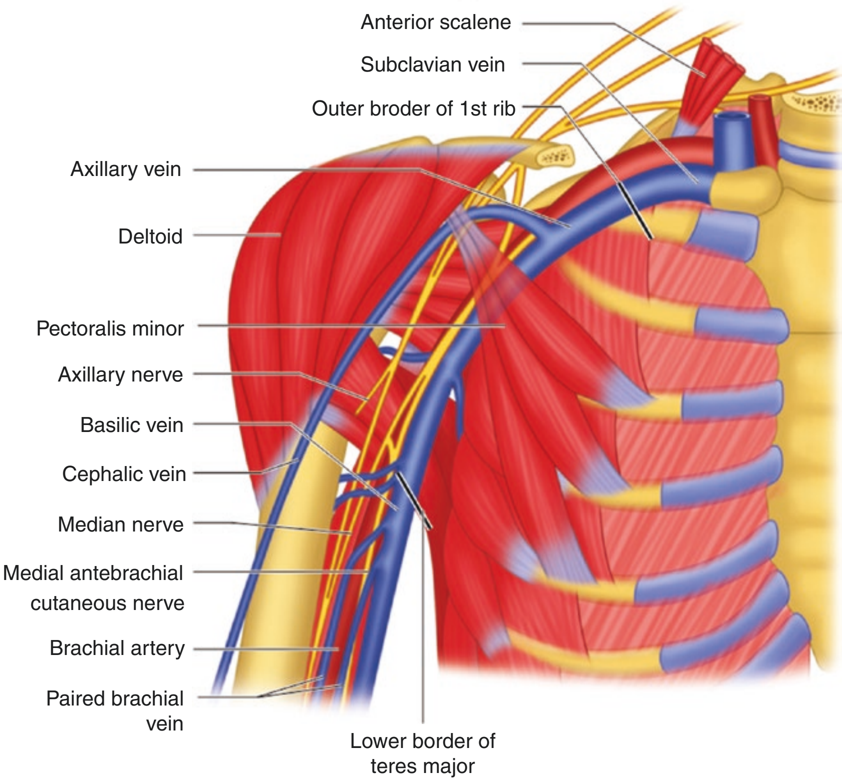


Fig. 6.8 Anatomy of the subclavian and related veins

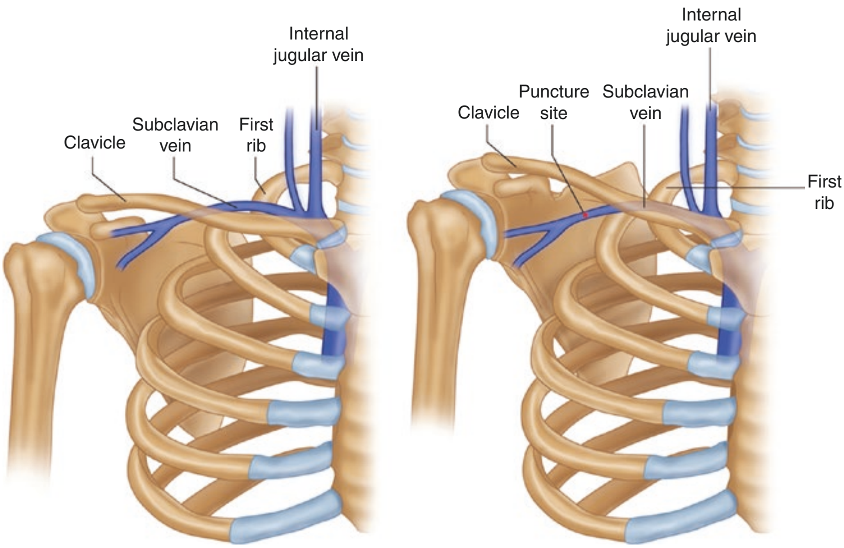


Fig. 6.9 Change in SC vein exposure with shoulder shrug

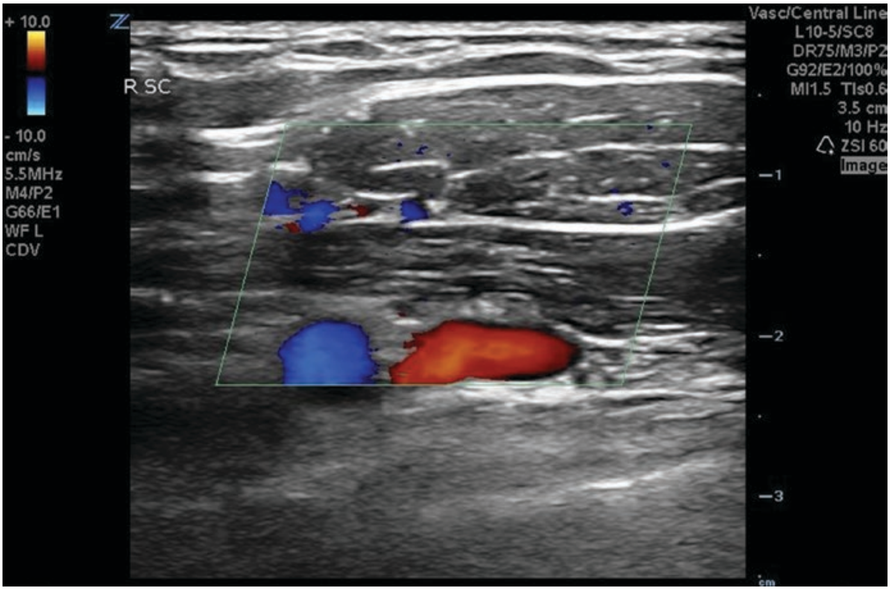


Fig. 6.10 Infraclavicular out-of-plane approach to the SC vein

Ultrasound guidance for the infraclavicular approach can be performed with either the in-plane or out-of-plane technique. Most often, identification of the subclavian vein can be accomplished within the *clavipectoral triangle* (i.e., deltopectoral triangle), which is bounded by the clavicle, the lateral border of the pectoralis major muscle (inferiorly), and the medial border of the deltoid muscle (superiorly). This may be significantly more lateral than the common starting position utilized with the landmark-based approach. The provider should start by positioning the linear probe just inferior to the far lateral aspect of the clavicle in long axis with the probe indicator cephalad and probe placement parallel to the path of the axillary vein. Care should be taken to ensure that the vein is being viewed, not the artery, as their appearance with US may be similar. The vein can be distinguished from the artery in the out-of-plane view (Fig. 6.10) and then the probe rotated 90 degrees to an in-plane approach over the vein (Fig. 6.11). Confirmation can be achieved by assessing for vascular compressibility and a venous hum with pulse wave Doppler. When appropriate positioning is confirmed, the needle is inserted using an in-plane approach (Fig. 6.12) and directed to the center of the axillary vein lumen under direct visualization [29]. The J-loop of the guidewire is fed with the distal J portion of the wire oriented toward the patient's feet to prevent the guidewire tracking cephalad. The remainder of CVC placement is the same as that outlined in the IJ CVC placement section. In one small single-center randomized-controlled trial performed by Fragou et al., the USG long-axis approach to infraclavicular SC CVC placement resulted in increased first-attempt success and fewer complications when compared to landmark methods [30].

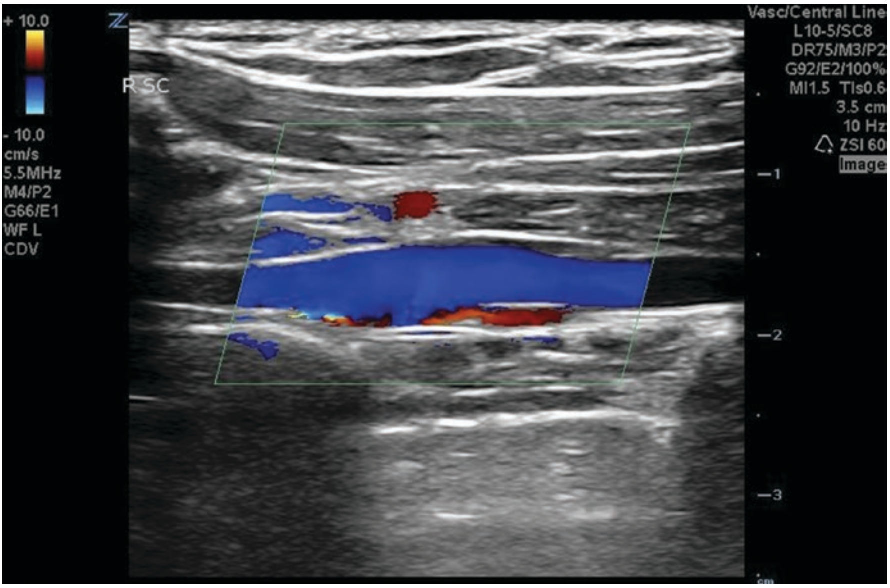


Fig. 6.11 Infraclavicular in-plane approach to the SC vein

Fig. 6.12 Probe and needle position with the infraclavicular in-plane approach to SC vein cannulation

Fig. 6.13 Probe and needle position for the infraclavicular out-of-plane approach to SC vein cannulation

The out-of-plane infraclavicular approach allows for continuous visualization of both the SC artery and vein (Figs. 6.10 and 6.13). However, given the stepwise nature of the out-of-plane technique, there is the possibility of misidentification of the needle tip, leading to the penetration of the needle deep to the vein. However, the out-of-plane technique is easier to master and decreases the likelihood of inadvertent arterial puncture [31].

Supraclavicular Approach

The subclavian vein is more easily identifiable on US using the supraclavicular approach, near to the site where the SC and IJ veins meet to form the brachiocephalic vein. The SC vein is identified above the clavicle, thus negating interference from the clavicle's acoustic shadow, and is also more superficial at this location, allowing for ease of cannulation [18, 29, 32]. However, as the subclavian vein is only visualized for a short distance at this location, dynamic needle guidance can be difficult. The supraclavicular approach has been shown to result in less catheter malposition when compared to the landmark technique. However, limited data exist comparing these two approaches. Depending on the anatomy of the patient and the amount of body surface available in the supraclavicular region, this approach may be optimal compared to an infraclavicular or landmark approach for certain patients [18, 29, 32].

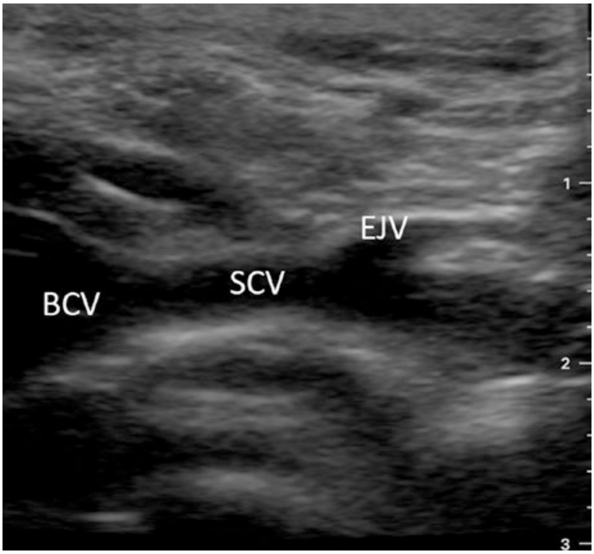


Fig. 6.14 Supraclavicular view of the right subclavian vein

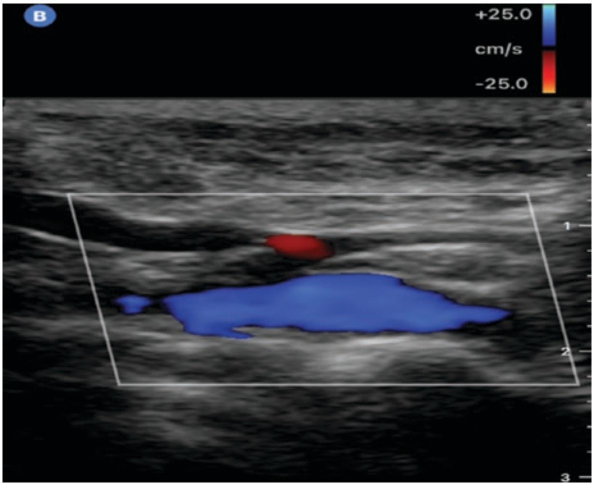


Fig. 6.15 Right supraclavicular view of the SC vein using color Doppler flow imaging

In contrast to infraclavicular SV CVC placement, the supraclavicular USG approach is obtained by first positioning the linear probe on the ipsilateral IJ vein in an out-of-plane fashion. The IJ vein is traced caudally until the probe abuts the patient's clavicle in the supraclavicular fossa, which is approximately the site of the confluence of the IJ vein and the SC vein. The probe is angled toward the patient's chest wall until the SC vein becomes visible in long axis (Figs. 6.14 and 6.15). In Fig. 6.14, note the SC vein (SCV) emanating from the *brachiocephalic (BC) vein* (BCV) on the left side of the image and the *external jugular (EJ) vein* (EJV) arising from the SC vein more superficially. In Fig. 6.15, the blue structure is the subclavian

Fig. 6.16 In-plane (long-axis) supraclavicular approach to the SC vein

vein and initial part of the brachiocephalic vein. The red structure is the external jugular vein with flowback toward the subclavian vein.

The *subclavian artery* lies just posterior to the SC vein at this location, and care should be taken to differentiate the SC artery from the vein using Doppler or by fanning the probe prior to any cannulation attempt [18, 32]. The vessel is then cannulated using an in-plane needle approach (Fig. 6.16), followed by CVC line placement, as described above.

Femoral (FEM) Vein

The *femoral triangle* is located inferiorly to the inguinal ligament. Within this anatomic region lies the *common femoral vein*, which is the target vein for femoral CVC placement (Fig. 6.17). The lateral border of the femoral triangle is formed by the medial edge of the sartorius muscle and the medial border formed by the lateral edge of the adductor longus muscle [26]. It is important for providers to distinguish the confluence of the *greater saphenous vein* from the common femoral vein. Inadvertent cannulation of the saphenous vein will result in difficulty advancing the guidewire or malpositioning of the CVC.

When attempting FEM vein cannulation, place the patient in a slight *reverse Trendelenburg* position (i.e., supine, head higher than the feet, as in Fig. 6.18) to increase venous filling in the femoral vein. In cases of cardiopulmonary resuscitation or dramatic volume depletion, this maneuver will allow for a more easily identifiable structure and again a larger diameter target vein.

The appearance of the common femoral vein in out-of-plane probe positioning is demonstrated in Fig. 6.19. If possible, the ipsilateral (i.e., same side) leg of the vein

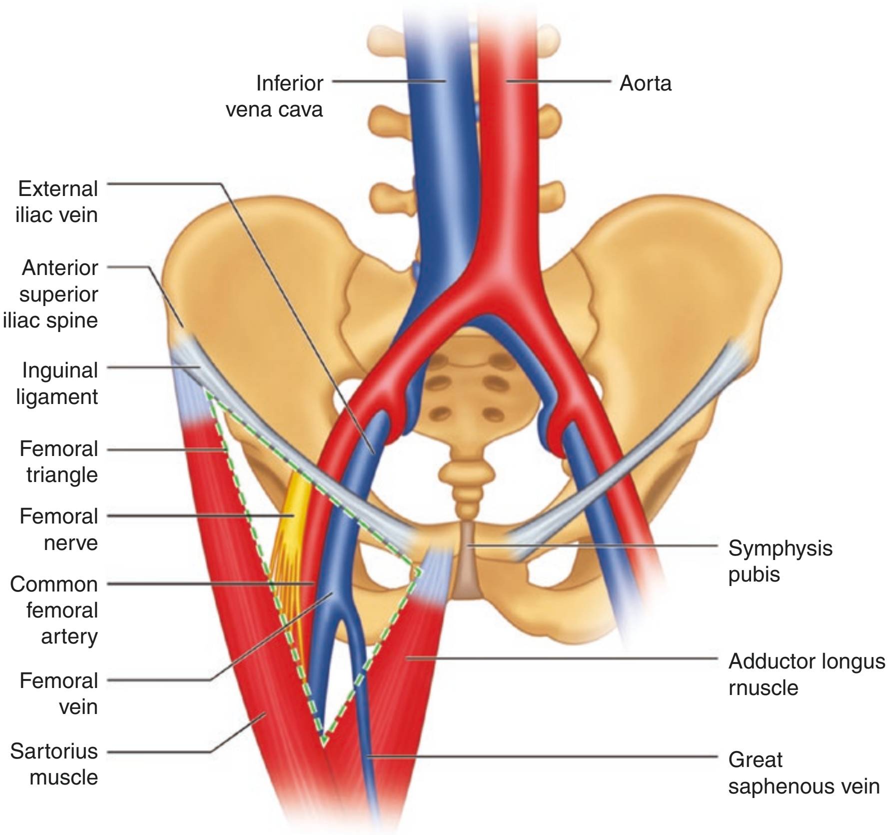
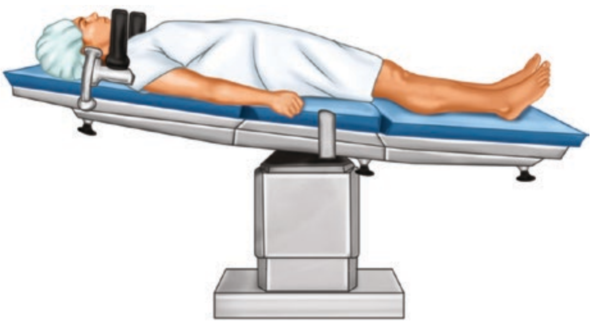


Fig. 6.17 Anatomy of the common femoral vein and related structures

Fig. 6.18 Reverse Trendelenburg positioning



of interest should be externally rotated and flexed to improve the positioning of the common femoral vein, bringing it to a more superficial position [20].

The practitioner should be positioned on the ipsilateral side as the vein targeted for cannulation. The US machine may be positioned on either side of the patient, as

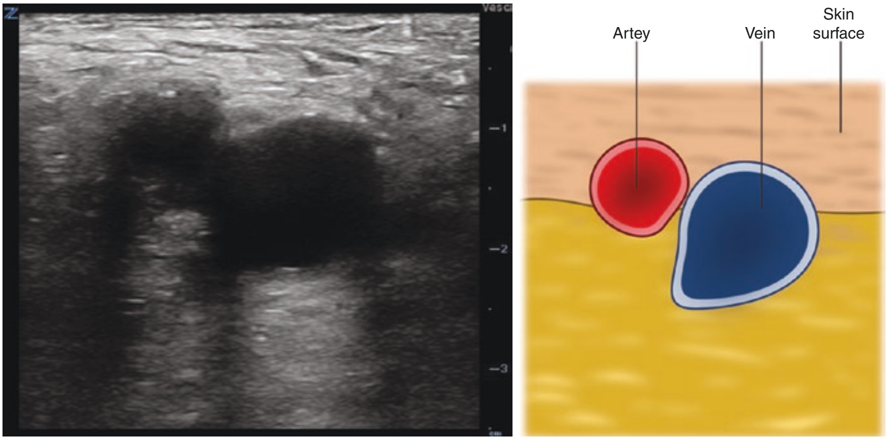


Fig. 6.19 Femoral vein in out-of-plane (short-axis) view

long as the needle insertion point, the US screen, and the patient are within view, so as to minimize the need for head movement by the practitioner during the procedure. Both the US screen and the patient should be at a height that is ergonomically comfortable for the practitioner [20].

Depth of insertion is simpler for FEM vein CVCs than for other CVCs. Femoral CVCs should be fully advanced to their hubs and sutured into position. Unlike CVCs placed in the IJ or SC vein, radiographic imaging is not required to confirm proper placement prior to use. The line is considered usable if each hub of the CVC draws venous nonpulsatile blood.

Pitfalls

Central venous catheter placement is fraught with potential pitfalls, although most of these can be mitigated by proper positioning of the patient, provider, and US machine. As with the placement of any CVC, one common pitfall is the inability to successfully thread the guidewire. This may be alleviated by dropping the angle of insertion of the needle relative to the skin, thus decreasing the initial angle of guidewire insertion into the vessel so that it is less steep and, therefore, less likely to catch on endovascular structures. Dynamic visualization of the needle tip within the central portion of the vessel lumen will also help during advancement of the guidewire [18]. Another common occurrence resulting in the inability to thread the guidewire is that the needle tip becomes inadvertently malpositioned due slight migration either by accidental movement on the part of the practitioner or patient movement due to respiratory variation or inadequate sedation (more common in the IJ and SC veins, as compared to the FEM vein). This occurrence can be addressed by using ultrasound to verify that the needle is within the central portion of the vessel lumen and not in contact with the back wall of the vessel. The needle can be adjusted under

USG intravascularly in long axis so that the tip once again lies in the center of the vessel and guidewire passage may be reattempted [18].

Taking the time to verify the location of the needle tip and to ensure proper dynamic visualization allows for increased first-attempt success rates and decreases the risk of complications. Loss of visualization of the needle tip using either the in-plane or out-of-plane technique can result in arterial puncture or damage to surrounding structures. To help prevent this, advancement of the needle should not proceed until the practitioner can once again identify the needle tip on ultrasound [18].

Complications

There are numerous complications associated with CVC placement. Previous studies have broken them down into several categories, including mechanical, infection, and thrombus formation. The rates of complications are noted to increase secondary to multiple variables including the use of the landmark-based technique for CVC insertion, provider inexperience, individual patient factors, multiple attempts at cannulation, or emergent situations.

Mechanical Complications

As with any procedure, a practitioner must consider the risks, benefits, and alternative therapies available when treating a patient. Numerous mechanical complications of CVC placement have been described, including malplacement, hematoma formation, arterial puncture, pneumothorax, hemothorax, nerve injury, and thoracic duct injury. The incidence of mechanical complications ranges from 6.2% to 19.4% [21, 33]. Arterial puncture is most prevalent in the landmark-based femoral central line placement, but pneumothorax is the most common in the landmark-based subclavian approach. The use of USG to perform CVC placement decreases the risk of all of these complications and thus has become the standard of care [11, 12].

Arterial puncture is the most common of all mechanical complications of CVC placement, although the use of US guidance decreases the risk of this complication by 72% and decreases the rate of hematoma formation by 73% [11]. Ultrasound guidance also allows for quick identification of iatrogenic pneumothorax, by allowing the user to evaluate for lung sliding using the linear probe. The use of US for dynamic guidance has been shown to decrease the number of placement attempts and, in doing so, decreases the rate of all complications [11, 12].

Infectious Complications

Though the overall rate of central line-associated bloodstream infection (CLABSI) is low, infections attributed to CVC placement still represent a significant source of iatrogenic patient morbidity and mortality [17, 34]. The use of aseptic technique for line placement, including the standard PPE, adequate draping of the patient, and an appropriately sized sterile probe cover, is of the utmost importance to prevent infectious complications. The placement of a sterile dressing over a newly placed CVC with either the BioPatch® or other approved form of antimicrobial impregnated dressing is also frequently mandated and may help in decreasing the incidence of infectious complications [34].

Documentation

According to the American College of Emergency Physicians (ACEP), documentation of all USG procedures should include the following data elements: patient demographic data including name, date of birth, medical record number, and gender. Information pertaining to the exam should also be included, such as the date and time of the exam, indication for the exam, the individual performing the exam, and (if applicable) the name of the person reviewing the images for quality assurance. Provider documentation should also contain information on the form of anesthesia used (i.e., local, procedural sedation or other), equipment used, and the technique (i.e., sterile versus emergent). Documentation should also include the anatomic location of the procedure (e.g., right internal jugular vein), compressibility and patency of the target vein, method of guidance (i.e., dynamic or static), the number of attempts, outcome, complications, and method used for confirmation of proper placement [35].

Key Points

- The use of ultrasound guidance for CVC placement increases the rate of successful vessel cannulation and decreases the risk of avoidable complications.
- Placement of USG CVC catheters requires the use of a linear US probe, appropriate US machine exam settings, and aseptic technique including a sterile probe cover.
- Ultrasound can be used to confirm proper CVC placement by guidewire visualization and to detect certain complications associated with this procedure.
- Pitfalls associated with USG CVC placement are similar to those encountered with the landmark technique but may be easier to troubleshoot through direct visualization of the anatomy and/or real-time redirection of the needle tip and guidewire.

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