MODULE 9

ARTERIAL AND VENOUS CATHETERIZATION

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I. OBJECTIVES

By the end of this laboratory session the residents should be able to…

A. Identify the anatomic landmarks to safely place arterial and central venous catheters.

B. Develop an algorithm to maximize safety in placement of arterial and central venous lines.

C. Demonstrate a working knowledge to the use of the “Site Rite” ultrasound for the placement of central venous catheters.

D. Demonstrate a working knowledge of complications that can occur and a treatment plan if they occur.

II. ASSUMPTIONS

The resident should have background knowledge regarding the following key points.

A. Anatomy to place radial arterial line, femoral arterial line, and central venous line (jugular approach and subclavian approach)

B. Indications for an arterial line and central venous line

C. Complications that can occur from placement of an arterial line and or central venous line

D. Complications that can occur from an arterial line and or central venous line after it has been placed
III. SUGGESTED READINGS

A. “Tips for monitoring the position of a central venous catheter, how placement can go awry – even when the anatomy is normal” in Journal of Critical Illness, 8:660-74, 1993.

B. “Central venous catheterization in the critical ill patient” Critical Care Medicine, 8:677-86, 1992.


G. “Cardiopulmonary Monitoring” in Care of the Surgical Patient from Scientific American Volume 1, Section 1, pages 3-27.


IV. DESCRIPTION OF LABORATORY MODULE

A. The arterial and venous catheterization laboratory module will begin with a 20 minute introduction and overview. During this time, key anatomical landmarks, indications for arterial and venous lines, techniques of placing arterial and venous line, and complications, will be discussed.

B. The next 1 ½ hours will be dedicated to dividing the class in to three groups to be positioned at three different stations/tables. The first station will be dedicated to the placement of a central venous line via the jugular approach. The second station will cover the placement of a central venous line via the subclavian approach. In addition, the Residents will become familiar with using the “Site Rite” ultrasound for identification and location of the internal jugular / subclavian veins. The third station will cover arterial catheterization in the radial and femoral arteries. The groups will rotate every 30 minutes.
C. The final 10 minutes of the session will be dedicated to a question and answer period. Residents/students are encouraged to ask questions and give any comments they may have in their participation of the placement of these lines.

V. DESCRIPTION OF TECHNIQUES AND PROCEDURE

A. Placement of a central venous line (jugular approach)

After initial assessment as to the indication of the line and the anticoagulation status, informed consent is obtained. The patient is placed in the supine position and the pillow is removed so the patient’s head is completely extended. Occasionally, depending on the body habitus of the patient, a shoulder roll may be helpful to increase the extension of the neck. The patient’s neck, shoulders, and chest down to the nipple line is exposed. After a side is chosen, the patient rotates their head to the contralateral side. A pad or towel is placed underneath neck and shoulder area to collect any blood that may drop from the field and down onto the bed. A generous betadine prep is then performed with the following boundaries including ear lobe, angle of the jaw, lateral and anterior neck past the midline, anterior chest past the midline and inferior portion of the chest to just above the nipple line, and laterally up to the shoulder along the edge of the trapezius muscle. The patient is then draped in order to expose the sternal notch, lateral neck, and the medial portion of the clavicle.

Prior to draping, all materials should be ready to expedite the procedure so the patient is not draped for an inordinate long period of time. It is often useful to prepare the line after the patient has been washed, i.e. antibiotic soaps have more effect after they dry.

A mask, gown, and sterile gloves should be worn for all insertions of central venous lines, except for emergencies. Ample saline flush should be available, as well as extra syringes. The central venous line should be flushed ahead of time. Often it is helpful to remove the heplocks at the end of each line and use the luerlock to minimize the contact with needles. Once the resident is gowned and the line is prepared, the patient is draped. The patient is then placed in Trendelenburg. The patient should be positioned with the head near the tip of the bed. Standing at the head of the bed, the resident should palpate the carotid pulse and locate the sternal notch as well as the anterior border of the sternocleidomastoid. Along the inferior portion, the clavicular and sternal heads of the sternocleidomastoid should be palpated. It is at this muscular apex that the jugular vein should be
cannulated. The skin wheel with 1% Lidocaine is then placed at this area and then a deeper penetration in the subcutaneous tissue and sternocleidomastoid using a 22 gauge needle. An empty syringe with a 22 gauge needle is then used as a finder needle. Although it is not necessary, two fingers, the second and third, of the contralateral hand, the hand that is not using the needle, can be gently placed on the carotid pulse. With the needle at a 60 degree angle, the skin is then penetrated and the syringe is pointed towards the ipsilateral nipple line. At all times the resident should keep in mind as to where the carotid artery is in relation to the tip of the 22 gauge needle. It is extremely important to remember that the jugular vein is slightly lateral and anterior to the carotid artery. Once a flash is obtained with the 22 gauge needle, the resident should note the depth of the needle as well as the angle and direction. All three of these components are extremely important to avoiding further injury with the 14 gauge needle.

An empty 10 cc syringe with the 14 gauge needle is then used in the same manner to locate the jugular vein. Prior to this, the wire should be prepared to be threaded into the needle. In addition, the bevel should be lined up with the numbers so the resident inserting the line always knows which angle the bevel is positioned. Once a flash is obtained, the syringe is removed and the wire is threaded into the jugular vein. If the patient is on a monitor, the resident should look for any ectopy. If the patient is not on a monitor, the nurse can palpate the pulse while the wire is being threaded. It is important for the resident to visualize where the heart is in relation to the length of the wire. The wire does not need to be put into the right ventricle. Placing it into the superior vena cava will suffice.

The needle is then removed while the wire is left in place. An 11 blade needle is then used to enlarge the skin, taking care to avoid any skin bridges. The introducer is then used to dilate the skin and subcutaneous tissue down to the vein. The dilator does not need to be placed to the hub. The dilator should be used just to dilate the skin and subcutaneous tissues. Often a twisting motion helps to obtain a dilated tract. Gentle pressure is then held on the exit site while the line is threaded over the wire. It is of the utmost importance that the other conduits of the line, that is the ones that the wire will not go through, are clamped. This is to avoid air embolus. Once the line has been threaded up to approximately 12-14 cm, depending on the side, the wire is removed and a thumb is placed over the end of the line to avoid air embolus. A 10 cc syringe with saline is then placed onto the luerlock and any air is withdrawn until blood comes into the syringe. The line is then flushed and clamped. This is done with the other lines that have already been clamped. They should be unclamped after the syringe has been placed onto the luerlock and withdrawn and flushed.
appropriately. Following this, the heplock portion can be placed onto the luerlock.

Depending on the body habitus and the length of the line, the appropriate area should be anesthetized to sew the line onto the skin. Once this has been done, betadine ointment is then placed at the exit site and a 2x2 gauze followed by a Tegaderm is placed over this portion to include all the line except the exiting three lines. This insures more safety as to preventing the line from coming out. The patient is taken out of Trendelenburg and the drapes are removed. A chest x-ray is ordered and reviewed by the individual placing the line.

B. Placement of a central venous line (subclavian approach)

This description will only include those techniques that are pertinent to the subclavian approach. All basic tenants that were discussed in the previous section for a jugular approach should be followed such as wearing sterile gloves, mask, and gown.

Positioning for the placement of the subclavian central venous line is slightly different from the jugular approach. The patient should be placed in the supine position and depending on the body habitus, a shoulder roll should be placed in line with the spine. Obese patients may benefit more from a shoulder roll. The patient’s neck should be extended and turned to the contralateral side. The border of the prep should include the anterior axillary line, top of the shoulder, mid-lateral neck, sternal notch past the midline, and anterior chest. The shoulder should be in the most comfortable inferior position.

All materials should be prepared prior to draping and placing the patient in Trendelenburg. Once this is done, landmarks are defined in the sterile field. The patient should be anesthetized with 1% Lidocaine. Using the thumb and second finger, a right angle is made from the sternal notch until the thumb rests comfortably against and below the angle of the clavicle. Approximately 1 figure breadth below this, a skin wheel is placed with local anesthetic. Using a longer 22 gauge needle, the subcutaneous tissue and the periosteum portion of the clavicle is anesthetized. It is important to anesthetize well in the area of the bone, as this is the most tender area that the patient experiences when placing a 14 gauge needle into the subclavian vein. The needle is then entered perpendicular to the clavicle and at a 45 degree angle. Once the correct depth is obtained by gently grazing the posterior and anterior portion of the clavicle, the direction of the needle is turned to point just above the sternal notch. In addition, the needle is brought down to the chest and more parallel to the torso. Next, the resident’s
other hand, that is not pushing on the needle, is used to guide the needle underneath the clavicle. During this time, the hand with the needle is withdrawing to get a flash of blood. It is important to know where the bevel is at this point. By lining it up with the numbers, the bevel should be placed anteriorly. Once the flash is obtained, the bevel is turned 45 degrees so it is pointing inferiorly. This is to facilitate the wire going into the subclavian vein without difficulty. Also of note, it is preferable not to have saline in the syringe when seeking to find the subclavian vein. As the darker venous blood mixes with saline, it becomes lighter and more red. Often, one cannot discern whether the subclavian artery is punctured. It should be noted that when the subclavian artery is punctured, pulsatile blood through the needle is not always obtained. This is extremely important to remember.

Once a venous flash of blood if obtained, the syringe is removed and the wire is quickly threaded through the needle. If there is any delay in getting the wire to the needle, the residents thumb that is holding the needle, should be placed over the hole of the needle to avoid air embolism. Once the needle is removed, the catheter, being appropriately prepared, is then threaded over the wire and the wire is removed. The syringe is then used to aspirate and flush saline. The catheter is then sewed in and a previously described bandage is applied. A chest x-ray is ordered.

C. Placement of a radial arterial line

Prior to performing a radial art line, an Allen’s test should be performed. If there is any question as to whether the palmer arch is patent or the hand is completely dependent upon the radial artery, this procedure should be avoided for this extremity.

D. Femoral arterial line

With the patient in a supine position, the antiseptic prep should include the appropriate lower quadrant of the abdomen, groin, medial and lateral thigh. Important landmarks include the inguinal ligament, pubic tubercle, the superior anterior iliac spine, and the femoral pulse in relation to these three landmarks. With the pulse palpated, the skin is anesthetized in the appropriate area to get as close to the inguinal ligament as possible. This assures that the common femoral artery will be cannulated and not the profunda or the superficial femoral arteries. By cannulating near the bifurcation, branches can be sheared by the needle tip leading to hematoma or the formation of pseudoaneurysm.
A 2-3 inch 20-22 gauge intravenous catheter should be used for the placement of a femoral arterial line. The arterial line and transducer should be completely set up and ready for attachment once the femoral artery has been cannulated. Putting the intravenous catheter and needle at a 45 degree angle, the femoral artery is punctured and the intravenous catheter is slid over the needle up into the common femoral artery. The arterial line catheter is then connected to the intravenous catheter, which is now in the common femoral artery. Arterial waveform is assured on the monitor. The line is then sewed into the skin. Betadine ointment, 2x2 gauze, and Tegaderm are then placed.

VI. COMMON ERRORS

A. Placement of central venous line (jugular approach)

- While less common than with a subclavian approach, the jugular approach can also result in a pneumothorax. The best preventive strategy is to avoid an approach that is nearly parallel with the body using a more upright angle to enter the jugular vein. This more upright approach increases the likelihood of successful identification of the vein with a finder needle as well.

- The failure to easily identify the jugular vein with a finder needle can be remedied with use of ultrasound.

B. Placement of central venous line (subclavian approach)

- One of the most common errors is pneumothorax. This complication can be lessened by keeping the needle and syringe as parallel to the chest wall as possible once under the clavicle. The incidence of the complication increases with number of passes and therefore can be avoided with making only three passes prior to allowing a more senior resident or faculty to attempt to locate the subclavian vein.

- Puncture of the subclavian artery is also a common error. This can be avoided with careful attention to technique and caution regarding the depth of needle placement.

- Frequently the inability to pass a catheter into the subclavian vein is due to subclavian vein occlusion. This complication may be avoided by taking a careful history of
previous subclavian lines and/or complications with subclavian lines.

C. Arterial Lines

- Serious ischemic complications may occur with failure to perform an Allans test routinely prior to placement of a radial arterial line.

VII. EXPERT VIDEO

Access a video of IJ and subclavian central venous line insertion at the New England Journal of Medicine. We are awaiting permissions for this expert video, however, if your institution has a license with the New England Journal of Medicine, then you would be able to access it. For details, please contact your librarian on how to access this video with the institution license. http://content.nejm.org/cgi/content/full/348/12/1123/DC1

VIII. SUPPLIES & STATION SETUP

A. Placement of central venous line (jugular and subclavian approach)

1. Dummy model, half torso
2. Central venous line kits
3. Gloves
4. Saline or water

B. Placement of radial and femoral art line

1. Dummy model, half torso
2. Dummy model, wrist and hand
3. Two to three inch intravenous catheters, 20 and 22 gauge needle
4. Arial catheters for radial art lines

IX. SUGGESTED TIME

2 hours