Vascular Access:

Over 5 million central venous catheters are placed in the United States in the internal jugular, subclavian, and femoral veins [1]. Ultrasound guidance for vascular access (venous and arterial) has been a landmark change in management of the critically ill patient over the last 10 years. Quality of care and reduction of complications has encouraged many organizations to publish documents making it standard of care to use ultrasound guidance in these procedures. Most of the evidence is for internal jugular vein for access [2]. Discussed below is general scanning techniques for the cannulation of vessel (arterial and venous), and afterwards with specific vessels that have growing literature supporting their use (subclavian vein, arterial access, peripheral vein, femoral vein).

Central Venous - Internal Jugular, Femoral, Subclavian

Probe Type: Vascular (linear array) high frequency 5-10 MhZ

Scanning Techniques: The ultrasound should be used to identify the location of the vessel prior to the procedure and utilize external landmarks during the procedure itself (static technique), or use the ultrasound to visualize cannulation during the procedure (dynamic technique). The dynamic technique is the preferred technique. The vein and artery couple should be seen and clarification of a vein by its collapsibility should be obtained to confirm appropriate vascular structure and to confirm patency. Multiple points should be evaluated to make sure patency is not compromised more proximal to the entry site so that difficulty with wire placement will not occur due to clot. Once collapsible and appropriate structure for cannulation has been identified, follow sterile procedure precautions and place sterile ultrasound probe cover before proceeding with cannulation. The static view has the advantage in that the ultrasound transducer is not needed during the sterile portion of the procedure, but it does not allow for direct visual confirmation of the cannulation during the procedure. The dynamic technique allows for direct visualization throughout the procedure, but requires more experience in the technique and requires use of the transducer during the sterile portion of the procedure. The dynamic technique can be used in either the long axis or the short axis [Figure 1]. The short axis is easier for novice operators due to increased ability to see the artery and vein but has higher risk of posterior perforation if the needle tip is not visualized well. Once the short axis is used to find the vein, turning the probe 90 degrees clockwise allows the operator to see the vein in long axis. In patients with short necks, it may be difficult to obtain the long axis view and needle inseration in the limited space. The long axis view allow for full visualization of the needle throughout the procedure and allows for better visualization and adjustment of needle depth. It is more technically difficult and key point is once a good section of the vein is obtained, the ultrasound probe should not be moved to find the hyperechoic needle, the needle trajectory should be adjusted into the ultrasound view. Make sure to visualize the vessel with the ultrasound such that you can see the greatest diameter of the vessel along the entire length of the ultrasound probe.

Keep the ultrasound steady during the procedure and insert the needle at an angle at the lateral edge of the ultrasound probe. Using this technique, the clinician can visualize the entire length of the needle. Once the vein is cannulated, and wire introduced, the ultrasound can be used again to confirm wire placement into the vessel (preference is long axis). Using ultrasound to confirm guidewire placement can add an additional safety measure [3].

Supporting Literature: The use of ultrasound to guide central venous access has been shown to reduce the failure rate, the risk of complications, and the number of attempts, as compared with the landmark technique, especially in the less experienced users or patients with more complex conditions [4, 5].

Ultrasound Guidance: femoral vein, subclavian vein, arterial access, peripheral veins

Femoral Vein: There are several clinical situations when emergent femoral vein cannulation may be preferred. During cardiac or respiratory arrest, the femoral veins offer easy access and free of chest compressions. In coagulopathy can be a good site to use while anti-coagulant agents are being reversed since this is an easily compressible site. It also eliminates the risk of pneumothorax in patients who have bilateral thoracic disease processes. Unlike literature for internal jugular access, femoral vein ultrasound access support is scarce. A meta analysis in 2011 showed that real time ultrasound guidance for hemodialysis catheters decreased arterial punctures, risk of placement failure, and risk of failed first time access. This analysis however only included one study from India that showed improved first attempt success and decreased complications [6, 7]. As mentioned earlier, posterior wall penetration is common in short axis view. In a study published by Blaivas and Adhikari in 2009, they showed a high incidence of posterior wall penetration and therefore recommendations in current literature is to use a long axis view to guide central venous placement, even in the femoral region [8].

Subclavian Vein: This is the site that has the most mechanical complications compared with internal jugular and femoral sites. Real time ultrasound guidance has resulted in lower technical failures and faster access. However most of these studies have occurred evaluating the internal jugular site [9, 10]. In a recent study, the ultrasound technique was confirmed to decrease access time and number of attempts, and reduction in complications such as arterial puncture, hematoma, pneumothorax, and hemothorax [11]. Scanning of the vessels prior to the procedure should be performed by obtaining appropriate infraclavicular views, and depth and caliber of the axillary vein and subclavian vein as well as patency should be evaluated. In anatomic terms, the axillary vein continues medially until it reaches the first rib when it becomes the subclavian vein. The probe marker can be placed towards the head of the patient and probe placed on the mid clavicle. The image seen should be the acoustic shadowing of the clavicle [Figure 2]. The probe can be moved laterally and the clinician will see the vein appear just below the clavicle. This is not easily found in every patient, but when it is gives opportunity to use ultrasound to cannulate the vessel. The probe can be moved a few more centimeters laterally and the vein and artery couple can be visualized. Once the axis is visualized in short axis, the probe can be turned 90 degrees clockwise to image the long axis of the vein [Figure 3]. Clinicians can use the acoustic shadow of the first thoracic rib and sternum to select as a site for access. The needle can be advanced slowly so that its trajectory is towards the lumen of the vein and purposefully directed towards the acoustic shadow of the thoracic rib underneath to minimize the risk of hitting the pleura.

Arterial access: Arterial access for hemodynamic monitoring has traditionally done by palpation techniques. Recently, ultrasound use has increased for access of sites such as radial, axillary, and femoral. The ultrasound techniques explained above for central venous catherization can be used for arterial access, with increased success, decreased time to cannulation, and decreased risk of complications and should be considered as a first line method of cannulation [12-14].

Peripheral Vein access: Peripheral vein cannulation using ultrasound has also grown over the past 10 years. Clinicians and nursing staff have started to use in increasing amounts in difficult venous access patients. In recent study by Gregg et al, it was shown that in critically ill patients placement of peripheral veins ultrasound guided has reduced the amount of central line placements [15]. The methods used is similar to the central venous catheter technique explained above. One significant difference is that in peripheral lines, the operator can follow the needle tip in the lumen of the vessel for longer distances. The author's success rate increased significantly for cannulation once the whole needle/catheter was advanced into the vessel and then needle removed. This can be done in short or long axis. Short axis seems to be easier since small movements of the ultrasound hand do not cause a loss of image, and so is easier to start teaching novices with this technique. The technique involves obtaining a 'bull's eye target' type view with the needle tip in the center of the lumen [Figure 4]. Once this is achieved, after following the needle tip into the vessel from the skin surface, the needle and catheter combo is continuously advanced as the ultrasound probe is moved more proximally, always showing a 'bull's eye target' view and adjusting the direction of the needle/catheter to remain in the center of the vessel. In order to remain in the vessel lumen, the operator usually has to get the needle/catheter combination parallel with the skin surface, otherwise the needle would puncture through the posterior wall.

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Figure 1 - short and long axis view of internal jugular
Figure 2 - acoustic shadow of clavicle
Figure 3 - subclavian vein, axillary vein short, first rib relationship
Figure 4a - bull’s eye target view; Figure 4b - long axis needle view