Background & Indications

- There are many reasons why patients may require central venous access. The most common include requirements for longer-term vascular access, need for larger lumens, multiple lumens for rapid administration of drugs, fluid, or blood products, and central venous pressure monitoring.
- The three most common sites for central venous catheter placement are the femoral, subclavian, and internal jugular veins. All three sites provide direct access to the central circulatory system, but each site comes with its own advantages and disadvantages.
- In all three sites, access to the vein can be obtained using either the landmark guided approach or under direct ultrasound guidance.
- Studies have shown that central lines placed using the landmark technique alone can lead to complications such as inadvertent arterial puncture, multiple punctures through the target vessel, extensive bleeding, or accidental puncture of adjacent structures such as the lung, lymphatic channels, arteries, nerves, or the urinary bladder.
- Ultrasound guidance saves time, maximizes successful line placement, and minimizes complications.

Probe Selection

- A high frequency (7-12 MHz) linear array transducer should be used to visualize most veins for central venous access (Image 1).
- If there is an abundance of soft tissue overlying the target vein, the lower frequency (3-5 MHz) curvilinear transducer can be used for deeper penetration (Image 2).
Performing the Exam

Femoral Vein Access Under Ultrasound Guidance

- Apply a large amount of ultrasound gel to improve the acoustic interface.
- Place the transducer in a transverse orientation inferior to the middle segment of the inguinal ligament with the indicator marker pointing towards the patient’s right side.
- Under ultrasound, the femoral vein appears as an oval, thin-walled, anechoic structure that collapses easily under pressure. The adjacent femoral artery will be the round, anechoic, thicker-walled, pulsatile structure lying just lateral to the femoral vein (Image 3).
Image 3: Ultrasound image of the right femoral artery and femoral vein with corresponding anatomic illustration.

- The femoral artery should not collapse under pressure from the probe unless the patient is profoundly hypovolemic.
- Application of color-Doppler over the vessel of interest can help distinguish an artery from a vein. Flow within an arterial lumen will appear pulsatile. In contrast, a vein will demonstrate a more constant rumble of color flow (Image 4).

Image 4: Pulse wave Doppler ultrasound comparing venous and arterial flow.

- Remember when using color Doppler imaging, the color blue does not equal venous and the color red does not equal arterial in all cases. The color corresponds to the direction of flow (towards or away from the transducer). Be sure to take note of the color scale displayed on your ultrasound screen to determine which color corresponds to flow towards the transducer, and which color is displayed with flow away from the transducer.
- Assess for anatomical variations or abnormal bifurcations by scanning in both a transverse and longitudinal fashion along the femoral vein.
- In approximately 25% of patients, the femoral vein may course directly posterior to the femoral artery just below the inguinal ligament.
- Scan caudally until the femoral vein can be visualized coursing distinctly away from the femoral artery.
- Patient positioning may alter the relationship between the femoral vein and femoral artery. Rotate and abduct the femur to achieve the ideal spatial relationship between the femoral vein and femoral artery.
- Access the femoral vein in a sterile fashion, using either static or dynamic ultrasound guidance, via the short axis or long axis approach.
- If the procedure is performed dynamically, remember to use sterile ultrasound gel and prep the ultrasound probe in a sterile fashion (Image 5).

Image 5: Prepping the ultrasound probe in a sterile fashion. Note that sterile ultrasound gel is applied to the outside of the sterile transducer sheath.

- When cannulating a vessel under dynamic ultrasound guidance, remember that direct visualization of the needle will only be seen when the ultrasound beam is directly in plane with the needle. Because the field visualized by ultrasound can be narrow, needle position may need to be inferred by visualizing ring down artifact, soft tissue changes, and tenting of the wall of the target structure (Image 6).

Image 6: Central venous cannulation in a phantom using the dynamic short-axis approach. Note that you cannot visualize the needle tip directly, but can discern the trajectory of the needle based on the ring down artifact seen.

- Remember that the short axis approach is easier to perform and requires less hand-eye coordination for novice users.
• The major disadvantage of the short-axis approach is not being able to visualize the needle tip without manipulating the transducer. You may unknowingly puncture through the posterior wall of the vessel in the short-axis approach unless you change the angle of your ultrasound beam as you advance your needle.

• The long-axis approach requires a steady hand and good hand-eye coordination. It is easy to slip off to the medial or lateral side of the vessel and lose direct ultrasound visualization during the actual cannulation.

• The advantage of performing the cannulation under long-axis guidance is the ability to visualize the needle tip entering the lumen of the vessel without having to manipulate the transducer during the procedure.

• In the long axis view, you can see if your needle tip has accidentally punctured through the posterior wall of the target vein. This is especially useful in hypotensive patients.

• Most experts recommend cannulating veins under long-axis guidance in order to maintain direct visualization of your needle at all times and avoid accidental puncture of adjacent vessels or structures (Image 7).

Image 7: Central venous cannulation in a phantom using the dynamic long-axis approach. Note that you can directly visualize the needle tip puncturing through the proximal wall of vessel.

• Obtaining an oblique view of the target vessel during dynamic cannulation enables the user to visualize the needle as it enters the vessel, meanwhile providing the operator with direct visualization of surrounding structures, as well.

Internal Jugular Vein Access Under Ultrasound Guidance

• Place the patient in Trendelenburg position and turn the patient’s head gently towards the contralateral side, away from the site you are planning to access (Image 8).

• Turning the patient’s head more than 45° past midline may cause compression of the internal jugular vein by the sternocleidomastoid muscle.
• Place the linear transducer at the bifurcation of the sternal and clavicular heads of the sternocleidomastoid muscle for the standard central approach.

Image 8: Probe position for cannulation of the right IJ under ultrasound guidance.

• Under ultrasound, the internal jugular vein appears as an oval, thin-walled, anechoic structure that collapses easily under pressure.
• The adjacent carotid artery will be the round, anechoic, thicker-walled, pulsatile structure lying just medial to the internal jugular vein. The carotid artery should not collapse under pressure unless the patient is profoundly hypovolemic.
• In the majority of patients, the internal jugular vein lies deep to the sternocleidomastoid muscle, lateral and superficial to the carotid artery (Image 9). Note that anatomic variations exist, so use the superficial landmarks solely to guide where you place the transducer to begin your scan (Image 10).

Image 9: Ultrasound of the right internal jugular vein (IJ) lying lateral to the carotid artery (CA) beneath the sternocleidomastoid muscle.
Image 10: Ultrasound of the left internal jugular vein (IJ) directly overlying the carotid artery (CA). Performing the procedure using the landmark approach alone may have led to accidental puncture and cannulation of the carotid artery.

- Compress the IJ gently to ensure that it is collapsible and not filled with an intraluminal clot.
- Don't be overzealous with your compression test of the IJ. Multiple compression attempts near the carotid sinus can stimulate baroreceptors causing bradycardia and hypotension if too much or prolonged pressure is applied.
- Pulse-wave or color-Doppler over the vessel of interest can help distinguish an artery from a vein. Flow within an arterial lumen will appear pulsatile, while a vein will demonstrate a more constant rumble of color flow (Image 11).

Image 11: Pulse-wave Doppler ultrasound comparing venous and arterial flow.

- Scan along the internal jugular vein in a transverse and longitudinal fashion to assess for any anatomic or pathologic variations.
- Access the internal jugular vein in a sterile fashion, utilizing either the static or dynamic ultrasound-guided approach, via the short axis or long axis approach.
• If the procedure is performed in a dynamic manner, remember to use sterile ultrasound gel and prep the ultrasound probe in a sterile fashion (Image 12).

Image 12: Prepping the ultrasound probe in a sterile fashion. Note that sterile ultrasound gel is applied to the outside of the sterile transducer sheath.

• When cannulating a vessel under dynamic ultrasound guidance, remember that direct visualization of the needle will only be seen when the ultrasound beam is directly in plane with the needle. Because the field visualized by ultrasound can be narrow, needle position may need to be inferred by visualizing ring down artifact, soft tissue changes, and tenting of the wall of the target structure (Image 13).

Image 13: Central venous cannulation in a phantom using the dynamic short-axis approach. Note that you cannot visualize the needle tip directly, but can discern the trajectory of the needle based on the ring down artifact seen.

• Remember that the short axis approach is easier to perform and requires less hand-eye coordination for novice users.
• The major disadvantage of the short-axis approach is not being able to visualize the needle tip without manipulating the angle of the transducer. You may unknowingly puncture through the posterior wall of the vessel in the short-axis approach unless you change the angle of your ultrasound beam as you advance your needle.
• The long-axis approach requires a steady hand and good hand-eye coordination. It is easy to slip off to the medial or lateral side of the vessel and lose direct ultrasound visualization during the actual cannulation.

• The advantage of performing the cannulation under long-axis guidance is the ability to visualize the needle tip entering the vessel lumen without having to manipulate the transducer during the procedure.

• In the long axis view, you can see if your needle tip has accidentally punctured through the posterior wall of the target vein. This is especially useful in hypotensive patients.

• Most experts recommend cannulating veins under long-axis guidance in order to maintain direct visualization of your needle at all times and avoid accidental puncture of adjacent vessels or structures (Image 14).

Image 14: Central venous cannulation in a phantom using the dynamic long-axis approach. Note that you can directly visualize the needle tip puncturing through the proximal wall of vessel.

• Obtaining an oblique view of the target vessel during dynamic cannulation enables the user to visualize the needle as it enters the vessel, meanwhile providing the operator with direct visualization of surrounding structures, as well.

Subclavian Vein Access Under Ultrasound Guidance

• Ultrasound can be used to visualize the subclavian vein as it connects to the caudal portion of the internal jugular vein.

• The subclavian vein is difficult to visualize with ultrasound if an infraclavicular approach is utilized because the sonographic window can be obscured by the clavicle. To circumvent this limitation, visualize the subclavian vein from a supraclavicular approach.

• Apply a large amount of ultrasound gel to improve the acoustic interface.

• Place the linear transducer in a transverse orientation 1 cm lateral to the sternal notch and just superior to the clavicle (Image 15).
Image 15: Probe placement to visualize the subclavian vein via the supraclavicular approach. Note that the ultrasound beams are angled caudally behind the clavicle.

- It is helpful to find the internal jugular vein, and then fan and slide the probe inferiorly until you visualize the IJ joining the subclavian vein. At their juncture, there should be a large venous pool visualized on ultrasound (Image 16).
- An oblique probe orientation may be required to obtain the best imaging of this confluence.

Image 16: Ultrasound of the internal jugular vein (IJ) joining the subclavian vein from a supraclavicular approach. Note the hyperechoic pulmonary pleura just deep to the subclavian vein.

- Scan along the subclavian vein to assess for any anatomic or pathologic variations.
- Access the subclavian vein in a sterile fashion, utilizing either the static or dynamic ultrasound-guided approach.
- If the procedure is performed in a dynamic manner, remember to use sterile ultrasound gel and prep the ultrasound probe in a sterile fashion (Image 17).
Image 17: Prepping the ultrasound probe in a sterile fashion. Note that sterile ultrasound gel is applied to the outside of the sterile transducer sheath.

- When cannulating a vessel under dynamic ultrasound guidance, remember that direct visualization of the needle will only be seen when the ultrasound beam is directly in plane with the needle. Because the field visualized by ultrasound can be narrow, needle position may need to be inferred by visualizing ring down artifact, soft tissue changes, and tenting of the wall of the target structure (Image 18).

Image 18: Central venous cannulation in a phantom using the dynamic short-axis approach. Note that you cannot visualize the needle tip directly, but can discern the trajectory of the needle based on the ring down artifact seen.

- Remember that the short axis approach is easier to perform and requires less hand-eye coordination for novice users.
- The major disadvantage of the short-axis approach is not being able to visualize the needle tip without manipulating the angle of the transducer. You may unknowingly puncture through the posterior wall of the vessel in the short-axis approach unless you change the angle of your ultrasound beam as you advance your needle.
- The long-axis approach requires a steady hand and good hand-eye coordination. It is easy to slip off to the medial or lateral side of the vessel and lose direct ultrasound visualization during the actual cannulation.
• The advantage of performing the cannulation under long-axis guidance is the ability to visualize the needle tip entering the vessel lumen without having to manipulate the transducer during the procedure.

• In the long axis view, you can see if your needle tip has accidentally punctured through the posterior wall of the target vein. This is especially useful in hypotensive patients.

• Most experts recommend cannulating veins under long-axis guidance in order to maintain direct visualization of your needle at all times and avoid accidental puncture of adjacent vessels or structures (Image 19).

Image 19: Central venous cannulation in a phantom using the dynamic long-axis approach. Note that you can directly visualize the needle tip puncturing through the proximal wall of vessel.

• Because visualization of the subclavian vein can be limited by the overlying clavicular bone, cannulating via the short-axis or the long-axis approach will largely be patient dependent. Image the vessel in both the long and short axis and determine which view offers you best visualization of the vein and anticipated needle path.

• Obtaining an oblique view of the target vessel during dynamic cannulation enables the user to visualize the needle as it enters the vessel, meanwhile providing the operator with direct visualization of surrounding structures, as well.

• Remember that the subclavian vein can be cannulated with ultrasound guidance by either the supraclavicular approach or infraclavicular approach.

Pearls & Pitfalls in Performing US-Guided Central Venous Access

• Ultrasound guided placement of a central venous catheter requires good hand-eye coordination and a basic understanding of ultrasound principles. The procedure becomes quicker and easier with more practice and experience.

• Ultrasound guidance for central venous cannulation is rapidly becoming the standard of care in clinical practice.
• When scanning the target vein for cannulation, make sure to evaluate for the presence of intraluminal clot. Apply gentle pressure over the target vein with the ultrasound transducer. Because veins are thin-walled vessels, they should collapse easily under pressure. If the walls of the vein do not collapse completely and “wink” at you on the ultrasound screen, an intraluminal clot may be present.

• Although you will be able to visualize most sub-acute, hyperechoic intravascular clots on ultrasound, know that acute clots may possess the same echogenicity as the surrounding blood in the vessel lumen, and are therefore very difficult to see. Always perform a compressibility test over the vessel you are aiming to cannulate.

• Always scan along the entire length of the target vessel. If you see a large valve or vessel stenosis, consider an alternative site for access.

• During the procedure you can use ultrasound guidance to monitor guidewire placement and ensure that it is feeding in the intended direction and not through the posterior wall of the vessel.

• After cannulation of the IJ or subclavian vein, perform a thoracic ultrasound of the ipsilateral lung to ensure that there was no inadvertent pneumothorax caused.

For more bedside ultrasound tips and tricks, check out the ultrasound app SonoSupport.
www.SonoSupport.com