A. ULTRASOUND GUIDED VASCULAR ACCESS

Obtaining vascular access is a vital procedure for clinicians. Previously, one had to rely on external landmarks to guide placement. However, this can be challenging in chronic medical conditions, intravenous drug use, and obesity. In addition, the proximity of such structures as the large arteries of the chest and neck as well as the apex of the lung results in a 6.2-11.3% rate of immediate mechanical complications when performing subclavian or internal jugular catheterization. With the advancement of ultrasound technology, we have been able to reduce this complication rate. Multiple studies have shown the benefit of ultrasound guidance in central venous catheter placement by multiple specialties, and the same technique has been extended to the placement of peripheral intravenous catheters. Ultrasound adds to vascular access in many ways: It provides knowledge of exact vessel location, allows detection of anatomic variations, helps avoid veins with pre-existing thrombosis, helps identify occluded vessels (one study noted this to occur in the internal jugular 18% of time in patients on hemodialysis), helps guidance of both guide wire and catheter placement after initial needle insertion, reduces venipuncture attempts, and finally, reduces overall complications.

Probe Selection

Remember that for ultrasound imagery of superficial areas use of a high frequency (5-12 MHz) flat linear probe with a small footprint will be best for image quality and ease of use during vascular access. Image orientation is also key. Make sure to identify the indicator marker on the probe and relate it to the indicator marker or the screen. The goal is to keep the indicator on the side of the probe oriented in the same direction as the orientation mark side of the screen. If there is any confusion about the orientation, one should place a finger on one side of the transducer surface after gel application to produce an image on the screen.

Image Optimization

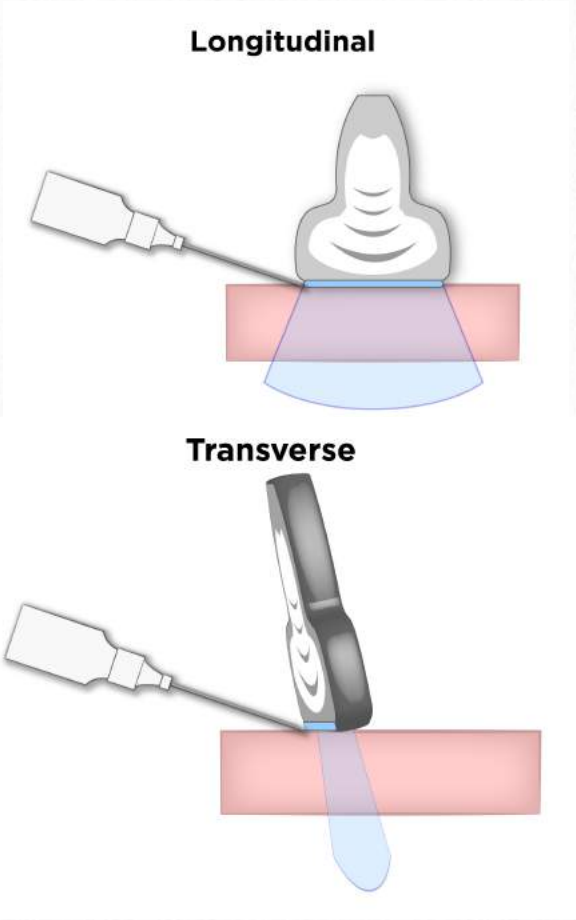
Adjustment of the previously discussed ultrasound settings is crucial to optimize the image. Realize that most ultrasound machines have a pre-programmed vascular setting that may help. Additionally, one must always minimize the depth such that the vessel of interest is in the middle of the screen. Having extra depth essentially wastes ultrasound waveforms and will result in poorer image quality. Also, one should adjust the gain such that blood appears black on the ultrasound screen. Finally, one should always adjust the focus at the level of the target vessel.

Differentiating Artery and Vein

It is essential to be able to differentiate between arterial and venous structures, which does get more difficult when trying to identify deep peripheral veins. One key difference is that the vein should be more compressible, requiring only minimal pressure from the probe, while arteries retain much of their original shape and appearance. Also, remember that Valsalva maneuvers and Trendelenberg positioning make veins larger but will have minimal affect on the carotid artery. The application of color Doppler is also very useful in differentiating artery from vein. Arteries have pulsatile flow visualized on color Doppler, while the vein has minimal flow more continuous flow. Finally, when it comes to peripheral vascular access, one should see the vein enlarge after the tourniquet is placed, while the size of the artery should not change.

Image Views

There are two planes of ultrasound that are used for vascular access: transverse and longitudinal views (see below). In the transverse view, the transducer plane is in cross section of the target vessel and the vessel is displayed on the screen as a circle. The transverse view gives the advantage of seeing surrounding structures, but one can’t see the entire needle. In longitudinal view, the transducer plane and vessel plane are parallel and the vessel is displayed as a long tube running across the screen. A longitudinal view allows visualization of the entire vessel of interest, but it does not show surrounding structures.



Utrasound for Central Venous Access

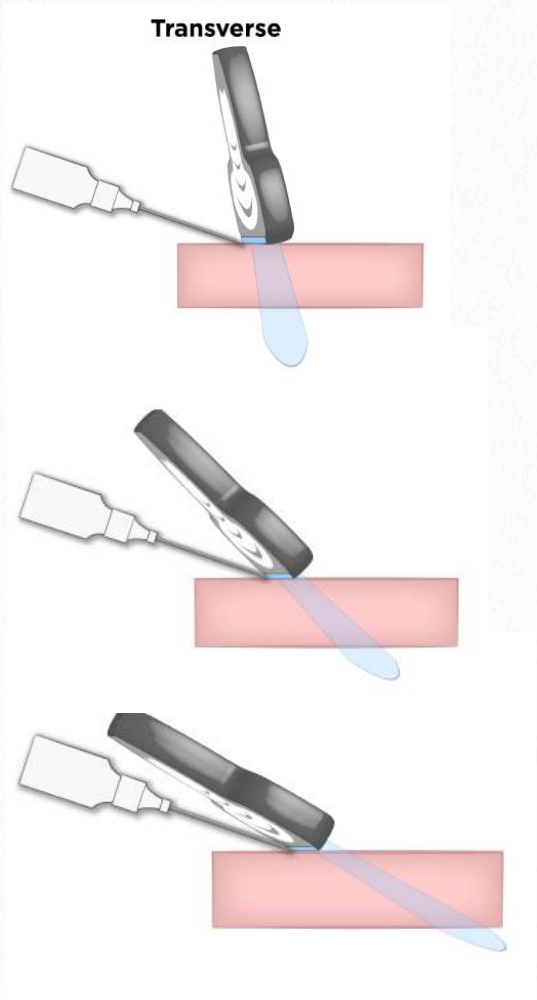
1. Internal Jugular Vein:

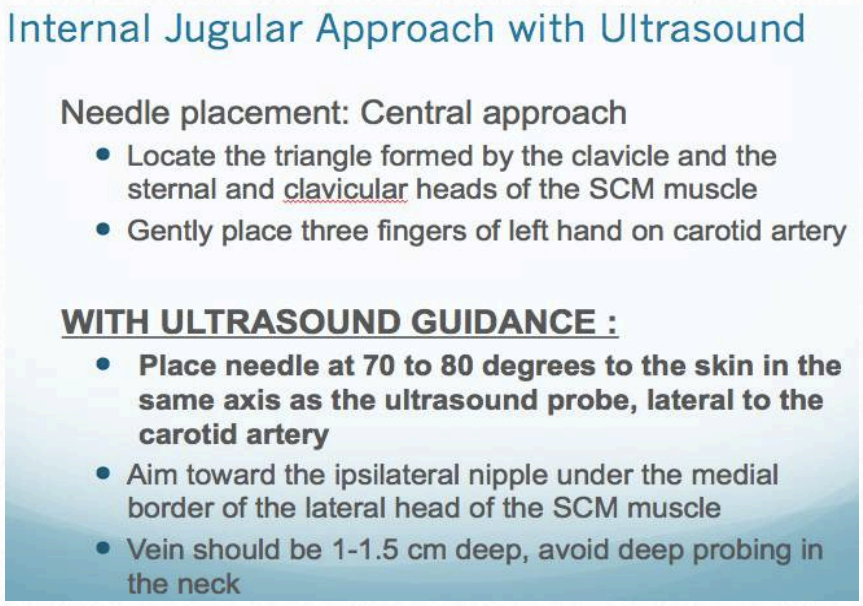
The internal jugular vein is typically located anterior and lateral to the carotid artery; however, there is a significant anatomic variation where the vein can overly the artery and can even be medial to the artery. Please note that in the longitudinal view, the IJ vein can be followed inferiorly, down to the level of the sternoclavicular joint where it joins the subclavian vein on each side and drains into the superior vena cava.

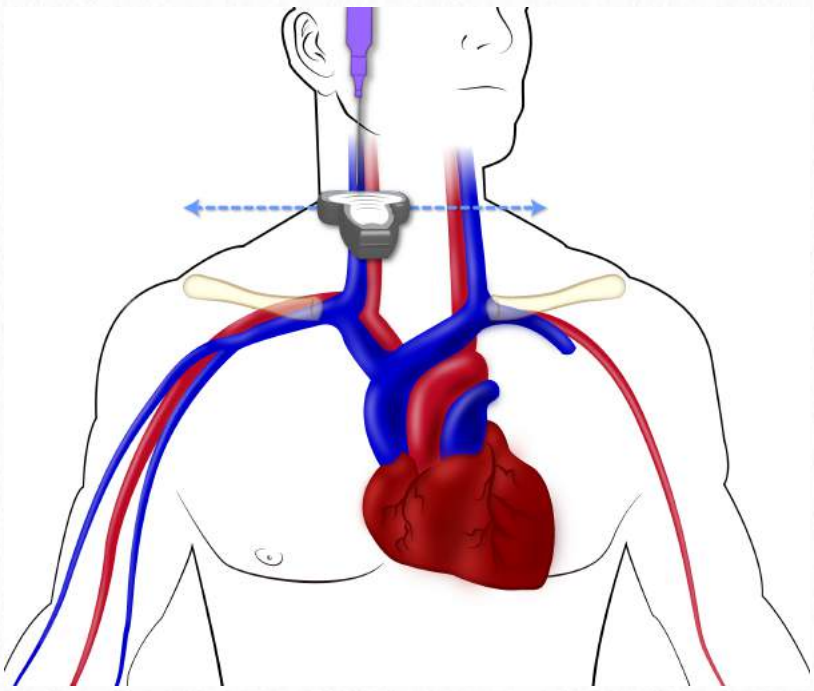
Positioning and preparation: It is important to have proper positioning of the patient. For the IJ cannulation, the patient's head should be rotated slightly contralaterally with the neck extended. Please note that extreme rotation of the neck may increase the amount of overlap of the carotid artery and IJ vein. The patient should be placed in the Trendelenberg position in order to maximally distend the IJ vein. The ultrasound machine should be placed by the same side of the bed and directly in front of the provider to provide a direct line of vision.

Ultrasound guided catheter insertion: One should start in the transverse view with the dominant hand controlling the needle and the non-dominant hand holding the transducer. One should place the vessel in the middle of the transducer and then place the catheter in the same plane of the ultrasound image (see diagram). Please note that this will result in a much steeper angle than would be used if one were performing a blind insertion. In this approach, the needle tip and the shaft are visualized as a hyperechoic dot. If the needle tip cannot be visualized, indenting the tissue overlying the vein or moving the transducer along the axis of the vein while "agitating" the needle may enhance the image of the needle and tip. As the needle progresses, one should "fan" the ultrasound probe to maintain a view of the needle (see diagram). If considering longitudinal plane, the needle is placed inline with and parallel to the transducer, in which the entire length of the needle and the tip are visualized as the vein is punctured. Once the vessel has been successfully punctured, the transducer can be set aside and the procedure can proceed normally with wire and catheter placement.

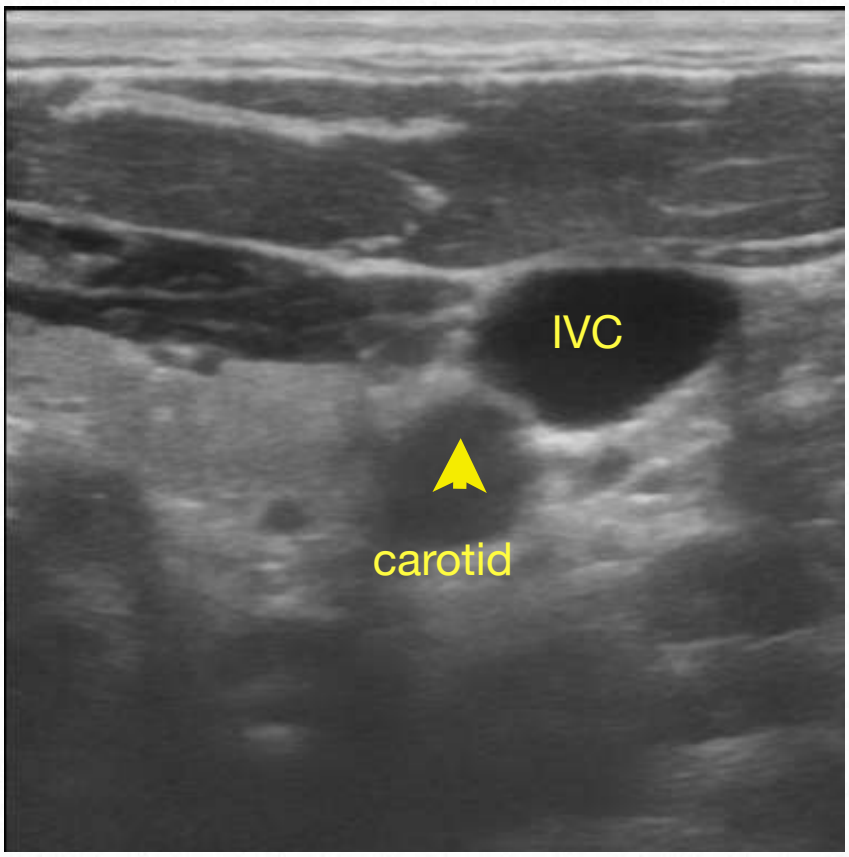
Transverse: Fanning Approach to follow Needle Tip







Internal Jugular Anatomy

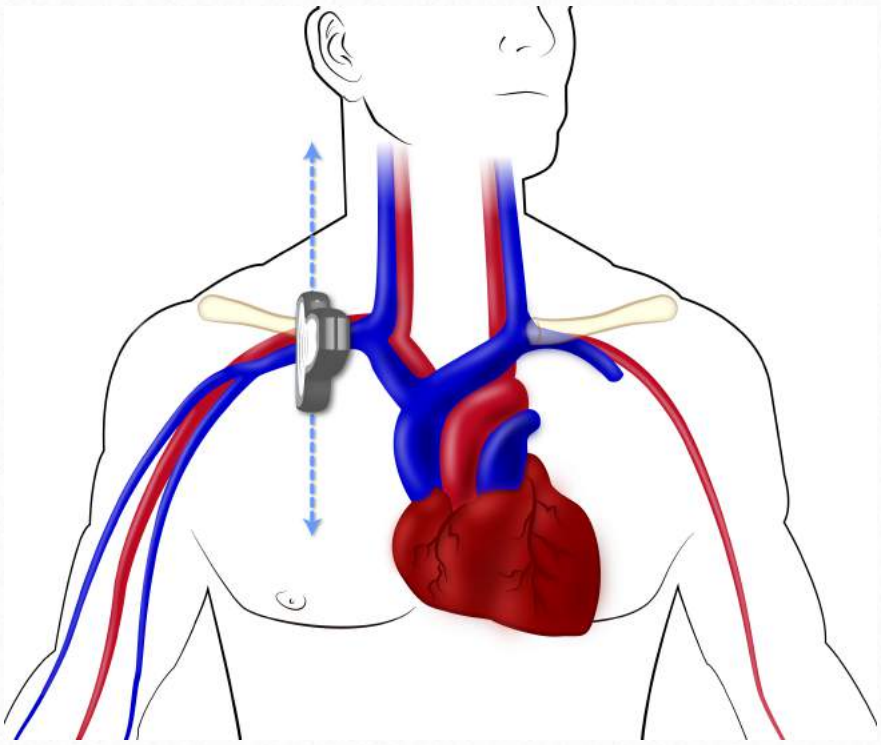


2. Subclavian Vein

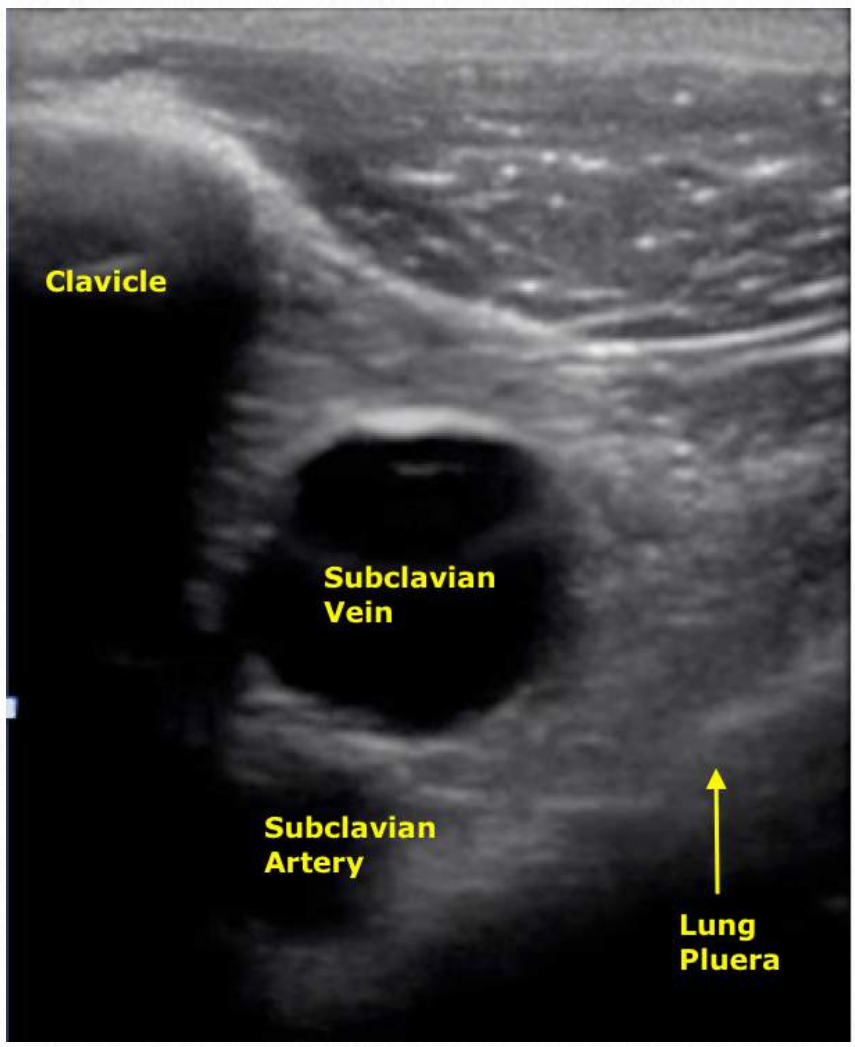
The subclavian vein is a continuation of the axillary vein at the lateral border of the first rib. It crosses over the first rib and passes in front of the anterior scalene muscle, which separates the vein from the subclavian artery. The subclavian (SC) vein continues behind the medial third of clavicle. At the junction of sternoclavicular joint on each side, SC veins join to the IJ veins and form the innominate vein to the left and brachiocephalic vein to the right side. Also, please note that the RUL is lower than the LUL, so first subclavian vein target should be the right when possible.

Positioning and Preparation: Positioning is key for subclavian vein access. One should again place the patient in Trendelenberg if possible. Also, a roll under the scapula may help make the outline of the clavicle more obvious. Finally, traction on the ipsilateral arm may flatten the clavicle and allow a more direct alignment for access of the subclavian vein. If possible, one should ultrasound the vein prior to sterile prep to get an idea of the anatomy and to see if these maneuvers listed help or hurt.

Ultrasound Guided Catheter Insertion: The subclavian vein can be visualized at the infraclavicular region by placing the transducer at the mid to lateral 2/3 of the clavicle, with half of the footprint covering the cross section of the clavicle and the lower half investigating the infraclavicular region (see picture below). With the probe in this position (using the non-dominant hand), one should have the needle at the junction of the middle and medial thirds of the clavicle, aiming to make contact with the clavicle with the angle of the needle being parallel to the skin. Once this is obtained, one should walk off the clavicle by slightly increasing the degree of steepness of the needle. This should be visualized with the ultrasound image. Once the needle is off the clavicle, one should aim for the subclavian vein, directing towards the supraclavicular notch using the ultrasound image to make sure not to violate the lung pleura. The approach should not be steeper than 45 degrees.

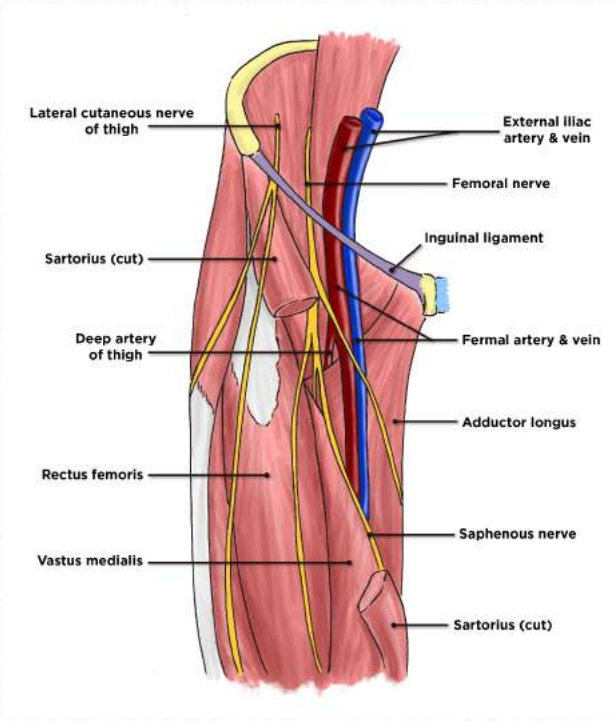


Subclavian Vein Anatomy



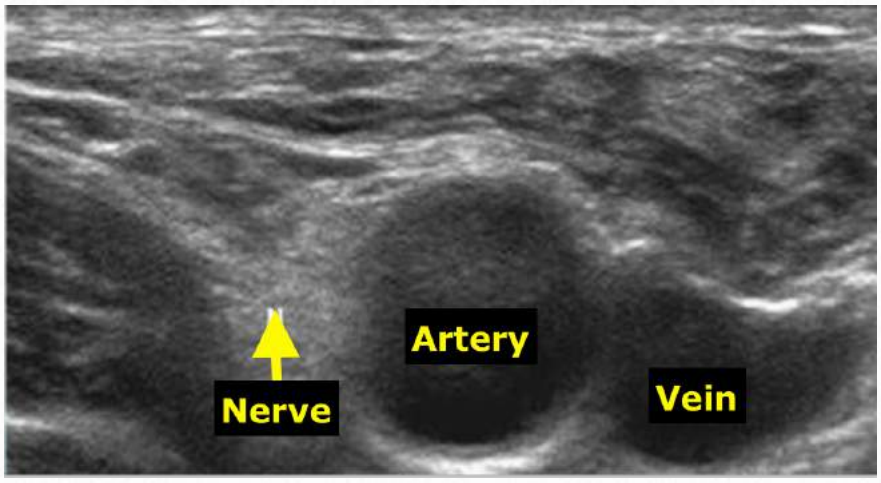
3. Femoral Vein

The proximal femoral vein is medial to the femoral artery/nerve, deep to the fascia iliaca, and superficial to the iliopsoas muscle (see picture below). At the lower level the vein gradually descends posterior to the femoral artery, which would be deeper in ultrasound scanning. Usually, for central catheter placement, one should consider more proximal placement where the vein is medial to the artery. Confirmation of the vein vs. the artery should be obtained using the techniques described above. Also note that minimal pressure on the vein can totally compress the vein, confirming the lack of thrombosis.



Positioning and Preparation: One should externally rotate the hip (frog leg) to optimize exposure to the femoral vein.

Ultrasound Guided Catheter Insertion: Similar to ultrasound of the SVC, one should have the transducer in the transverse position along the inguinal crease. If the femoral artery and nerve are too deep, the machine imaging capability should be adjusted appropriately by increasing the depth and adjusting the gain. Starting with a short axis view will provide a sufficient image of adjacent structures and facilitate a proper needle insertion. Again, the needle should be in line with the ultrasound probe (similar as described for the SVC). Also, as with the SVC, the transducer can be rotated 90 degrees while the femoral vein image is kept in the center of the screen, providing a longitudinal view of the vein. Generally, the needle insertion should be around 2 cm below the inguinal ligament and the needle should be directed to the umbilicus.



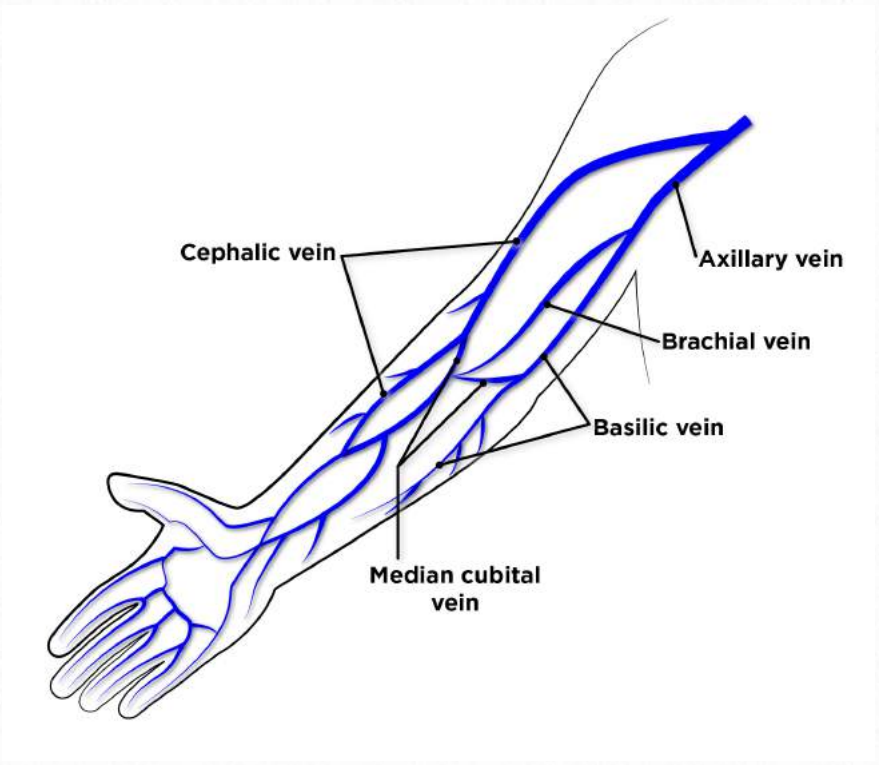
D. Selecting the Location of Central Venous Access

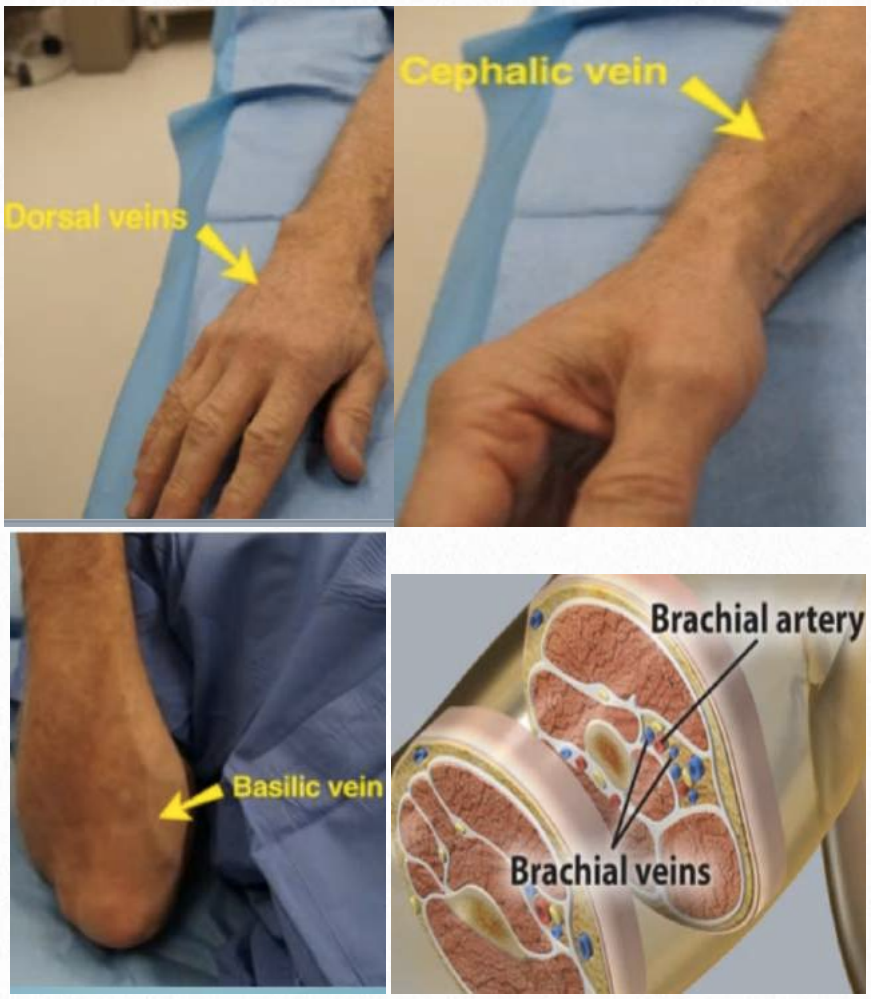
Location	Advantage	Disadvantage
Internal Jugular	• Bleeding can be recognized and controlled • Malposition is rare • Less risk of pneumothorax	• Risk of carotid artery puncture • PTX possible
Femoral	• Easy to find vein • No risk of pneumothorax • Preferred site for emergencies and CPR	• Highest risk of infection • Risk of DVT • Not good for ambulatory patients
Subclavian	• Most comfortable for conscious patients • Lowest infection rates	• Highest risk of PTX,

Ultrasound for Peripheral Venous Access

Intravenous (IV) access is a basic yet critical procedure. While this procedure is usually performed by medical technicians or nurses, sometimes they are unable to obtain access, and the physician should be knowledgeable in the use of ultrasound to establish IV access. This knowledge can help obtain an IV quicker, with fewer complications, and may prevent the unnecessary placement of central venous catheters.

Here's a brief review of anatomy (see pictures). The upper extremity consists of two types of veins: superficial and deep. The deep veins accompany the arteries, and they are connected to the superficial system by perforating veins. The superficial veins start on the back of the hand and are called the dorsal veins. Note that for pediatrics and obese adults one can reliably "predict" that a dorsal vein lies between the third and fourth digits. Dorsal veins of the hand empty into the cephalic vein on the lateral aspect and into the basilic vein on the medial aspect of the forearm. The cephalic vein ascends in the lateral aspect of wrist and courses laterally upward around the anterior surface of the forearm. Under the front of the elbow, it divides into some branches, receives a communicating branch from the deep veins of the forearm (median cubital vein), and passes across to join the basilic vein. In the upper arm, the cephalic vein terminates in the infraclavicular fossa and empties into the axillary vein. This vein can be quite superficial compared to the basilic. The basilic vein runs medially along the ulnar part of the forearm and penetrates the deep fascia as it courses past the elbow in the upper arm. It then joins with the deep brachial veins to become the axillary vein. The basilic vein is the first choice for PICC line insertion. The median cubital vein joins the cephalic and the basilic veins on the ventral surface of the elbow. The axillary vein becomes the subclavian vein at the lateral border of the first rib as described above.





Positioning and Preparation: Please review the criteria to differentiate between veins and arteries. The depth key should be adjusted to make sure veins are in an approachable depth.

Ultrasound Guided Catheter Insertion: The high frequency, linear probe is appropriate for peripheral IV access. Please review the above section on the differentiation between veins and arteries. One should have the ultrasound probe in the transverse view, making sure to be aware of the orientation marker and its relationship to the indicator of the US monitor. Remember, the depth key should be adjusted to make sure veins are in an approachable depth. Using the transverse axis approach, the vein should be positioned in the middle of screen. In this situation, the middle of the transducer is compatible with the middle of the US screen. Appropriate angiocatheter size should be used. Introduce the angiocatheter at a 45 degree angle to the probe with a 3-5 mm distance between the catheter and the US probe (see picture below). *This approach is different than the US technique for larger/ deeper structures.* This technique is used for all superficial structures because, with this approach, the needle tip should be visualized by the US probe, the same point that is about to cannulate the vein. *When trying to use ultrasound to cannulate superficial structures, it is better to trace out a triangle such that the catheter tip will intersect the plane right at the entry point of the vessel* (see pictures below). You should see the tip of the needle as a hyperechoic structure as you approach the vein. You should stop advancing your needle as soon as you get blood flush back. Now, remove the introducer and advance the plastic angiocatheter all the way in, reducing your angle prior to catheter advancement.