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Ultrasound-Guided Cannulation of the Subclavian Vein

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The following text summarizes information provided in the video.

OVERVIEW

Evidence suggests that elective, real-time, ultrasound-guided cannulation of the subclavian vein may be more effective than the landmark-guided technique when performed by an experienced operator.[1-3] As compared with the landmark-guided technique, the use of ultrasound guidance for subclavian vein cannulation may reduce the rate of mechanical complications, decrease insertion time, and improve the overall success rate of the procedure.[1,3]

INDICATIONS

Indications for central venous cannulation include the need to administer intravenous fluids, therapeutic agents, or nutrition; monitor central venous pressure or other hemodynamic indexes; insert a pulmonary-artery catheter or cardiac pacing leads; perform hemodialysis; and manage any other situation requiring direct access to the central circulation. There is no consensus regarding one preferred site for central venous cannulation; it is important to consider the risks and benefits of each site before making a selection. Specific indications for subclavian venous cannulation include infections and pathologic conditions affecting alternative sites or distortion of landmarks of alternative sites. The subclavian site is often preferred for placement of cardiac pacing leads and subcutaneous ports and for maximization of patient comfort when an indwelling catheter is needed. Although there are no definitive data regarding the advantages of the subclavian site, specific advantages as compared with other sites may include reduced risks of infection and thrombosis.[4-7]

CONTRAINDICATIONS

Specific contraindications to cannulation of the subclavian vein include infection of the area overlying the target vein, fracture or suspected fracture of the clavicle or proximal ribs, and thrombosis of the target vein. Coagulopathy is not an absolute contraindication, but it may preclude use of the subclavian vein because of the difficulty in applying direct pressure to the artery and vein as they pass beneath the clavicle. Cannulation of the subclavian vein should also be avoided in patients with moderate-to-end-stage chronic kidney disease because the increased risk of subclavian venous stenosis associated with this technique may compromise future venous access for dialysis. The procedure should also be avoided in patients with severe hypoxemia or apical bullous lung disease owing to the risk of a pneumothorax, which may lead to further respiratory compromise.

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EQUIPMENT

The equipment required to perform cannulation of the subclavian vein includes a sterile gown and gloves, a surgical cap, a mask, and a face shield. Commercially prepared kits are generally available. These kits contain a catheter that is the appropriate length and number of lumens, a compatible skin dilator, and a guidewire. A kit should also include an antiseptic agent, sterile towels or drapes large enough to cover the entire body, 1 or 2% lidocaine, sterile gauze pads measuring 4 by 4 inches, non–Luer-Lok or slip-tip syringes (which are easy to remove from the needle), a scalpel with a number 11 blade, saline flushing solution, a needle, suture material, and a needle driver.

Ultrasound machines with linear-array, high-resolution vascular transducers are preferred for cannulation of the subclavian vein. Sterile transduction gel, an acoustically transparent sterile transducer sheath, and sterile rubber bands or clips to secure the sheath around the transducer are also needed.

PREPARATION

Explain the procedure to the patient and obtain written informed consent, in accordance with institutional policy. Potential complications — such as infection, bleeding, hemothorax, and pneumothorax — should be discussed.

Before starting the procedure, perform an ultrasound survey to evaluate the anatomy of the chest wall and to assess the location and patency of the subclavian vein. Place the probe inferior and perpendicular to the clavicle at a point that correlates with the lateral third of the clavicle (Fig. 1). Probes typically have a marker on one side that corresponds with a dot or marker on one side of the ultrasound screen. Align these markers to ensure that the image appearing on the ultrasound screen is oriented correctly. The probe marker should be directed cephalad.

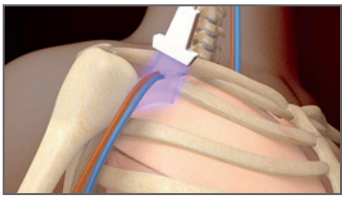

Figure 1. Position and Orientation of the Ultrasound Probe.

Identify the clavicle by moving the probe slightly cephalad, so that a portion of the probe overlies the clavicle, which should appear as a bright echogenic line at the left of the screen. A moderate amount of medial and lateral tilt may be helpful to optimize the view of the vascular targets. You should be able to see a short-axis image of the subclavian vein and the subclavian artery. The clavicle is typically seen when the footprint of the ultrasound probe, which is the portion that makes contact with the skin, overlaps it slightly. If the footprint of the probe is fully inferior to the clavicle, you may visualize the subclavian vein, the subclavian artery, and the pleura but not the clavicle.

The subclavian vein usually appears toward the right of the screen and at a greater depth than the clavicle. The subclavian artery is typically visualized between the clavicle and the subclavian vein. The subclavian vein is typically larger than the artery, more compressible, and nonpulsating. The pleura appears as a thin, echogenic, linear structure below both the subclavian vein and subclavian artery.

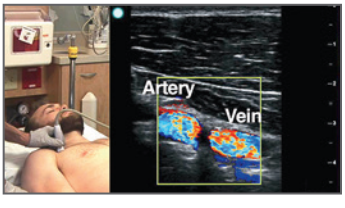

Figure 2. Color-Flow Doppler Ultrasound Imaging.

Make sure that the subclavian vein is patent by gently compressing it with the transducer; slight pressure should be sufficient to collapse the lumen. Note that the subclavian artery is pulsatile. The use of color-flow Doppler imaging can help to identify and confirm the location of the vessel and to determine patency (Fig. 2).

Appropriate monitoring must be in place, including electrocardiography, blood-pressure monitoring, pulse oximetry, and possibly end-tidal carbon dioxide monitoring. Equipment for providing advanced cardiovascular life support must be readily available.

To decrease the risk of air embolism and engorgement of the vein, adjust the patient's bed so that the patient is in a 10-to-15-degree Trendelenburg position.

Consider placing a small roll between the scapulae to help make the clavicles more prominent. Position the ipsilateral arm against the body.

Follow standard sterile precautions when placing a central venous catheter. Remove jewelry, wash your hands, and don a sterile gown, gloves, surgical cap, mask, and face shield.

Prepare the central venous catheter for insertion by flushing each lumen with saline or heparinized saline. Remove the cap from the port through which the guidewire will be threaded; this lumen is often the longest.

Sterilize the skin with an antiseptic agent and cover the area with a sterile fenestrated drape. Be sure to include all landmarks in the sterile field.

To prepare the ultrasound probe, have an assistant dispense enough acoustic gel to cover the transducer surface. Then have the assistant carefully feed the probe into a sterile transducer sheath while extending the sheath away from you, over the length of the probe cable. Eliminate any wrinkles or air bubbles that appear between the transducer and the sheath to ensure secure acoustic coupling. Secure the sheath around the transducer using sterile rubber bands or plastic clips. Apply a small amount of sterile ultrasound gel to the covered ultrasound probe or to the patient's skin. Because the sterile ultrasound probe is used intermittently throughout the procedure, you should identify a convenient sterile area on which the probe can be placed when it is not in use.

PLACEMENT OF THE CATHETER

Stand at the patient's side, ipsilateral to the target vein. To identify landmarks with ultrasonography, place the probe just proximal to the insertion site. Ensure that the image that appears on the ultrasound screen is oriented correctly by aligning the probe marker with the marker on the screen.

Place the transducer perpendicular to the clavicle, just inferior to the midportion of the clavicle, with the orientation marker directed cephalad. A transverse, or short-axis, image of the clavicle, subclavian vein, and subclavian artery should be visualized on the ultrasound screen. The vein and artery can be distinguished either by assessing their compressibility or by using color-flow Doppler imaging to reveal pulsatility or nonpulsatility. The transducer should be slowly moved 1 to 2 cm toward the shoulder to obtain the best view of the subclavian vein. It is important to note that the lung lies inferior and posterior to the vessel; the pleura can be recognized as an echogenic linear structure below the subclavian vein.

Position the transducer so that the subclavian vein is near the center of the ultrasound image. Gently palpate the skin to confirm that the intended puncture site is aligned with the center of the ultrasound transducer. The approximate depth of the subclavian vein and pleura can be determined by using the depth marker located on the side of the ultrasound screen. Unless the patient is under general anesthesia or deeply sedated, use a 25-gauge needle to infiltrate the skin with a local anesthetic, such as 1 or 2% lidocaine.

Align the introducer needle with the center of the transducer. Approach the site at an angle of 30 to 45 degrees, with the long axis of the needle directed toward the sternal notch. Puncture the skin with the introducer needle at the center of the transducer, being careful not to damage the sterile sheath. When the needle passes underneath the transducer, the needle tip and the tenting of soft tissue can be viewed on the ultrasound screen. As soon as the tip of the needle appears as a dot on the screen, be sure to keep the needle tip under direct ultrasound visualization. The location of the needle tip may also be visualized by tilting the transducer back and forth or by withdrawing the needle and realigning it. If the needle contacts the clavicle, withdraw the needle and use a slightly deeper trajectory. As

you advance the needle toward the vein, maintain negative pressure in the syringe until the vein is punctured (Fig. 3).

To minimize the risk of a pneumothorax, always bear in mind the approximate depth of the subclavian vein and the extent to which the needle has been advanced. Check continuously for the aspiration of blood into the syringe. If blood is not aspirated as the needle is advanced, slowly withdraw the needle while maintaining negative pressure. Venous puncture may become evident as you withdraw the needle. As soon as blood is freely aspirated, set the transducer down, securely stabilize the needle, and disconnect the syringe. Confirm that the blood flow is nonpulsatile. Bright red, pulsatile blood suggests arterial puncture. However, dark, nonpulsatile blood does not rule out arterial puncture. A commercially available pressure-monitoring device or blood-gas analysis can also be used to confirm venous rather than arterial puncture.

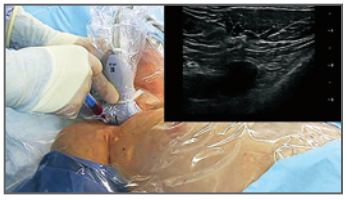

Figure 3. Trajectory of the Introducer Needle.

Introduce a flexible guidewire through the needle and into the vein to a depth of 15 to 20 cm, depending on the size of the patient. While holding the guidewire in place, remove the needle. Now use ultrasonography to visualize the guidewire in the lumen of the vein on the screen in both the cross-sectional and longitudinal view. If there is any doubt about the location of the wire, confirm its location by advancing a small-gauge catheter over the wire, removing the wire, and connecting the catheter to a manometer or pressure transducer. Once you have ruled out the possibility of arterial cannulation, reinsert the guidewire through the catheter and then remove the catheter while leaving the guidewire in place.

Using a scalpel with a number 11 blade, make a small superficial incision at the entry point of the wire to facilitate passage of the dilator through the skin. Pass the dilator over the guidewire, being certain to maintain control of the wire at all times. Hold the dilator close to its tip and insert it under the skin, making sure that you do not create a kink in the guidewire. Generally, the dilator needs to be inserted only a few centimeters. Remove the dilator and anticipate increased bleeding at the puncture site. Maintain a grasp on the wire. A 4-by-4-inch gauze pad can be applied to the insertion site to minimize blood loss. Once again, only the wire remains in place.

Next, feed the catheter over the guidewire, being certain to maintain control of the external end of the wire before advancing the catheter through the skin. You will probably have to pull the wire out of the skin just slightly, until the external end of the wire extends beyond the catheter hub and can be grasped. While grasping the external end of the wire, advance the catheter over the wire. If you meet resistance, the tract may not have been adequately dilated. If this issue occurs, remove the catheter and reinsert the dilator. Insert the catheter to a depth that places the tip at the junction of the superior vena cava and the right atrium. Remove the guidewire and make sure that blood can be aspirated easily from all ports.

Flush all ports with sterile saline or heparinized saline solution. Place caps on the hubs, and secure the catheter. Apply a sterile dressing before removing the drape, or cover the area with a sterile 4-by-4-inch gauze pad, remove the drape, and then apply the sterile dressing (Fig. 4). Obtain a chest radiograph to ensure that the catheter has been properly placed and that no hemothorax or pneumothorax has occurred. Dispose of all sharps in approved containers.

Figure 4. Catheter in Place with Sterile Dressing.

COMPLICATIONS

Cannulation of the subclavian vein is an invasive procedure that can result in infection, air embolism, or death. Mechanical complications include placement of the catheter in the wrong position, bleeding, arrhythmia, pneumothorax, and hemo-

thorax as well as injury to the subclavian artery, thoracic duct, myocardium, aorta, or surrounding nerves.

Mechanical irritation of the heart by the guidewire is possible and may cause atrial or ventricular dysrhythmias or even a bundle-branch block. If an arrhythmia occurs, withdraw the wire back into the subclavian vein. Arrhythmias are usually transient, but if they are persistent, immediate attention is required.

Arterial injury is also a serious potential complication. If pulsatile or bright red blood flows into the syringe, arterial puncture should be suspected. However, in patients with hypotension, hypoxemia, or both, it may be difficult to differentiate arterial from venous puncture. If arterial puncture occurs before dilatation of the vessel, remove the needle or angiocatheter and apply firm direct pressure to the site for 10 minutes, or until there is no further bleeding. If arterial dilation occurs, do not remove the dilator or large-bore catheter, since their removal could cause hemorrhagic shock or a catastrophic cerebrovascular complication. Consult a surgeon immediately.

Occasionally, air may be aspirated into the syringe. If aspiration occurs, check the syringe to make sure that the needle or catheter and syringe are firmly attached. If you continue to aspirate air despite firm connections, immediately remove the needle or catheter, since the presence of air may indicate that a pneumothorax has occurred. This step is especially important if the patient is having symptoms of increasing respiratory distress. In mechanically ventilated patients, lung injury can rapidly result in tension pneumothorax. Immediately obtain a chest radiograph and insert a chest tube, if indicated. Consult a surgeon or another skilled provider to place the chest tube, if necessary. Do not attempt to place the catheter at the opposite site (i.e., in the contralateral subclavian or internal jugular vein), since this action would introduce the risk of a contralateral pneumothorax and further respiratory compromise.

For persistent bleeding at the catheterization site, apply direct pressure and check the results of coagulation studies. Administer blood products as needed. If bleeding continues, there may be an arterial or venous tear that requires surgical exploration. Again, in any of these circumstances, do not attempt to place the catheter at the opposite site.

No potential conflict of interest relevant to this article was reported.
Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

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