

Supraclavicular approach of central venous catheter insertion in critical patients in emergency settings: Re-visited

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Abstract

The supraclavicular approach was first put into clinical practice in 1965 by Yoffa and is an underused method for gaining central access. It offers several advantages over the conventional infraclavicular approach to the subclavian vein. At the insertion site, the subclavian vein is closer to the skin, and the right-sided approach offers a straighter path into the subclavian vein. Also, this site is often more accessible during CPR and surgical procedures. In patients who are obese, this anatomic area is less distorted and in patient with congestive heart failure and cervical spine instability repositioning is not required.

Keywords: Central venous catheter cannulation, complications, emergency, supraclavicular method

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Introduction

The quick and safe access to the central venous circulation is an important intervention in critically ill patients for a variety of purposes, including volume resuscitation, central venous pressure monitoring, frequent blood sampling, transvenous cardiac pacing, hemodialysis access, and hypertonic or inotropic continuous infusion. Central lines are typically introduced into the internal jugular, subclavian, femoral veins or peripherally via basilic vein. The proper choice of insertion site is essential for success. Various methods of placement have evolved, each with its own advantages and potential complications with varying success rates.^[1]

Percutaneous catheterization of the subclavian vein via infraclavicular approach has been widely used. Unfortunately, this approach is associated with a few

well-known complications like subclavian arterial puncture, pneumo- and hemothorax, which may be due to vague anatomical landmarks such as controversial skin entry points and ambiguous targets located far from the insertion site. Sometimes, these complications are life-threatening.

Since Aubaniac's original description in 1952,^[2] subclavian vein catheterization via the infraclavicular approach has become a well-established technique. In 1965, an alternate supraclavicular approach was described by Yoffa.^[3] This supraclavicular route to the subclavian vein has some distinct advantages over the infraclavicular approach; however, it is less often taught and utilized for reasons that are not clear. Secondly, there may be a fear of directly entering into the pleural cavity and damage to vital structures, and there may be initial difficulty in identifying the landmarks, the angle, and proper direction of the needle, resulting in failures.

Why to Prefer Supraclavicular Approach over Conventional Technique

Reasons to prefer supraclavicular approach over the infraclavicular technique include: A well-defined insertion landmark (the clavisternomastoid angle); a shorter distance from skin to vein; a larger target area;

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a straighter path to the superior vena cava; less proximity to the lung; and fewer complications of pleural or arterial puncture.^[3,4-7] In addition, the supraclavicular approach less often necessitates interruption of CPR than the infraclavicular method.^[8,9]

Indications

- Volume resuscitation
- Emergent venous access
- Nutritional support
- Administration of caustic medications (e.g., vasopressors)
- Central venous pressure monitoring
- Transvenous pacing wire introduction
- Hemodialysis
- Pulmonary artery catheterization.

Contraindications

Absolute

- Trauma to ipsilateral clavicle, neck, or subclavian vessels
- Coagulopathy (Direct pressure to stop bleeding cannot be applied to the subclavian vein or artery due to their location beneath the clavicle.

Relative

- Chest wall or neck deformity
- Chronic obstructive pulmonary disease.

Anesthesia

- Local anesthesia using 1% lidocaine is required but not in patients under general anesthesia or sedoanalgesia.

Positioning

- The patient should be preferably in the trendelenberg or supine position but can be in the sitting or fowlers position in case of congestive heart failure. Head and

neck need not to be rotated towards opposite side as with infraclavicular or internal/external jugular approaches of accessing central vein, so beneficial in patients with cervical and atlanto-axial instability

- If possible, the bed should be raised to a comfortable height for the operator, so bending over is unnecessary.
- Needle insertion site options include the following: [Figures 1 and 2]
- One centimeter lateral to the lateral border of the clavicular head of the sternocleidomastoid muscle and one centimeter superior to the clavicle (The needle approach should bisect the angle of the muscle border and the clavicle)
- One centimeter medial and one centimeter superior to the midpoint of the clavicle (direct the introducer needle to the ipsilateral sternoclavicular joint)^[10]
- Just posterior to the clavicle at the middle/medial third junction of the clavicle (Direct the needle toward the ipsilateral sternoclavicular joint with the needle oriented parallel to the coronal plane)^[11]
- Options for directing the needle include the following:
 - The contralateral nipple may be used as a target for directing the introducer needle
 - A point just superior and posterior to the sternal notch may be used as a target for directing the introducer needle.

Technique

- Position the bevel of the introducer needle in line with the numbers on the syringe. Upon insertion, orient the bevel to open caudally so as to facilitate the caudal progression of the guide wire down the vein toward the right atrium
- While continuing to aspirate with the syringe, insert the introducer needle along the 45° bisection of the approximately 90° angle formed by the superior aspect of the clavicle and the lateral border of

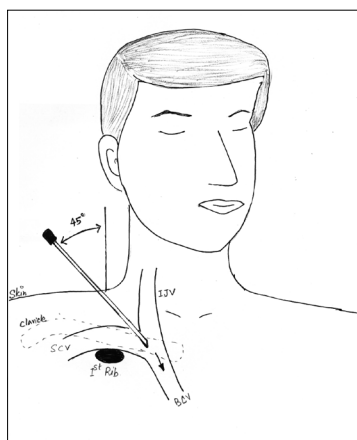


Figure 1: Yoffa's approach of supraclavicular CVC insertion

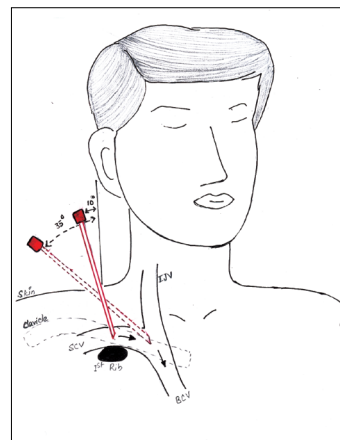


Figure 2: Newer approach of supraclavicular CVC cannulation

the sternocleidomastoid muscle. The needle should be virtually parallel to the chest wall in the coronal plane

- If the vein is difficult to locate, remove the introducer needle, flush it clean of clots, and try again. Change insertion sites after 3 unsuccessful passes with the introducer needle
- Verify line placement with a chest radiograph, either at the time of intervention or just after the procedure. The catheter should end in the vena cava at the manubriosternal angle, not in the right atrium
- Apply a clean dressing. Antibiotic ointments or creams at insertion sites are contraindicated, except for dialysis catheters, because of their potential to promote fungal infections and anti-microbial resistance. Transparent dressings are desirable but not mandatory.

Clinical pearls

- The key to a successful line placement is meticulous preparation and setup before starting or donning sterile garb. This includes consideration of what equipment may be needed if complications arise
- Use the same preparation technique every time this procedure is performed
- Prepare a sterile field from the jaw to several finger breadths below the clavicle
- The amount of lidocaine provided in most kits is often inadequate. The authors recommend supplementing the kit with a 10-mL syringe and a bottle of 1% lidocaine without epinephrine
- In the technique, first described by Yoffa in 1965, the needle is directed at an angle of 45° from the sagittal plane and 15° anterior from the coronal plane. Newer literature using 3-dimensional CT have shown higher success rates by placing the needle at the clavisternomastoid angle and directing the needle 10° from the sagittal plane and 35° posteriorly from the coronal plane. This change allows for the shortest distance to the target vessel and for the first rib to act as a physical barrier to reduce the risk of pneumothorax^[12]
- If the wire does not pass easily through the needle down the vein, remove the wire, re-attach the syringe, and confirm that the needle is still in the lumen of the vein before re-attempting the procedure
- Beware a return of red or pulsatile blood. If this occurs, the wire is in an artery
- Beware aspirating air bubbles through the probing introducer needle. This indicates a pneumothorax
- Anesthetize the suture site as well as the insertion site
- Some clinicians find it useful to remove the contents of the line kit and lay them out in the order and configuration that they will be used
- Never place equipment on a patient
- Antibiotic ointments are contraindicated, except

in long-term hemodialysis access. Transparent dressings are not necessary

- Replace dressings used on short-term CVC sites at least every 2 days for gauze dressings and every 7 days for transparent dressings.

Complications

Complication rates for the various approaches are shown in the [Tables 1 and 2] below.

Complication and Success Rates of Different Approaches^[15] [Table 1].

Complication Rates of Central Venous Catheterization^[7,10,13-15] [Table 2].

- *Local site or systemic infection:* Multiple studies have shown lower infection rates with the use of maximal sterile-barrier precautions, including mask, cap, sterile gown, sterile gloves, and large sterile drape. This approach has been shown to reduce the rate of catheter-related bloodstream infections^[6]
- *Arterial puncture:* As in other central venous catheter approaches, lacerating the subclavian artery is theoretically possible. Also, the subclavian vein cannot be compressed; therefore, this approach should be avoided in patients who are anti-coagulated
- *Hematoma:* A hematoma usually requires monitoring only
- *Hemothorax:* Check the chest radiograph for evidence of a hemothorax. If evidence is found, consult a surgeon immediately and consider tube thoracostomy
- *Pneumothorax:* Check a chest radiograph when finished or before switching to the contralateral side after failed insertion on one side
- *Catheter-related thrombosis:* This complication might lead to pulmonary embolism.

Table 1: Complication and success rates of different approaches^[13]

	CS, %	SCA, %	ICA, %	IJA, %
Overall complication rate	1.7 (0.6-3.6)	0.56-2	1-10	1-5
Insertion success rate	92 (88.7-94.6)	74-98	80-95	90-99

CS: Czarnik et al. study; ICA: Infraclavicular approach; IJA: Internal jugular approach; SCA: Supraclavicular approach

Table 2: Complication rates of central venous catheterization^[6,9,13-15]

Complications	Internal jugular	Subclavian	Femoral	Supraclavicular
Arterial puncture	6.3-9.1	3.1-4.9	9.0-15.0	0.8-3.36
Hematoma	<0.1-2.2	1.2-2.1	3.8-4.4	N/A
Hemothorax	N/A	0.1-0.6	N/A	N/A
Pneumothorax	<0.1-0.2	1.5-3.1	N/A	0.48-0.56
Thrombosis	7.6	1.9	21.5	N/A

- *Air embolism*: An air embolism is caused by negative intrathoracic pressure, with inspiration drawing air into an open line hub. Be sure the line hubs are always occluded, and note that placing the patient in the Trendelenburg position lowers this risk. If air embolism occurs, the patient should be placed in the Trendelenburg position with a left lateral decubitus tilt, which may prevent the movement of air into the right ventricle and onward. One hundred percent oxygen should be administered to speed the resumption of air. If a catheter is located in the heart, aspiration of air should be attempted
- *Dysrhythmias*: Dysrhythmia is due to cardiac irritation by the wire or catheter tip. Placing a central venous catheter without a cardiac monitor is unwise.
- *Atrial wall puncture*: This complication leads to pericardial tamponade
- *Lost guide wire*: If the clinician is not conscientious about maintaining control of the guide wire, it may be lost into the vein and require retrieval by interventional radiology
- *Anaphylaxis*: Patients who are allergic to antibiotics may experience anaphylaxis upon insertion of an antibiotic-impregnated catheter
- *Catheter tip too deep*: Check for this complication on the post-procedure chest radiograph, and pull the line back if the tip disappears into the cardiac silhouette
- *Catheter in the wrong vessel*: When the subclavian catheter is not in the correct position, it usually deviates cranially up the internal jugular instead of down the subclavian vein. This complication is rare with the supraclavicular approach
- *Chylothorax*: This complication is possible on the left side.

Approaches

Yoffa's approach (Traditional)^[3]

The objective of the supraclavicular technique is to puncture the subclavian vein in its superior aspect just as it joins the internal jugular vein. The key to success, according to Yoffa, is correct identification of the clavisternomastoid angle formed by the junction of the lateral head of the sternocleidomastoid muscle and the clavicle. Active raising of the patient's head may make this landmark more apparent. The needle is inserted 1 cm lateral to the lateral head of the sternocleidomastoid muscle and 1 cm posterior to the clavicle and directed at a 45-degree angle to the sagittal and transverse planes and 15 degrees below the coronal plane aiming toward the contralateral nipple.^[7] The needle bisects the clavisternomastoid angle as it is advanced in an avascular plane, away from the subclavian artery and the dome of the pleura, entering the junction of the subclavian and internal jugular veins^[3,6,16] [Figures 1].

The right side is preferred because of the lower pleural dome, more direct route to the superior vena cava, and absence of thoracic duct. The Trendelenburg position is recommended to decrease risk of air embolus and to potentially help distend the vein as the subclavian vein is not bound by fascia on its superior aspect.^[4] To further minimize complications, the needle bevel should be facing down prior to insertion, attempts should cease after 2-3 unsuccessful tries, and most importantly, the clavisternomastoid angle must be clearly identified prior to insertion.^[11]

Newer modifications of the insertion technique

Modified supraclavicular approach

Garcia *et al.*,^[17] evaluated 83 attempts at subclavian vein catheterization using a modified supraclavicular approach. This modification used the same landmarks as Yoffa;^[3] however, the needle was directed at a 5-degree angle from the coronal plane, 50 degrees from the sagittal plane and 40 degrees from the transverse plane. This adaptation was based on a cadaver study, in which authors noted that a wider "sling" target formed by the confluence of the internal jugular and subclavian veins could be easily cannulated with a more superficial needle trajectory than the original approach.

Haapaniemi and Slatis,^[18] in 1974, introduced an alternative technique with a puncture site 2-3 cm above the clavicle near the posterior border of the sternocleidomastoid muscle. The needle was then advanced caudad at an angle of 35 degrees towards the sagittal plane and slightly upwards from the coronal plane between the sternocleidomastoid and anterior scalene muscles. The site of venipuncture was the confluence of the subclavian and internal jugular veins.

Muhm *et al.*,^[6] in 1977, studied an adaptation of Yoffa's approach in 175 patients requiring hemodialysis access. With this method, the needle was introduced at the lateral margin of the clavicular insertion of the sternocleidomastoid muscle and was then directed toward the sternal end of the right-sided second intercostal space 20 degrees cephalad to the transverse plane and 20 degrees anterior to the coronal plane.

Junctional/Central approach

Conroy *et al.*,^[10] defined a newer approach of supraclavicular catheterization as: Palpating the midpoint of the clavicle from sternoclavicular junction to the acromion process, we entered the skin 1 cm medially and superiorly to this midpoint. With gentle aspiration, the needle is directed towards the sternoclavicular joint 20-degree from the horizontal and 20-degree from the

coronal plane of the body. By lowering the angles of the approach, they probably enter the vein more medially, at the junction of IJV and SCV.

MacDonnell *et al.*,^[11] in 1992, evaluated another modification of the supraclavicular technique in 35 human cadavers. The new landmark for needle insertion was the junction of the middle and medial thirds of the clavicle. The needle entered the skin at this point just posterior to the clavicle and was advanced parallel to the coronal plane toward the ipsilateral sternoclavicular joint.

Pocket approach

Gorchynski *et al.*,^[9] in 2004, evaluated another variation of the supraclavicular technique. Landmarks are located between the sternal and clavicular heads of the SCM. The needle entrance site is located at the midpoint between the sternoclavicular joint and the insertion of the clavicular head of the SCM. This site is located at the inferior border of the triangle formed by the sternal head of the SCM, the clavicular head of the SCM, and the clavicle. Of note, this is also the same triangular region used to access the internal jugular (IJ) vein. However, while the IJ is cannulated at the apex of the triangle, needle insertion for the pocket approach occurs at a more inferior position. Following insertion, the needle is advanced toward the ipsilateral nipple at an angle of 45 degrees to a depth of 1-1.5 cm in a caudal direction.

This modified approach has all of the benefits of traditional supraclavicular line placement as well as one additional benefit: It eliminates the necessity of moving the patient's head from neutral position.

CT-guided approach^[12]

Newer literature using 3-dimensional CT have shown higher success rates by placing the needle at the clavisternomastoid angle and directing the needle 10° from the sagittal plan and 35° posterior from the coronal plane. This change allows for the shortest distance to the target vessel and for the first rib to act as a physical barrier to reduce the risk of pneumothorax.

Discussion

Nevarre *et al.*, published a review of the literature and his own series of 178 supraclavicular line placements. He reported 1 pneumothorax, 1 malposition, and 2 instances of inability to thread the wire. The overall complication rate was 0.56%. This site is likely among the safest approaches for central venous access (but note that an experienced surgeon performed the procedures reported by Nevarre).^[16]

A study by Muhm *et al.*, of 208 supraclavicular lines in 168 hemodialysis patients focused on large bore catheters such as may be needed for hemodialysis or resuscitation of patients with trauma or sepsis. Complications included 1 pneumothorax, 7 arterial punctures, and 2 thoracic duct punctures without sequelae. Catheter malpositions occurred only sporadically (1%). Thus, even with large bore catheters, the supraclavicular approach may be a preferable route of placement.^[7]

Czarnik *et al.*, published a study demonstrating a high overall success rate (92%) of the supraclavicular approach in 370 patients. Most of the patients (78.4%) were mechanically ventilated during the procedure, and the overall complication rate was 1.7%, including 3 subclavian artery punctures and 3 contralateral subclavian vein catheterizations. No life-threatening complications occurred. The authors noted this approach to be another viable site for venous access, even in those being mechanically ventilated.^[9]

These studies are encouraging, especially considering that a large percentage of the studied patients represented a situation in which the line placement was complicated or difficult. However, the number of patients included is still small, and the operators were experienced with this technique.

While ultrasonographic guidance has proved to be a useful adjunct for internal jugular cannulation, its use for subclavian routes has been infrequently studied. Given the anatomy of the supraclavicular approach, there is little room to effectively position the transducer while manipulating the needle. Using an ultrasound transducer to locate and superficially mark the vessel prior to needle insertion remains an option.^[19] Real-time ultrasound guidance with the supraclavicular approach is technically difficult because little room is available to position the transducer while inserting the needle. Because of the short distance from the skin to the subclavian vein in supraclavicular approach, it seems that two-dimensional ultrasound guidance technique should not be the routine in clinical practice but rather alternative method in difficult cases.

Identification of landmarks was critical to the success of supraclavicular approach. At the author's institution, 40 critically ill patients with or without ventilator support in surgical and neurosurgical ICU were percutaneously catheterized via supraclavicular approach by placing the needle at the clavisternomastoid angle and directing the needle 10° from the sagittal plane and 30-35° posteriorly from the coronal plane.^[12] We found that supraclavicular approach was easier

in thin medium-build patients, as compared to obese patients with short necks. Further, difficulty was faced in unconscious patients who could not lift their head for identification of clavicolosternomastoid angle. In such cases, manual palpation of the angle was used, which usually led to success. We didn't report any incidence of malposition, pneumo- or hemothorax, and carotid artery puncture. However, failure to cannulate via this approach was seen in 4 patients. Malposition of CVC via this approach is rarely seen as it follows the direct straight course of subclavian vein into superior vena cava.

The supraclavicular approach should be considered, especially in neuroanesthesia, where the right jugular approach could be associated with cerebral perfusion pressure reduction, intracranial pressure elevation, and venous stasis.^[20] The supraclavicular approach seems to be more comfortable than the jugular approach in a conscious patient. This method can be used successfully and relatively safely as a primary or alternative technique when other catheterization sites are not available. It can augment the spectrum of catheterization possibilities, even in mechanically ventilated patients.^[13] It is also an easy cannulation technique for the inexperienced physician and a useful alternative to traditional approaches for the experienced physician.^[8]

The literature demonstrates the effectiveness of the supraclavicular approach using Yoffa's original technique as well as those using modifications to landmarks, angles, and patient position. No central venous access is without potential complications, and no one technique is ideal for every patient. Large scale, multicenter studies may help in better comparison between the two techniques.

Conclusion

While ultrasound is an enormous advance in the placement of central lines, it is not always available. For this reason alone landmark-based central line access will remain a skill physicians need to have in their armamentarium. The supraclavicular approach appears to be at least as safe as other approaches with greater ease of performance and less chances of misplacement.

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