Subclavian Vein Catheterization

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The subclavian approach to central venous cannulation provides rapid access for fluid and blood administration, hemodynamic monitoring, pacemaker insertion, and placement of catheters for parenteral nutrition. This approach is also useful when peripheral intravenous sites are not available due to extensive burns or trauma, or simply are not present because of obesity or vein depletion from prior use. Cannulation of the subclavian vein is possible by either a supraclavicular or infraclavicular procedure, with the latter more routinely performed by most surgeons.

History

During World War II, French military surgeon Robert Albaniac used his previous investigation of subclavian vein anatomy to devise the procedure of infraclavicular subclavian venipuncture for resuscitation of battle casualties. His technique used a large-bore needle which, once inserted, was left in place for venous access. Later applications of radiologic techniques using catheters threaded through an introducer needle made the procedure more clinically useful. In 1962, Wilson described shifting the approach of central venous cannulation from femoral and then antecubital cutdowns to subclavian venipuncture using a "through-the-needle" catheter. His report of more than 250 subclavian catheterizations without complications helped popularize this technique, as did the development of suitable commercially available catheter sets. In 1968, Dudrick described the adaptation of subclavian cannulation for administering hyperalimentation solutions when he reported the successful use of long-term parenteral alimentation. Ultimately, adoption of the Seldinger exchangeable guidewire technique led to the broad application of this approach to central venous access.
To safely perform this procedure, appreciation of the anatomy of the region is essential (Fig. 1). As the axillary vein passes over the lateral margin of the first rib, it becomes the subclavian vein. The subclavian vein resides within the costoclavicular-scalene triangle formed by the first rib inferiorly, the clavicle anteriorly, and the anterior scalene muscle posteriorly. The subclavian vein is covered by the medial aspect of the clavicle and is joined by the internal jugular vein near the medial border of the anterior scalene to form the brachiocephalic (innominate) vein. This descends behind the sternoclavicular joint and joins the opposite brachiocephalic vein to form the superior vena cava (SVC), which has the largest diameter of any vein in the body.\textsuperscript{5,6,7}
The axillary-subclavian vein junction lies behind the medial third of the clavicle (Figs. 2 and 3). The subclavian vein is anterior and inferior to the subclavian artery, from which it is separated by the 10- to 15-mm thickness of the anterior scalene muscle. The parietal pleura, however, is only 5 mm posterior to the vein, which explains the clinical risk of pneumothorax. Moving laterally, the artery and vein are adjacent, and the risk of inadvertent arterial puncture increases. Medial to the attachment of the anterior scalene muscle to the first rib, the phrenic nerve, internal thoracic artery, and apical pleura are in contact with the subclavian vein and jugulo-subclavian junction posteriorly and inferiorly. The thoracic duct on the left and the smaller right lymphatic duct cross the anterior scalene to enter the subclavian vein superiorly near the junction with the internal jugular vein. The risk of lymphatic duct injury with fistula or chylothorax is greater with left-sided and supraclavicular approaches.
Both the supraclavicular and infraclavicular approaches to the vein are based on these anatomic relationships (Fig 4). In the supraclavicular procedure, the subclavian vein is approached from above and behind the clavicle, anterior to the first rib at the level of the anterior scalene muscle, ideally passing anterior to the artery and away from the pleura, which should be protected by the first rib. The infraclavicular approach utilizes the space between the clavicle and first rib as the vein crosses over the rib. The vein is approached from beneath the clavicle, with the venipuncture directed anterior and superior to the artery and pleura.
The patient is placed supine with the arms relaxed at the sides. Some surgeons prefer to place a roll between the scapula to possibly widen the space between the clavicle and first rib, as well as to let the shoulders drop back, allowing the proper angle of approach with the needle. In the very obese patient, this helps expose the infraclavicular region. The Trendelenburg position may improve venous filling, particularly if the patient is hypovolemic, but will not necessarily offer any advantage in the well-hydrated patient. The junction of the middle and medial thirds of the clavicle generally corresponds to the subclavian vein crossing the first rib, with the approximate point of venipuncture 1 cm below that location. The suprasternal notch marks the other important landmark, with the desired path of the venipuncture following a roughly horizontal line between these two points. It may be helpful to palpate the subclavian artery at this time to ensure that the proposed tract lies medial to that structure. This is particularly true in very thin patients and children.
SURGICAL TECHNIQUE

6 Local anesthetic is infiltrated. Many surgeons will try to "find" the vein at this point with a 25-gauge or larger 23-gauge needle. The larger venipuncture needle is now inserted, with an attempt made to pass it in a roughly horizontal plane from the entry landmark to the sternal notch or sternoclavicular junction. The needle must pass through the pectoralis major and subclavius muscles, under the clavicle, and over the first rib before entering the subclavian vein. Slight negative pressure is held on the syringe to demonstrate blood return on entering the vein. If no blood returns on passing the needle, then the needle is withdrawn slowly with negative pressure, because the needle may have compressed the vein and gone through both walls and may "back out" into the lumen.
Enter the vein will usually produce a rapid blood return, although the return may be very slight if the patient is hypovolemic. When disconnecting the syringe, the needle should be occluded quickly to prevent air entry.
A flexible J-wire is carefully passed through the venipuncture needle. The wire is advanced gently while feeling for any resistance. If the patient is not on a monitor, then a nurse should palpate the pulse and report premature ventricular contractions or cardiac rhythm changes, which may occur from the guidewire stimulating the atrium or ventricle, obviously indicating the need to withdraw to the point at which they cease. As the guidewire is advanced, the patient is asked whether he or she feels any discomfort in the neck or ear—a sure sign that the guidewire has passed upward into the internal jugular vein.
10 and 11 If the guidewire has passed satisfactorily, then the needle is removed and a small incision is made with an 11 blade scalpel. A vein dilator is passed over the guidewire. Some of these are fairly long and should not be passed more than 10 cm to reduce the risk of the dilator projecting beyond the end of the J-wire, possibly causing vascular perforation. The objective of using the dilator is to make the tract from skin to vein (a distance of 4-6 cm) accessible for the catheter or sheath. Extending the dilator beyond this point is irrelevant to the procedure and dangerous to the patient.
An important observation can be made on withdrawing the vein dilator over the guidewire. The dilator will conform to the path taken by the wire, showing a downward curve if the guidewire advanced properly toward the SVC but an unmistakable upward bend if the guidewire lies superiorly in the jugular vein. Frequently this can be corrected by passing an 18-gauge angiocatheter over the guidewire into the vein and then carefully repositioning the guidewire, often feeling when it takes the proper path without initial resistance. Rechecking with the vein dilator will show whether it is now positioned correctly.
Once the guidewire is established, the desired catheter can be placed, with care taken to slide the catheter over the wire and to not inadvertently force the wire ahead. In general, a catheter advanced 15 cm from the right and 20 cm from the left will lie at the desired position at the junction of the SVC and right atrium. Most fixed-length devices, such as dialysis catheters, are provided in these lengths.

The catheter is usually sutured in place. For catheters with a slip collar provided for suturing, it is often wise to secure the catheter hub as well. Otherwise, unexpected traction on the catheter, can cause these to “fall out”. 
The catheter is covered with an occlusive dressing, which also helps keep it from dislodging. If a multilumen catheter is placed, a lumen is marked for exclusive use for total parenteral nutrition (TPN). Ideally, a central line team maintains all catheters used for TPN with protocols for dressings and tubing changes. We currently use a needleless adapter system that eliminates breaks in sterility. A sticker on the patient's chart identifies the dates when catheters are placed and changed; this is particularly useful when studying infection and other complication rates. Fifteen years ago, our infection control committee recommended that central vein catheterizations be treated as an operative procedure. Together with the Argon Company (now Maxxim Medical, Athens, TX), we developed a central line insertion tray that includes all necessary supplies: gown, mask, adequate drapes, all needles, syringes, guidewire, local anesthetics, and so on. The nurse does not have to search for supplies, and only the desired catheter or introducer must be opened. This saves time, encourages sterile technique, and is cost-effective, as there is a considerable mark-up for catheters and introducers packaged in their own insertion "kits."
Complications

Early complications, often related to operator error and insertion difficulties, include pneumothorax, hemothorax, and hydrothorax, hydromediastinum, air emboli, tracheal, esophageal, and vascular laceration, retained catheter fragments, retained guidewires, and cardiac perforation. Late complications include venous thrombosis, thrombophlebitis, venous stenosis, and catheter-related bacteremia and sepsis. Noninfectious complications are related to individual operator experience, with a learning curve showing sharply reduced complications after 50 procedures. Noninfectious complications are related to individual operator experience, with a learning curve showing sharply reduced complications after 50 procedures.11

The venipuncture needle should always be advanced near the horizontal plane, as previously described. The more posterior the path, the greater the potential for pneumothorax, arterial injury, and brachial plexus injury. Changing the direction of the needle after it has been deeply advanced increases the risk of lacerating the vein or artery.6

Air must never be allowed to enter an open needle or catheter because of the risk of air embolization. I have seen this occur, and a large volume of air can be sucked in rapidly. In addition to quickly covering the needle hub, placing the patient in Trendelenburg position and having the patient exhale or perform Valsalva’s maneuver also lessens this risk.

If catheterization fails, one should be very cautious in proceeding to the opposite side before obtaining a chest x-ray. A bilateral pneumothorax can be life-threatening. A chest x-ray should always be performed after completing the procedure to rule out pneumothorax or other complications and to verify catheter location. Nursing staff is instructed to refrain from using a new catheter until a satisfactory x-ray is documented. Even if the initial x-ray is clear, one should not hesitate to repeat the study if the patient's condition changes. A pneumothorax or other serious complication may not be evident on the immediate postprocedure film and may still subsequently evolve.

Bleeding may be related to arterial puncture or coagulopathy. Ideally, coagulation studies should be normal or corrected before this procedure; however, in situations where this is not possible (e.g., liver disease and hemophilia), successful subclavian catheterization has been reported.12,13

Because “through-the-needle” catheters are no longer routinely used, the risk of sheared-off catheter fragments is largely eliminated. However, we have seen several instances of Silastic catheter disruption requiring angiographic retrieval. In addition, guidewires have been lost during catheter exchanges. One must always remain alert to all possible complications during this procedure.

Catheter sepsis must be suspected when no other clinical source is apparent; the risk increases with increasing duration of catheterization, provision of hyperalimentation, and use of multilumen catheters. Blood cultures should be obtained and the catheter removed and cultured.

If a multilumen catheter is used for hyperalimentation, then a dedicated lumen should be reserved for that purpose only. Ideally, single-lumen Silastic catheters should be used for long-term hyperalimentation. Although tunneled, cuffed catheters are preferred, we have had good results with the percutaneously placed Silastic Hohn® catheter (Bard Critical Care, Salt Lake City, UT), which has a suture wing and a subcutaneous silver collagen collar at the insertion site.

Subclavian stenosis is increasingly recognized, particularly in patients with hemodialysis catheters (which tend to be larger and used for prolonged periods), and multiple catheter placements. In one review, 52% of patients in whom the subclavian vein was cannulated for dialysis access showed stenosis or thrombosis on a venogram performed within 4 weeks of catheter removal. Although reexamination at 3 months showed improvement, 28% of patients maintained a definite stenosis or occlusion.13 Subclavian hemodialysis catheters should be used only when jugular access is not available and should be removed as early as possible.

Summary

Subclavian catheterization is a practical procedure providing central venous access for multiple purposes. Potential complications are related to anatomic considerations and diminish with increasing operator experience. Infectious complications can be reduced by aseptic surgical placement and meticulous care of the catheter itself, preferably by a dedicated intravenous therapy team. Single-lumen silastic catheters are preferable for long-term TPN and subclavian placement should be discouraged for hemodialysis catheters because of the high incidence of subclavian vein stenosis.

REFERENCES