

CHAPTER 2

ARTERIAL AND VENOUS ACCESS

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I. CENTRAL VENOUS ACCESS

Central venous catheters are frequently used in the intensive care unit (ICU) and operating room for monitoring and for venous access. Although this procedure is routine for most surgical house officers, central line insertion should be approached with caution and adequate preparation. Patient positioning is crucial to success. Informed consent should be obtained prior to performing elective access procedures, and bleeding parameters (i.e., hematocrit, platelet count, and PT/PTT ratios) should be optimized.

A. SUBCLAVIAN VENOUS ACCESS—TWO APPROACHES

1. Indications:

- a. Central venous pressure (CVP) monitoring
- b. Total parenteral nutrition (TPN)
- c. Long-term infusion of drugs
- d. Inotropic agents
- e. Poor peripheral access

2. Contraindications:

- a. Venous thrombosis
- b. Coagulopathy (PT or PTT $>1.5 \times$ control)
- c. Untreated sepsis
- d. For the standard (infraclavicular) approach: need for hemodialysis

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access, because there is an association with subclavian vein stenosis

3. Anesthesia:

1% lidocaine

4. Equipment:

- a. Sterile prep solution
- b. Mask, sterile gown, gloves, towels, dressings

- c. 22- and 25-gauge needles
 - d. 5-ml syringes (two)
 - e. Shoulder roll towel
 - f. Appropriate catheters and dilator
 - g. Intravenous (IV) tubing and flush
 - h. 18-gauge insertion needle (5–8 cm long)
 - i. 0.035 J-shaped wire
 - j. Scalpel
 - k. 2-0 silk suture
5. Positioning:

Supine, in Trendelenburg. Place a towel roll between the scapulas underneath the thoracic vertebrae as shown. Allow the patient's shoulders to fall down and back (or have an assistant apply gentle traction to the ipsilateral arm), and have the patient's head turned away from the side of the line placement (see Figure 2.1).



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6. Technique—Standard (Infraclavicular) Approach:

- a. In a sterile fashion, dress with mask and gown and prep and drape the patient's left or right subclavian area. It is often useful to prep the ipsilateral neck into the sterile field in case it is necessary to attempt an internal jugular vein approach.
- b. Place an index finger at the sternal notch and the thumb at the intersection of the clavicle and first rib (see Figure 2.2). Administer 1% lidocaine with a 25-gauge needle into the skin and subcutaneous area 2 cm lateral to your thumb and 0.5 cm caudal to the clavicle. Use a 22-gauge needle to anesthetize the periosteum of the clavicle 2–3 cm lateral to the first rib intersection. Always aspirate before injecting.



- c. Using the 18-gauge insertion needle with a 5-ml syringe, puncture the skin that is lateral to your thumb and 0.5 cm caudal to clavicle. While aspirating, slowly advance the needle underneath the clavicle toward your index finger at the

sternal notch. The needle must be horizontal (parallel to the

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floor) at all times to avoid pneumothorax, and the bevel should be facing up or toward the patient's feet to encourage the guidewire to advance toward the heart rather than into the neck. The needle may be depressed with your thumb to get underneath the clavicle (see Figure 2.3).

Fig. 2.3.

- d. If there is no venous blood return after advancing 5 cm, slowly withdraw needle while aspirating (the needle might have punctured both vessel walls). After completely withdrawing needle, redirect it, aiming 1 cm above sternal notch. If there is still no venous blood return, reanesthetize the skin 1 cm lateral puncture site rather than previous site and reattempt access. If still unsuccessful, consider moving to the contralateral side after obtaining a portable chest radiograph (CXR) to rule out pneumothorax.
- e. If air or arterial blood is encountered, stop immediately and see complications section.
- f. If venous access is obtained with good flow, remove syringe while keeping a finger over the needle to prevent air embolism.
- g. Introduce the J wire, with the tip aimed toward the heart, through the needle while maintaining the needle in the same location (Seldinger technique). The wire must pass with minimal resistance. Note that if an inferior vena cava

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(IVC) filter is known to be in place, use the non-J end of the wire to avoid snaring the filter in case the wire is advanced through the heart and into the IVC.

- h. If resistance is met, remove the wire, check needle placement by withdrawing blood with a syringe, and if good flow is obtained, introduce the wire again while turning the patient's head to the ipsilateral side (to close the angle that would allow the wire to ascend the ipsilateral jugular vein).
- i. Once the wire is passed, remove the needle while keeping control of the wire at all times.
- j. Enlarge the puncture site with a sterile scalpel.
- k. While keeping control of the wire, introduce the dilator over the wire 3–4 cm to dilate the subcutaneous tissues (see Figure 2.4). Advancing the dilator the entire length can lacerate the subclavian vein and is not recommended.





Fig. 2.4.

- I. Remove the dilator, and introduce the central venous catheter over the wire to the length of 15 cm on the right and 18 cm on the left (see Figure 2.5).



Fig. 2.5.

- m. Remove the wire, aspirate blood from all ports to confirm venous placement, and then flush with sterile saline. Suture the catheter to the skin, and apply sterile dressing.
- n. Run IV fluids at 20 ml/hr and order a portable CXR to confirm placement in superior vena cava (SVC) and rule out pneumothorax.

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7. Technique—Supraclavicular Approach:

- a. In a sterile fashion, dress with mask and gown and prep and drape the patient's left or right subclavian area. It is often useful to also prep the ipsilateral neck into the sterile field in case it is necessary to attempt an internal jugular vein approach.
- b. Select an insertion site 1 cm medial and superior to the midpoint of the clavicle (preferably the right, to avoid injury to the thoracic duct). Administer 1% lidocaine with a 25-gauge needle into the skin and subcutaneous tissue.
- c. Direct an 18-gauge introducer needle attached to a syringe toward the sternoclavicular joint 20° cephalad to the transverse plane of the clavicle and 20° anterior to the coronal plane of the patient. Maintain gentle aspiration until the vein is entered, usually at a depth of 2 cm. The vein puncture site is posterior to the clavicular head of the sternocleidomastoid muscle and medial to the subclavian artery pulsation. The vein is entered at the confluence of the subclavian and internal jugular veins (see Figure 2.6).



Fig. 2.6.

- d. If air or arterial blood is encountered, stop immediately and see complications section.
- e. If venous access is obtained with good flow, remove the syringe while keeping a finger over the needle to prevent air embolism and introduce the J wire, following the same

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Seldinger technique described above for the infraclavicular approach.

8. Complications and Management:

a. Arterial puncture

- Withdraw needle immediately, and apply manual pressure for 5 minutes.
- Monitor hemodynamics and breath sounds for hemothorax.

b. Air embolus

- Attempt to withdraw air by aspirating through catheter.
- If hemodynamically unstable (cardiac arrest), initiate Advanced Cardiac Life Support (ACLS) protocol and thoracic surgery consultation.
- If stable, position patient in left lateral decubitus and Trendelenburg position to trap air in right ventricle.

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CXR in this position can show significant air and be used for follow up.

- Air will eventually dissolve.

c. Pneumothorax

- If a tension pneumothorax is suspected, decompress with 16-gauge angiographic catheter in the second intercostal space, midclavicular line.
- If < 10%, 100% oxygen and serial CXRs
- If > 10%, tube thoracostomy

d. Malpositioning

- Into right atrium (RA) or right ventricle (RV), against wall of vein—withdraw or advance as needed to place in SVC.
- Into other subclavian vein—stable position, no adjustment needed
- Into jugular or mammary vein—reintroduce J wire, remove catheter, thread long 18-gauge angiographic catheter and confirm placement in vein by aspiration of blood. The J wire can now be redirected into SVC by maximizing positioning (pull caudally on arm, and turn the head and neck ipsilaterally to close internal jugular vein angle).

e. Dysrhythmias

- Atrial or ventricular dysrhythmias are associated with wires and catheters in the RA or RV and usually resolve after withdrawing the catheter into the SVC.
- Persistent dysrhythmias may need medical management.

B. INTERNAL JUGULAR VENOUS ACCESS—TWO APPROACHES

1. Indications:

- a. CVP monitoring
- b. TPN
- c. Long-term infusion of drugs
- d. Inotropic agents
- e. Hemodialysis
- f. Poor peripheral access

2. Contraindications:

- a. Previous ipsilateral neck surgery
- b. Untreated sepsis
- c. Venous thrombosis

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3. Anesthesia:

1% lidocaine

4. Equipment:

- a. Sterile prep solution
- b. Mask, sterile gown, gloves, and towels
- c. 22- and 25-gauge needles
- d. 5-ml syringes (two)
- e. Appropriate catheters and dilator
- f. IV tubing and flush
- g. 18-gauge insertion needle (5–8 cm long)
- h. 0.035 J wire, sterile dressings
- i. Scalpel
- j. 2-0 silk suture

5. Positioning:

Supine, in Trendelenburg. Turn the patient's head 45° contralaterally to expose the neck (see Figure 2.7).





Fig. 2.7.

6. Technique—Central Approach:

- a. In a sterile fashion, dress with mask and gown. Identify the apex of the triangle formed by the heads of the sternocleidomastoid muscles (SCM), and prep and drape this area. Also locate the external jugular vein and the carotid artery (see Figure 2.8). It is often useful to prep the ipsilateral clavicle artery into the sterile field in case it is necessary to attempt the subclavian approach.



Fig. 2.8.

- b. Administer anesthetic with 25-gauge needle into skin and subcutaneous tissue at the apex of the triangle. Always withdraw before injecting because the vein can be very superficial.
 - c. Palpate the carotid pulse and apply gentle traction medially with the other hand.
 - d. Insert the 22-gauge finder needle with a syringe at the apex of the triangle 45°–60° to the skin and advance it slowly toward the ipsilateral nipple while aspirating.
 - e. If there is no venous blood return after 3 cm, slowly withdraw needle while aspirating. If still no return, redirect the needle through the same puncture site aiming 1–3 cm more laterally and then, if unsuccessful, 1 cm medially. Watch the carotid artery. If there is still no blood return, reassess landmarks
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- and consider posterior approach if unable to obtain access after three attempts.
- f. If air or arterial blood is encountered, stop immediately and see complications section.
 - g. If good venous return, memorize the site and angle of entry of the finder needle and then remove the needle. Apply digital pressure to minimize bleeding. Alternatively, the needle may be left in place as a guide.
 - h. Insert the 18-gauge needle, following the same angle as the finder needle (see Figure 2.9).



Fig. 2.9.

- i. If venous access is obtained with good flow, remove syringe while keeping a finger over the needle to prevent air embolism.

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- j. Introduce the J wire, with the tip aimed toward the heart (medially), through the needle while maintaining the needle in the same location (Seldinger technique). The wire must pass with minimal resistance.
- k. If resistance is met, remove the wire, check needle placement by withdrawing blood with a syringe, and reintroduce wire if good blood return.
- l. Once the wire is passed, remove the needle while keeping control of the wire at all times.
- m. Enlarge the puncture site with a sterile scalpel.
- n. Introduce the venous catheter over the wire while maintaining a constant hold on the wire to the length of about 9 cm on the right and 12 cm on the left.
- o. Remove the wire, aspirate blood from all ports to confirm venous placement, and then flush with sterile saline. Suture the catheter to the skin and apply sterile dressing.
- p. Run IV fluids at 20 ml/hr and order a portable CXR to confirm placement in SVC and rule out pneumothorax.

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7. Technique—Posterior Approach:

- a. In a sterile fashion, dress with mask and gown. Identify the lateral border of the SCM where the external jugular vein crosses over it. It is about 4–5 cm above the clavicle (see Figure 2.10). It is often useful to prep the ipsilateral clavicle into the sterile field in case it is necessary to attempt the subclavian approach.



Fig. 2.10.

- b. Administer anesthetic with a 25-gauge needle into skin and subcutaneous tissue 0.5 cm superior to the intersection of the SCM and external jugular vein. Always withdraw before injecting because the vein can be very superficial.
- c. Insert the 22-gauge finder needle with a syringe at point A and advance slowly anteriorly and inferiorly toward the sternal notch while aspirating (see Figure

2.11).

Fig. 2.11.

- d. If there is no venous blood return after 3 cm, slowly withdraw needle while aspirating. If there is still no return, redirect the needle through the same puncture site aiming

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slightly ipsilateral to the sternal notch. If there is still no blood return, reassess landmarks and consider attempting the contralateral side after three attempts. CXR must be obtained to rule out pneumothorax before changing sides.

- e. If air or arterial blood is encountered, stop immediately and see complications section.
- f. If good venous return, memorize the site and angle of entry of the finder needle and then remove the needle. Apply digital pressure to minimize bleeding. Alternatively, the needle may be left in place as a guide.
- g. Insert the 18-gauge needle, following the same angle as the finder needle. If venous access is obtained with good flow, remove syringe while keeping a finger over the needle to

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prevent air embolism and introduce the J wire, following the same Seldinger technique described above for the central approach.

8. Complications and Management:

a. Carotid puncture

- Withdraw needle immediately and apply manual pressure.
- If cannulation occurred and manual pressure is not successful, surgical intervention may be needed.

b. Air embolus

- Attempt to withdraw air by aspirating through catheter.
- If hemodynamically unstable (arrest), initiate ACLS protocol and thoracic surgery consultation.
- If stable, position patient in left lateral decubitus and Trendelenburg position to trap air in right ventricle. CXR in this position can show significant air and be used for follow up.
- Air will eventually dissolve.

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- c. Pneumothorax
 - If a tension pneumothorax is suspected, decompress with 16-gauge angiographic catheter in the second intercostal space, midclavicular line.
 - If < 10%, 100% oxygen and serial CXRs
 - If > 10%, tube thoracostomy
- d. Malpositioning
 - Into RA or RV, against wall of vein—withdraw or advance as needed to place in SVC.
 - Into subclavian vein—stable position, no adjustment needed.
 - Into jugular or mammary vein—re-introduce J wire, remove catheter, thread long 18-gauge IV catheter and confirm placement in vein by aspiration of blood. The J wire can now be redirected into SVC by maximizing positioning (pull caudally on arm and turn the head and neck ipsilaterally to close internal jugular vein angle).
- e. Horner's syndrome
 - Puncture of the carotid sheath can result in a temporary Horner's syndrome that usually resolves.
- f. Dysrhythmias
 - Atrial or ventricular dysrhythmias are associated with wires and catheters in the RA or RV and usually resolve after withdrawing the object into the SVC.
 - Persistent dysrhythmias may need medical management.

C. FEMORAL VENOUS ACCESS

1. Indications:
 - a. Emergent central access
 - b. Hemodialysis
 - c. Unable to obtain subclavian or internal jugular venous access for CVP or inotropic agents
2. Contraindications:
 - a. Prior groin surgery (relative)
 - b. Patient must maintain bed rest while the catheter is in place

3. Anesthesia:

1% lidocaine

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4. Equipment:

- a. Sterile prep solution
- b. Mask, sterile gown, gloves, and towels
- c. 25-gauge needle
- d. 5-ml syringes (two)
- e. Appropriate catheters and dilator
- f. IV tubing and flush
- g. 18-gauge insertion needle (5 cm long)
- h. 0.035 J wire, sterile dressings
- i. Safety razor
- j. Scalpel
- k. 2-0 silk suture

5. Positioning:

Supine

6. Technique:

- a. In a sterile fashion, dress with mask and gown. Shave, prep, and drape left or right groin area.
- b. Palpate the femoral pulse at the midpoint along an imaginary line between the anterior superior iliac spine and the symphysis pubis. The femoral vein runs parallel and immediately medial to the artery (see Figure 2.12).

Fig. 2.12.

- c. Administer anesthetic with 25-gauge needle into the skin and subcutaneous tissue 1 cm caudally and laterally to the palpated pulse.
- d. Retracting the artery laterally with your finger, use the 18-gauge insertion needle with a 5-ml syringe to puncture the skin. Advance the needle while aspirating cranially at a 45° angle to the skin, parallel to the pulse. There is less risk with being medial to the vein rather than lateral to it (see Figure 2.13 and Figure 2.14).

Fig. 2.13.

Fig. 2.14.

- e. If there is no venous blood return after 5 cm, slowly withdraw needle while aspirating. If still no return, redirect the needle through the same puncture site, aiming in a cranial and more lateral direction 1–2 cm closer to the artery.
- f. If still no blood return, reassess landmarks and attempt access 0.5 cm medial to the femoral pulse.
- g. If arterial blood is encountered, withdraw needle and hold manual pressure according to the complications section.
- h. If venous access is obtained with good flow, remove syringe while keeping a finger over the needle to prevent air embolism.

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- i. Introduce the J wire, with the tip aimed toward the heart, through the needle while maintaining the needle in the same location. The wire must pass with minimal resistance.
- j. If resistance is met, remove the wire and check needle placement by withdrawing blood with a syringe.
- k. Once the wire is passed, remove the needle while keeping control of the wire at all times.
- l. Enlarge the puncture site with a sterile scalpel.
- m. Introduce the dilator over the wire 3–4 cm to dilate the subcutaneous tissues. Advancing the dilator the entire length can lacerate the femoral vein and is not recommended.
- n. Remove the dilator and introduce the catheter over the wire to the length of 15 cm.
- o. Remove the wire, aspirate blood from all ports to confirm venous placement, and flush with sterile saline. Suture the catheter to the skin and apply sterile dressing.

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- p. Patient should maintain bed rest until the catheter is removed.

7. Complications and Management:

- a. Femoral artery puncture/hematoma
 - Withdraw the needle
 - Hold manual pressure for at least 15–25 minutes. A sand bag is then placed over the site for another 30 minutes.
 - Bed rest for 4 hours
 - Monitor leg pulses and site for hematoma every 30–60 minutes.

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II. OTHER VENOUS ACCESS PROCEDURES

Other forms of venous access include peripherally inserted central catheters (PICCs), which allow central venous access through a peripheral vein, tunneled central venous catheters, and surgical access in emergent situations, such as venous cutdowns and intraosseous access. These procedures are not as commonly performed as the previously mentioned methods of venous access. Also included in this chapter is a protocol for removal of Hickman, Groshon, and other long-term indwelling venous catheters. Surgical house officers are frequently called upon to remove these devices in the outpatient clinics.

A. PERIPHERALLY INSERTED CENTRAL CATHETER, LONG ARM IV

A long, thin catheter inserted via basilic or cephalic vein to subclavian vein

1. Indications:
 - a. Long-term intravenous access for drugs
 - b. TPN fluids
 - c. Not for CVP monitoring
2. Contraindications:
 - a. Lack of upper arm veins visible or palpable with tourniquet in place
 - b. Presence of phlebitis or cellulitis in arm
3. Anesthesia:

1% lidocaine without epinephrine
4. Equipment:
 - a. Most PICC kits come with everything necessary, including Betadine and alcohol swabs, sterile drapes, 3-ml syringe and 25-gauge needle, introducer (14-gauge angiographic catheter [some catheters require peel-away design]), Silastic catheter with guidewire, scissors, needle-holders, 3-0 silk suture,

suture wing, gauze pads, tape measure.

- b. Equipment not contained in kits includes sterile gloves and heparinized saline for flushing catheter.

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5. Positioning:

Patient should sit or recline with arm externally rotated and abducted to about 45° to axis of body. Arm should be slightly dependent with elbow extended.

6. Technique:

- a. In a sterile fashion, dress with mask and gown. Place tourniquet and identify a vein in the forearm that is continuous with the basilic or cephalic vein (see Figure 2.15). Prep and drape the anticipated insertion site.

Fig. 2.15.

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- b. Measure approximate distance to SVC from insertion site.
- c. Use a small amount of lidocaine to infiltrate skin on either side of vein.
- d. Kits that have attached hub require that the catheter be trimmed prior to insertion. Trim from the end opposite the hub (i.e., the tip). Do not trim the tip of a Groshon catheter. Flush Silastic catheter before inserting it.
- e. Place 14-gauge introducer catheter into vein as if inserting a peripheral IV. After obtaining a flash of blood, remove needle and advance plastic portion of introducer.
- f. Insert Silastic catheter through plastic introducer catheter.
- g. Remove tourniquet and advance Silastic catheter to premeasured length (some kits come with forceps to advance catheter).
- h. Remove guidewire and peel away plastic introducer catheter.
- i. Trim end of Silastic catheter to manageable length, but only if it has a detachable hub. Attach hub, heparin lock, and wings, and suture catheter to the skin. Withdraw blood and flush catheter.
- j. Confirm placement with chest radiograph.

7. Complications and Management:

- a. Bleeding
 - Apply pressure at insertion site for at least 5 minutes.

- b. Arrhythmia
 - Usually secondary to catheter being advanced too far
 - Withdraw catheter until arrhythmia resolves.
 - Medical management, if necessary
- c. Line infection
 - Suspected by positive blood cultures from the line and not from peripheral cultures.
 - Remove catheter and culture intradermal component.
 - Institute appropriate antibiotics.
- d. Clotted catheter
 - Be suspicious of intravenous clot.
 - Obtain Doppler study or venogram.
 - If clot present, line removal is recommended.
- e. Cracked or leaking catheter
 - PICCs with attachable hub can be repaired by obtaining new attachable hub, trimming catheter slightly, and placing new hub.
 - Otherwise, PICCs should be removed.

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B. HOHN CATHETER

A Hohn catheter is a long-term indwelling catheter with an antibiotic-coated cuff. It is tunneled through a short distance of the chest wall soft tissue and inserted into the subclavian vein. It is extremely flexible, with a wide lumen; successful insertion requires a two-step process, whereby a standard central line is placed and the soft-tissue tunnel is aggressively dilated prior to using Seldinger technique to rewire to the Hohn catheter.

1. Indications:

- a. Long-term intravenous access for drugs
- b. TPN fluids
- c. Not for CVP monitoring

2. Contraindications:

- a. Vein thrombosis
- b. Coagulopathy (PT or PTT > 1.5 × control, platelets < 20K)

- c. Untreated sepsis
3. Anesthesia:
 - 1% lidocaine
 4. Equipment:
 - a. Standard single-lumen central line kit, including Betadine swabs, sterile drapes, 22- and 25-gauge needles, 5-ml syringes (two), appropriate catheter and dilator, 18-gauge insertion needle (5–8 cm long), 0.035 J wire, scalpel, 2-0 silk suture.
 - b. Standard Hohn catheter kit, including 5-ml syringes (two), appropriate wire, and catheter.
 - c. Equipment not contained in kits include shoulder roll towels, mask, sterile gown, gloves, and heparinized saline for flushing catheter.
 5. Positioning:

Supine, in Trendelenburg. Place a towel roll between the scapulas underneath the thoracic vertebrae. Allow the patient's shoulders to fall down and back (or have an assistant apply gentle traction to the ipsilateral arm).

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6. Technique:
 - a. Follow the technique described previously (Section I A 6) for placing a subclavian central venous catheter using materials from a standard single-lumen central line kit.
 - b. After the standard central venous catheter is in position, introduce the guidewire from the Hohn catheter kit through the central venous catheter and remove the catheter over the wire (Seldinger technique).
 - c. While keeping control of the wire, introduce the dilator from the Hohn catheter kit over the wire 3–4 cm to further generously dilate the subcutaneous tissues.
 - d. Remove the dilator and introduce the Hohn catheter over the wire. A strong, persistent twisting motion around the long axis of the catheter is required to advance the large, floppy Hohn through the soft tissue. The antibiotic-coated cuff should come to rest just above the insertion site in the soft tissue tunnel.
 - e. Remove the wire, aspirate blood to confirm venous placement, and flush with sterile saline. Suture the Hohn catheter to the skin and apply sterile dressing.
 - f. Run IV fluids at 20 ml/hr and order a portable CXR to confirm placement in SVC and rule out pneumothorax.
7. Complications and Management:
 - a. Arterial puncture

- Withdraw needle immediately and apply manual pressure for 5 minutes.
 - Monitor hemodynamics and breath sounds for hemothorax.
- b. Air embolus
- Attempt to withdraw air by aspirating through catheter.
 - If hemodynamically unstable (cardiac arrest), initiate ACLS protocol and thoracic surgery consultation.
 - If stable, position patient in left lateral decubitus and Trendelenburg position to trap air in right ventricle. CXR in this position can show significant air and be used for follow up.
 - Air will eventually dissolve.
- c. Pneumothorax
- If a tension pneumothorax is suspected, decompress with 16-gauge angiographic catheter in second intercostal space, midclavicular line.
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- If < 10%, 100% oxygen and serial CXRs
 - If > 10%, tube thoracostomy
- d. Malpositioning
- Into RA or RV, against wall of vein—withdraw or advance as needed to place into SVC
 - Into other subclavian vein—stable position, no adjustment needed
 - Into jugular or mammary vein—re-introduce J wire, remove catheter, thread long 18-gauge angiographic catheter and confirm placement in vein by aspiration of blood. The J wire can now be redirected into SVC by maximizing positioning (pull caudally on arm and turn the head and neck in the ipsilateral direction to close internal jugular vein angle).
- e. Dysrhythmias
- Atrial or ventricular dysrhythmias are associated with wires and catheters in the RA or RV and usually resolve after withdrawing the catheter into the SVC.
 - Persistent dysrhythmias may need medical management.
- f. Line infection (line should be removed within 6 weeks)
- Confirmed by positive blood cultures from the line and not from peripheral cultures
 - Remove catheter and culture intradermal component.

- Institute appropriate antibiotics.

C. HICKMAN REMOVAL

1. Indications:

- a. Infected catheter
- b. Intractably clotted catheter
- c. Completion of therapy

2. Contraindications:

- a. Severe coagulopathy (PT or PTT $>1.5 \times$ control)
- b. Continued need for therapy

3. Anesthesia:

1% lidocaine

4. Equipment:

- a. Betadine prep solution
- b. Sterile drapes

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- c. Sterile hemostats, scalpel with blade, needle holder
- d. 4-0 nylon suture

5. Positioning:

Supine

6. Technique:

- a. Prep Hickman insertion site and catheter.
- b. Infiltrate site with local anesthetic, including catheter tract up to and including cuff.
- c. With gentle, steady pressure, pull Hickman catheter. Sometimes this is enough to dislodge cuff from surrounding fibrous tissue.
- d. When cuff is close to skin incision, insert hemostat via tract to cuff site. Use blunt spreading technique to divide fibrous tissue (see Figure 2.16).

Fig. 2.16.

- e. Occasionally it is necessary to enlarge the skin incision. Use the scalpel, taking care to avoid lacerating catheter. If necessary, make an incision directly over the cuff and then use blunt dissection to free the cuff.
 - f. Once the cuff is freed from the fibrous tissue, gently and steadily pull the catheter from the tract.
 - g. Apply pressure to the subclavian or internal jugular vein area as the tip of catheter exits the vein.
 - h. If skin incision is large, approximate edges with suture. Apply dressing.
7. Complications and Management:

a. Air embolus

- Unlikely with removal of tunnelled catheter
- If hemodynamically unstable, initiate ACLS protocol and thoracic surgery consultation.
- If stable, place patient in left lateral decubitus and Trendelenburg position to trap air in right ventricle.
- Follow with serial CXRs. Air will eventually dissolve.

b. Bleeding

- Apply direct pressure for 15 minutes.

c. Catheter breakage

- If external to skin site, prevent air embolus by clamping catheter proximal to breakage site and remove catheter.

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- If break occurs under the skin and the catheter end retracts through the tunnel, interventional radiology will need to retrieve catheter.
- This is a serious complication. Avoid it by not pulling catheter too hard and by keeping sharp instruments out of the tunnel.

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D. GREATER SAPHENOUS VEIN CUTDOWN

1. Indications:

Saphenous vein cutdown is performed when percutaneous access to the venous system cannot be gained. It can be used to gain lower extremity access for trauma, but in recent years has been replaced by the percutaneous femoral vein approach. The preferred site for saphenous vein cutdown is at the ankle. Although the saphenous vein can also be reached by a cutdown in the groin, it is rarely performed

as an elective bedside procedure.

2. Contraindications:

- a. Coagulopathy (PT or PTT > 1.5 × control)
- b. Vein thrombosis

3. Anesthesia:

1% lidocaine

4. Equipment:

- a. Tourniquet
- b. Mask and sterile prep solution, gown, gloves, drape
- c. Gauze pads
- d. 3-ml syringe with 25-gauge needle
- e. Sterile scalpel, hemostat, fine scissors
- f. IV catheter and heparin lock cap
- g. 3-0 silk ties

5. Positioning:

Patient should be in position comfortable for the operator, usually supine, with extremity of interest in dependent position.

6. Technique:

- a. The greater saphenous vein is consistently located about 1 cm anterior and superior to the medial malleolus (see Figure 2.17). A tourniquet is unnecessary for access to the vein.

Fig. 2.17.



- b. Prep and drape area surrounding the ankle. Infiltrate the skin over the vein with lidocaine using a 25-gauge needle.
- c. Make a full-thickness transverse incision through the anesthetized skin to a length of 2.5 cm.

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- d. Using a curved hemostat, identify the saphenous vein and gently dissect it free from the saphenous nerve, which is attached to the anterior wall of the vein. It is imperative that the saphenous nerve be identified to avoid injury and subsequent pain.

- e. Elevate and dissect the vein free from its bed for a distance of approximately 2 cm (see Figure 2.18).

Fig. 2.18.

P.65

- f. Pass the silk ties around the exposed vein proximally and distally.
- g. Ligate the vein distally, leaving the suture in place for traction.
- h. Make a small transverse venotomy and gently dilate the venotomy with the tip of the closed hemostat. A vein introducer may also be used (see Figure 2.19).

Fig. 2.19.

- i. Place angiographic catheter into the vein directly or after tunnelling it through the skin distal to the incision. Tie the proximal silk suture to secure the catheter, being careful not to occlude the catheter. The catheter should be inserted an adequate distance to prevent easy dislodgement (see Figure 2.20).

Fig. 2.20.

- j. Close wound with interrupted nylon sutures. Apply sterile dressings.

7. Complications and Management:

a. Bleeding

- Apply pressure if bleeding occurs.

P.66

b. Infection/Phlebitis

- Remove catheter. Apply warm compresses and elevate leg.
- Use antibiotics if necessary

E. INTRAOSSEOUS ACCESS

1. Indications:

Need for emergency access, usually in a child less than 3 years old, when other

attempts at venous access have failed and time is too short for a cutdown. The technique has been used in older children and adults. Once intravascular volume has been replaced, other access should be obtained.

2. Contraindications:

- a. Because this is an emergency procedure and is to be used in the severely injured or critically ill patient, the only relative contraindication is injury to the extremity of interest.
- b. Avoid placing the needle distal to a fracture site.

3. Anesthesia:

None

4. Equipment:

16- or 18-gauge bone marrow aspiration or intraosseous infusion needle

5. Positioning:

Supine

P.67

6. Technique:

- a. Insert needle, bevel up, at 60°–90° angle into the marrow of a long bone. The preferred site is the tibia 2–3 cm inferior to the tibial tuberosity; alternatively, use the inferior third of the femur (see Figure 2.21).



Fig. 2.21.

P.68

- b. Aspiration of marrow confirms proper location. Other clues to proper position include firm upright position of needle in bone and easy infusion of 5–10 ml of fluid (see Figure 2.22).



Fig. 2.22.

- c. Secure the needle with tape.

7. Complications and Management:

- a. Infiltration
 - Remove and replace needle.

- b. Cellulitis
 - Remove needle.
 - Treat cellulitis with antibiotics.

- c. Osteomyelitis
 - Appropriate long-term IV antibiotics
- d. Compartment syndrome
 - Fasciotomy

P.69

III. ARTERIAL CANNULATION

Arterial lines permit continuous monitoring of heart rate and blood pressure necessary in ICU patients who are receiving inotropic agents or who are hemodynamically unstable. Intraoperative monitoring is also required with high-risk patients. In order of preference, we attempt radial > ulnar > femoral > dorsalis pedis > axillary sites. We recommend using “quick” catheters or angiographic catheters for radial, ulnar, and dorsalis pedis arteries, and the Seldinger technique for femoral and axillary arteries.

A. RADIAL ARTERY CANNULATION

1. Indications:
 - a. Continuous hemodynamic monitoring
 - b. Frequent assessment of arterial blood gases

2. Contraindications:

Allen test.

- a. Occlude both ulnar and radial arteries and allow venous drainage to exsanguinate the hand (see Figure 2.23).



Fig. 2.23.

- b. Release the ulnar artery while keeping the radial artery compressed.
- c. If hand color does not return in < 5 seconds, the Allen test is positive and cannulation should be aborted.

3. Anesthesia:

1% lidocaine

4. Equipment:

- a. Sterile prep solution
- b. Mask, sterile gown, gloves, and towels
- c. 25-gauge needle
- d. Syringe
- e. 16-, 18-, or 20-gauge angiographic catheter (2 inches long) quick catheters
- f. 2-0 silk sutures
- g. Pressure bags with IV tubing
- h. Heparinized flush system with sensor attachments for monitoring
- i. Sterile dressings
- j. Hand towel

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5. Positioning:

Expose the ventral surface of the forearm, dorsiflex the wrist, and place a rolled-up hand towel underneath the dorsal surface of the wrist. Secure the palm and forearm to an arm board (see Figure 2.24).

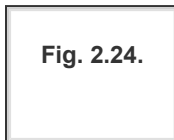


Fig. 2.24.

6. Technique (use technique similar to ulnar artery cannulation):

- a. In a sterile fashion, dress with mask and gown. Prep and drape ventral surface of the wrist.
- b. Palpate the radial pulse near the distal radius.
- c. Administer anesthetic with a 25-gauge needle into the skin above this point. Use a 19-gauge needle as a skin breaker to puncture the skin.
- d. Using an angiographic catheter, enter at a 45° angle and advance toward the pulse until blood return is seen in the hub of the needle (see Figure 2.25).

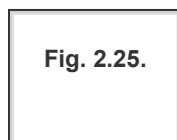


Fig. 2.25.

- e. If there is no blood return, withdraw the angiographic catheter slowly and

make another pass at a 60° angle toward the palpated pulse.

- f. If good blood return is seen in the hub, advance the angiographic catheter another 2 mm to ensure intraluminal placement of the angiographic catheter. If you are using a quick catheter, this additional 2 mm is not necessary and the wire portion of the system is then advanced into the artery.
- g. Slowly advance the catheter portion of the angiographic catheter into the artery while holding the needle steady.

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- h. Remove the needle and keep digital compression on the proximal radial artery to prevent excessive bleeding.
- i. If there is no bleeding, the catheter is not intraluminal. Withdraw the catheter slowly in case it has punctured the posterior wall. If there is still no blood, remove the catheter, hold pressure for 5 minutes. Reassess landmarks and reattempt placement. Often the artery lies more medially than expected.
- j. If successful, attach flush system and sensors to the monitor to assess arterial waveform.
- k. Suture the catheter to the skin and apply sterile dressing.
- l. If unsuccessful after three attempts, stop and assess a more proximal site.

7. Complications and Management:

- a. Poor arterial waveform
 - Check all line connections and stopcocks.
 - Exclude extrinsic proximal arterial compression.
 - Check position of arm and wrist; the arm cannot be elevated and the wrist must be dorsiflexed.
 - If waveform and blood return are poor, replace catheter.
- b. Ischemic digits
 - Remove catheter and monitor the hand.

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B. DORSALIS PEDIS ARTERY CANNULATION

1. Indications:

- a. Continuous hemodynamic monitoring
- b. Frequent assessment of arterial blood gases

2. Contraindications:

No palpable dorsalis pedis artery

3. Anesthesia:

1% lidocaine

4. Equipment:

- a. Sterile prep solution
- b. Mask, sterile gown, gloves, and towels
- c. 25-gauge needle
- d. 5-ml syringe
- e. 16-, 18-, or 20-gauge angiographic catheter (2 inches long) or quick catheters
- f. 2-0 silk sutures
- g. Pressure bags with IV tubing
- h. Heparinized flush system with sensor attachments for monitoring
- i. Sterile dressings

5. Positioning:

Expose the dorsal surface of the foot in neutral position.

6. Technique:

- a. In a sterile fashion, dress with mask and gown. Prep and drape dorsal surface of the foot.
- b. Palpate the dorsalis pedis pulse lateral to the extensor hallucis longus at the level of the metatarsal-1st cuneiform joint (see Figure 2.26), and administer anesthetic with a 25-gauge needle into the skin above this point.



Fig. 2.26.

- c. Using a 20-gauge angiographic catheter with the bevel up, puncture the skin at a 45° angle to the skin. Advance the angiographic catheter toward the palpated pulse until blood return is seen in the hub of the needle (see Figure 2.27).



Fig. 2.27.

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- d. If there is no blood return, withdraw angiographic catheter slowly and make another pass at a 60° angle toward the palpated pulse.
- e. If there is good blood return in the hub, advance the angiographic catheter another 2 mm to ensure intraluminal placement. If you are using a quick catheter, this additional 2 mm is unnecessary and the wire portion of the system is advanced into the artery.
- f. While maintaining a firm hold on the needle portion of the angiographic catheter, slowly advance the catheter portion into the artery.

P.75

- g. Remove the needle and keep digital compression proximally to prevent excessive bleeding.
- h. If there is no bleeding, the catheter is not intraluminal. Withdraw the catheter slowly in case it has punctured the posterior wall. If there is still no blood, remove the catheter and hold pressure for 5 minutes. Reassess landmarks and reattempt placement.
- i. If successful, attach flush system and sensors to the monitor to assess arterial waveform.
- j. Suture the catheter to the skin and apply a sterile dressing.
- k. If unsuccessful after three attempts, stop and assess another site.

7. Complications and Management:

- a. Poor arterial waveform
 - Check all line connections and stopcocks.
 - Exclude extrinsic proximal arterial compression.
 - If waveform and blood return are poor, replace catheter.
- b. Ischemic toes
 - Remove catheter and monitor foot.

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C. FEMORAL ARTERY CANNULATION

1. Indications:

- a. Continuous hemodynamic monitoring
- b. Frequent assessment of arterial blood gases
- c. Access for arteriography studies

- d. Intra-aortic balloon pump insertion (see Chapter 3)
2. Contraindications:
 - a. Prior groin surgery (relative)
 - b. Patient should maintain bed rest while catheter is in place.
3. Anesthesia:

1% lidocaine
4. Equipment:
 - a. Sterile prep solution
 - b. Mask, sterile gown, gloves, and towels
 - c. 25-gauge needle
 - d. 5-ml syringes (two)
 - e. 16-gauge catheter (6 inches)
 - f. 18-gauge insertion needle (5 cm long)
 - g. 0.035 J wire, sterile dressings
 - h. Safety razor
 - i. 2-0 silk sutures
 - j. Pressure bags with IV tubing
 - k. Heparinized flush system with sensor attachments for monitoring
5. Positioning:

Supine
6. Technique:
 - a. In a sterile fashion, dress with mask and gown. Shave, prep, and drape left or right groin area.
 - b. Palpate the femoral pulse at the midpoint along an imaginary line between the anterior superior iliac spine and the symphysis pubis. Palpate its course 1–2 cm distally.

 - c. Administer anesthetic with 25-gauge needle into the skin and subcutaneous tissues along the course of the artery (see Figure 2.28).

P.77

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P.78

- d. Using the 18-gauge insertion needle with a 5-ml syringe, puncture the skin at point A and advance the needle while aspirating cranially at a 45° angle to the skin toward the pulse (see Figure 2.29 and Figure 2.30).



Fig. 2.29.



Fig. 2.30.

- e. If there is no arterial blood return after 5 cm, slowly withdraw needle while aspirating. If still no return, redirect again toward the pulse or reassess landmarks and attempt access at a site that is 1 cm more proximal along the course of the artery.
- f. If there is venous return, withdraw needle and hold pressure according to the complications section.
- g. If arterial access is obtained, remove the syringe while keeping a finger over the needle to prevent excessive bleeding.
- h. Introduce the J wire, with the tip aimed toward the heart, through the needle (Seldinger technique). The wire must pass with minimal resistance.

P.79

- i. If resistance is met, remove the wire and check needle placement by withdrawing blood with a syringe.
- j. Once the wire is passed, remove the needle while keeping control of the wire at all times.
- k. Enlarge the puncture site carefully with a sterile scalpel.
- l. Introduce the catheter over the wire.

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- m. Remove the wire and attach flush system and sensors to the monitor to assess arterial waveform. Suture the catheter to the skin and apply a sterile dressing.
- n. Patient should maintain bed rest until the catheter is removed.

7. Complications and Management:

- a. Femoral vein puncture
- Withdraw the needle.

- Hold pressure for 10 minutes.
- b. Thrombosis
 - Remove catheter.
 - Closely monitor leg pulses and observe for distal emboli.
- c. Hematoma
 - Remove catheter.
 - Hold pressure for at least 15 minutes. A sand bag is then placed over the site for another 30 minutes.
 - Bed rest for 4 hours.
 - Monitor leg pulses.

D. AXILLARY ARTERY CANNULATION

1. Indications:
 - a. Continuous hemodynamic monitoring
 - b. Frequent assessment of arterial blood gases
 - c. Access for arteriography studies
 2. Contraindications:
 - a. Unable to abduct arm
 - b. Poor distal peripheral pulses
 3. Anesthesia:

1% lidocaine
 4. Equipment:
 - a. Sterile prep solution
 - b. Mask and sterile gown, gloves, and towels
 - c. 25-gauge needle
 - d. 5-ml syringes (two)
 - e. 16-gauge catheter (6 inches)
 - f. 18-gauge insertion needle (5 cm long)
 - g. 0.035 J wire
 - h. Sterile dressings
-

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- i. Safety razor
 - j. 2–0 silk sutures
 - k. Pressure bags with IV tubing
 - l. Heparinized flush system with sensor attachments for monitoring
5. Positioning:
Supine with the shoulder externally rotated and the arm fully abducted
6. Technique:

- a. In a sterile fashion, dress with mask and gown. Shave, prep, and drape axilla.
- b. Palpate the axillary pulse as proximally as possible inferior to the pectoralis major.
- c. Administer anesthetic with 25-gauge needle into the skin and subcutaneous tissues along the course of the artery (see Figure 2.31).



Fig. 2.31.

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- d. Using the 18-gauge insertion needle with a 5-ml syringe, puncture the skin and advance the needle while aspirating at a 45° angle to the skin toward the pulse (see Figure 2.32).



Fig. 2.32.

- e. If there is no arterial return after 5 cm, slowly withdraw needle while aspirating and redirect toward the pulse. If there is still no return, reassess landmarks and attempt access at a site that is 1 cm more distal along the course of the artery.
- f. If venous blood is encountered, withdraw needle and hold pressure according to the complications section.
- g. If arterial access is obtained, remove the syringe while keeping a finger over the needle to prevent excessive bleeding.
- h. Introduce the J wire through the needle with the tip aimed toward the heart, while maintaining the needle in the same location. The wire must pass with minimal resistance.

P.83

- i. If resistance is met, remove the wire and check needle placement by withdrawing blood with a syringe.
- j. Once the wire is passed, remove the needle while keeping control of the wire at all times.
- k. Enlarge the puncture site carefully with a sterile scalpel.
- l. Introduce the catheter over the wire.
- m. Remove the wire and attach flush system and sensors to the monitor to assess arterial waveform. Suture the catheter to the skin and apply sterile dressing.

7. Complications and Management:

- a. Venous puncture
 - Withdraw needle.
 - Hold pressure for at least 10 minutes.
- b. Thrombosis
 - Remove catheter.
 - Monitor distal pulses and watch for ischemic digits.
- c. Brachial plexus injury
 - Remove catheter.
 - Assess neurological function. If no improvement, initiate neurosurgery consultation.

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