Chapter 1

Central Venous Catheterisation

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Central venous catheterisation was first performed in 1929 (Smith & Nolan, 2013) and is now a commonly performed procedure in anaesthesia and intensive care medicine. A central venous catheter is a type of venous access device whose tip lies within a central vein, i.e. the superior or inferior vena cava.

Applied anatomy

Internal jugular vein

The internal jugular vein begins at the jugular foramen (medial to the mastoid process) and runs within the carotid sheath, initially posterior to the internal carotid artery. It then passes lateral to the internal carotid artery and deep to the sternocleidomastoid muscle. It terminates behind the triangular 'window' between the two heads of sternocleidomastoid where it joins the subclavian vein.

A typical approach is to position the patient in the Trendelenburg position with the head rotated 45^{o} away from the site of insertion. The needle is passed at the apex of the triangle formed by sternocleidomastoid, lateral to the carotid pulsation and advanced in the direction of the ipsilateral nipple. The vein is relatively superficial and should be encountered after around 1.5cm (or less) of needle has been inserted.

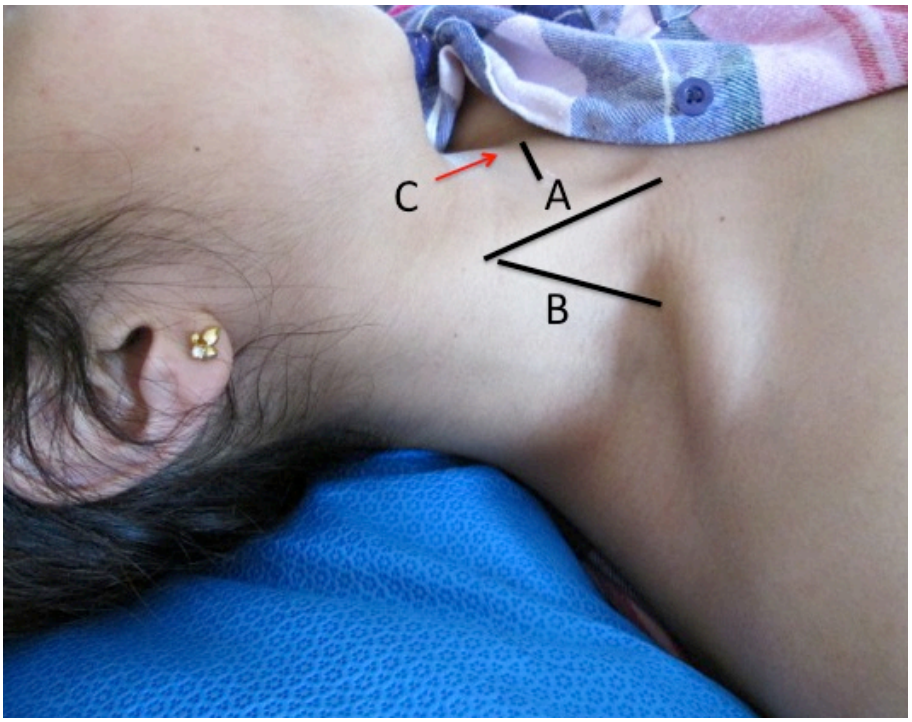

Figure 1: Illustrates the site of needle entry at the apex of triangle formed by two heads of sternocleidomastoid muscle.
A: Sternal head of sternocleidomastoid, B: Clavicular head of sternocleidomastoid and C: cricoid cartilage

Subclavian vein

The subclavian vein is a continuation of the axillary vein, commencing at the lateral border of the first rib. It runs below the clavicle and subclavius muscle. It joins the internal jugular vein at the medial border of the scalenus anterior muscle.

Subclavian vein can be approached by puncturing the skin 1 to 2cm caudal to the midpoint of the clavicle. The needle is then advanced in the direction of the sternal notch until the tip of the needle makes contact with the clavicle at the junction of its medial and middle thirds. The needle is then passed below the clavicle, just under its inferior border where the vein will be punctured.

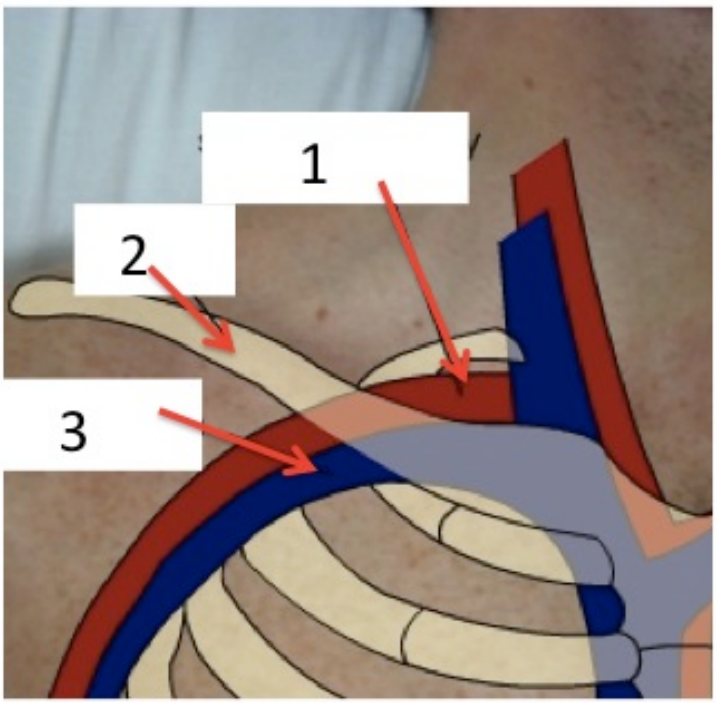

Figure 2: Illustrates the anatomy of subclavian vein. 1.Subclavian artery, 2. Clavicle and 3. Subclavian vein.

Routes of central venous access

A central venous catheter (CVC) can be inserted into a peripheral vein, then guided into a central vein under fluoroscopic guidance. A peripherally inserted central venous catheter (PICC) is a typical example of this technique. These are usually single lumen lines inserted via the brachiocephalic vein. It is more common for the larger multi-lumen catheters to be inserted directly into a larger central vein, such as the internal jugular, subclavian or femoral veins. These lines can either be tunnelled (such as a Hickman line) or non-tunnelled, which is more commonly seen in anaesthesia and intensive care medicine. Non-tunnelled lines are ideally suited to short-term use (around 10 days), whereas Hickman lines can be used for much longer periods of time, but require a small invasive procedure to remove them.

Which rout to use?

In choosing between the internal jugular, subclavian or femoral vein the clinician must consider whether there are any contraindications to using a particular site (such as infection of the overlying skin or vein thrombosis), their own experience with

using each approach, and the frequency of complications associated with each approach.

Femoral CVC's are associated with a higher frequency of catheter-associated infections due to the inherent difficulties of keeping this site clean. They are also associated with a higher incidence of arterial puncture, though this is lessened with the use of ultrasound. The use of the subclavian route confers a higher incidence of iatrogenic pneumothorax and if the subclavian artery is inadvertently punctured it is difficult to apply compression to the site to stem the bleeding. It is also more difficult (though not impossible) to use ultrasound guidance when inserting a subclavian CVC. The most commonly used route is the internal jugular vein which carries a risk of arterial puncture and pneumothorax, particularly if a more caudal approach is used.

Ultrasound guidance

The use of ultrasound to guide CVC insertion has been shown to reduce the incidence of arterial puncture. It's use is now recommended by NICE.

For a right internal carotid approach, the probe should be held vertically and horizontally straight, perpendicular to the neck, ensuring that the medial side of the probe is displayed on the left hand side of the screen. This view will allow the internal jugular vein and internal carotid artery to be seen parallel to one another. The internal jugular vein is (usually) the larger vessel, and is easily compressible with gentle pressure applied with the probe. The internal carotid artery is pulsatile and not compressible.

Figure 3: Technique of holding US probe and image displayed on the monitor

Indications

There are a number of reasons for inserting a central venous catheter (CVC). Some drugs, such as parenteral nutrition (PN) should only be given through a CVC (see below). Other indications include monitoring of central venous pressure, monitoring of central venous oxygen saturations (used in intensive care medicine to guide fluid resuscitation) and the insertion of a temporary dialysis catheter (a type of CVC) for renal replacement therapy and temporary trans-venous cardiac pacing. It should be noted that the practice of inserting a CVC solely for the purpose of measuring the central venous pressure is becoming much less common in light of evidence that this is a very poor indicator of intravascular volume.

Drugs administered through central route include

- Vasoactive and inotropic drugs such as noradrenaline and dobutamine
- Parenteral nutrition
- Amiodarone (continuous infusion)
- Concentrated potassium chloride solution
- Chemotherapy drugs

Contraindications

Although most of the contraindications to insertion are relative, a clinical decision should be made based on risks and benefits of CVC insertion in a given scenario. The contraindications include

- Coagulopathy
- Thrombocytopenia
- Vein thrombosis or stenosis
- Infection overlying the insertion site
- Presence of other indwelling venous devices

In the presence of haemothorax or pneumothorax or a potential risk of pneumothorax (e.g: rib fracture), it is preferred to insert the CVC on the ipsilateral side.

Complications

The insertion of a CVC carries the risk of a number of complications. These can be classified into immediate and delayed complications.

Immediate

- Mechanical complications such as arterial puncture, pneumothorax, haemorrhage, and arrhythmia
- Air embolus

Delayed

- Mechanical complications such as cardiac tamponade, erosion or perforation of vessel and venous stenosis
- Infectious complications such as CVC colonisation or catheter-associated bloodstream infection
- Thromboembolic complications such as catheter-related embolus and air embolism

Performing the procedure

This section will concentrate on the insertion of a non-tunnelled multi-lumen CVC via the right internal jugular vein. The principles discussed can be applied to all non-tunnelled CVC's.

Preparation

Patient

If the patient is conscious, the procedure should be explained to them and written consent should be obtained once the potential complications have been discussed. In an emergency, where the patient is unconscious the clinician should consider whether the CVC is in the best interests of the patient.

Position

The patient should be in the Trendelenburg position with the head rotated 45 degrees towards the left.

Operator (Clinician)

Strict aseptic technique is required when inserting a CVC and so the clinician must clean their hands using a surgical scrub technique and wear a hat, face mask, sterile gown and sterile gloves.

A skilled assistant should be available.

Equipment

These days most of the equipment required for CVC insertion is contained within a single sterile pack. However the clinician should check the tray carefully for any missing or malfunctioning equipment. Other items, such as the ultrasound probe sheath are packaged separately.

Before the CVC is inserted all of its lumens should be flushed with 0.9% sodium chloride to purge air from each lumen. If this step is omitted air can be injected directly into the superior vena cava resulting in air embolus.

A list of equipment required for central venous cannulation

- Ultrasound probe and gel
- 0.9% sodium chloride
- Local anaesthetic: 1% lignocaine
- Chlorhexidine solution
- Sterile drape
- Sterile ultrasound probe sheath
- 22G and 20G needles for drawing local anaesthetic and saline flush
- 20ml syringe
- 5ml syringe x 2
- 18G introducer needle
- Guide wire
- Scalpel
- Dilator
- Multi-lumen CVC
- Hubs or three-way taps to seal each lumen
- Suture hubs
- Suture
- Dressing

Figure 4. Equipment required for central venous cannulation

Technique

1. Clean the skin overlying the insertion site with Chlorhexidine solution
2. Position the sterile drape over the patient with the insertion site exposed through the aperture of the drape
3. Ensure that the CVC is flushed and position all equipment so that it is readily at hand
4. Roll the ultrasound sheath (like a sock) ready to receive the probe
5. Ask and assistant to apply ultrasound gel to the probe, then hold the probe while the sheath is unrolled over it
6. Apply some sterile ultrasound gel to the patients skin, then use the ultrasound probe to locate the vein (see above)
7. If the patient is conscious, infiltrate the skin overlying the insertion site with local anaesthetic
8. Attach a 5ml syringe to the introducer needle
9. Hold the needle perpendicular to the probe and at a 30-45 degree angle to the skin
10. Under direct ultrasound visualisation advance the introducer needle into the internal jugular vein with constant traction on the syringe plunger so that blood will be aspirated as soon as the vein is punctured
11. Taking great care not to advance or withdraw the needle, lower the angle of the needle towards the patients ear
12. Check that the needle is still within the vein by aspirating blood with the syringe
13. Carefully detach the syringe from the needle
14. Place the guide wire introducer on to the needle and advance the guide wire into the vein
15. The guide wire should pass easily and without resistance – do not attempt to force it
16. Whilst advancing the guide wire you should monitor the ECG. If the guide wire enters the right atrium it can trigger arrhythmia. Should this occur immediately withdraw the guide wire.
17. Once around 15cm of the guide wire is in place, remove the guide wire introducer and the introducer needle from the wire taking care not to dislodge the wire
18. At this point, check that the guide wire lies within the internal jugular vein by positioning the ultrasound probe in the same position as before, then tilting the probe caudally. You should see the wire enter the internal jugular vein.
19. Make a small (around 1-2mm) incision in the skin at the point where the guide wire passes though it
20. Pass the dilator over the guide wire and while applying gentle pressure, pass the dilator until it just reaches the internal jugular vein, then remove the dilator from the guide wire. Do not advance too far. The main purpose of dilator is to dilate the skin and soft tissues.
21. Pass the CVC over the guide wire and advance it towards the skin but not through it. Ensure that the guide wire has emerged from the proximal end of the distal lumen of the CVC, and hold onto it with one hand

22. Whilst holding on to the guide wire, advance the CVC until 11-13cm of it is inside the patient, then withdraw the guide wire
23. Ensure that blood can be aspirated from all lumens of the CVC, then flush them again with 0.9% sodium chloride.
24. Attach the suture hubs to the CVC, then suture the CVC in position
25. Apply a dressing over the insertion site
26. Connect the most distal lumen to the transducer tubing to measure CVP. Use the mostwidest lumen (14 G) for intravenous fluids administration.
27. Make sure that all unused lumen are clamped and three taps are closed securely to prevent air entering the jugular vein blood draining out through the lumen.

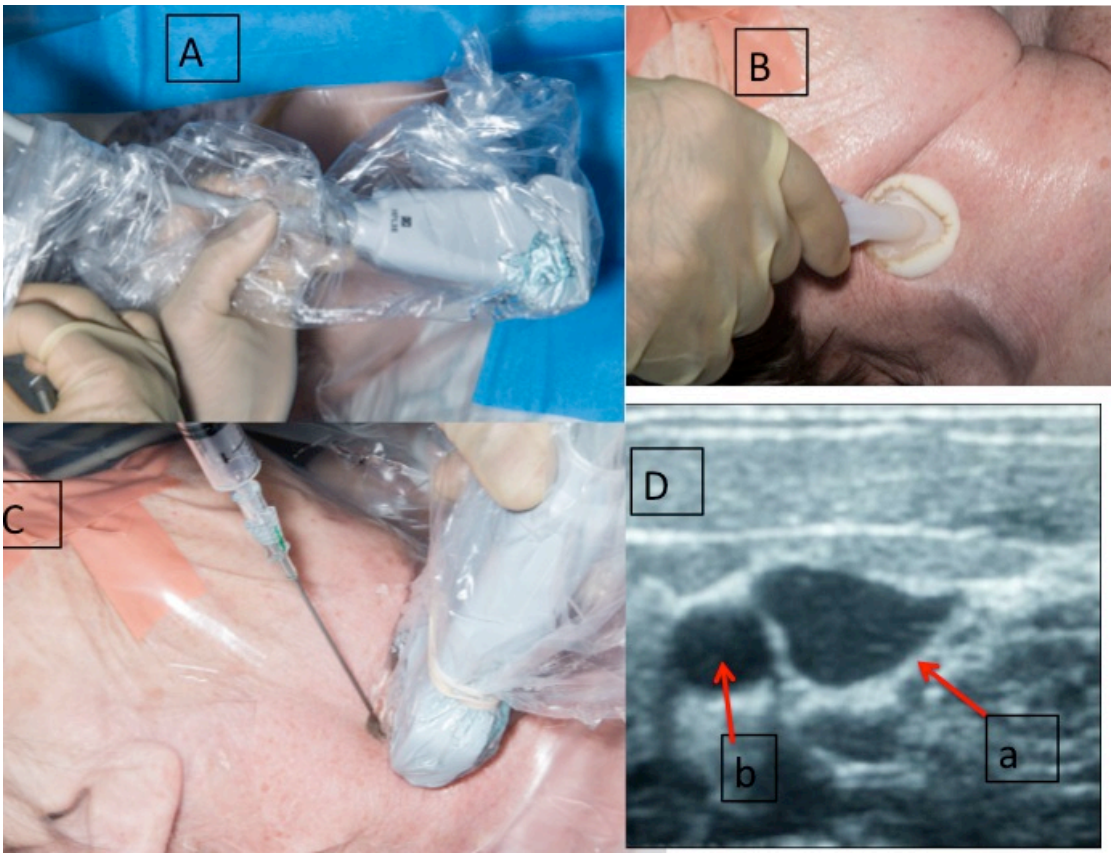

Figure 5: Preparing the ultrasound probe (A), cleaning the skin with chlorhexidine solution (B), Needle insertion point under the guidance of image observed on the ultrasound monitor screen (a: internal jugular vein, b: carotid artery).

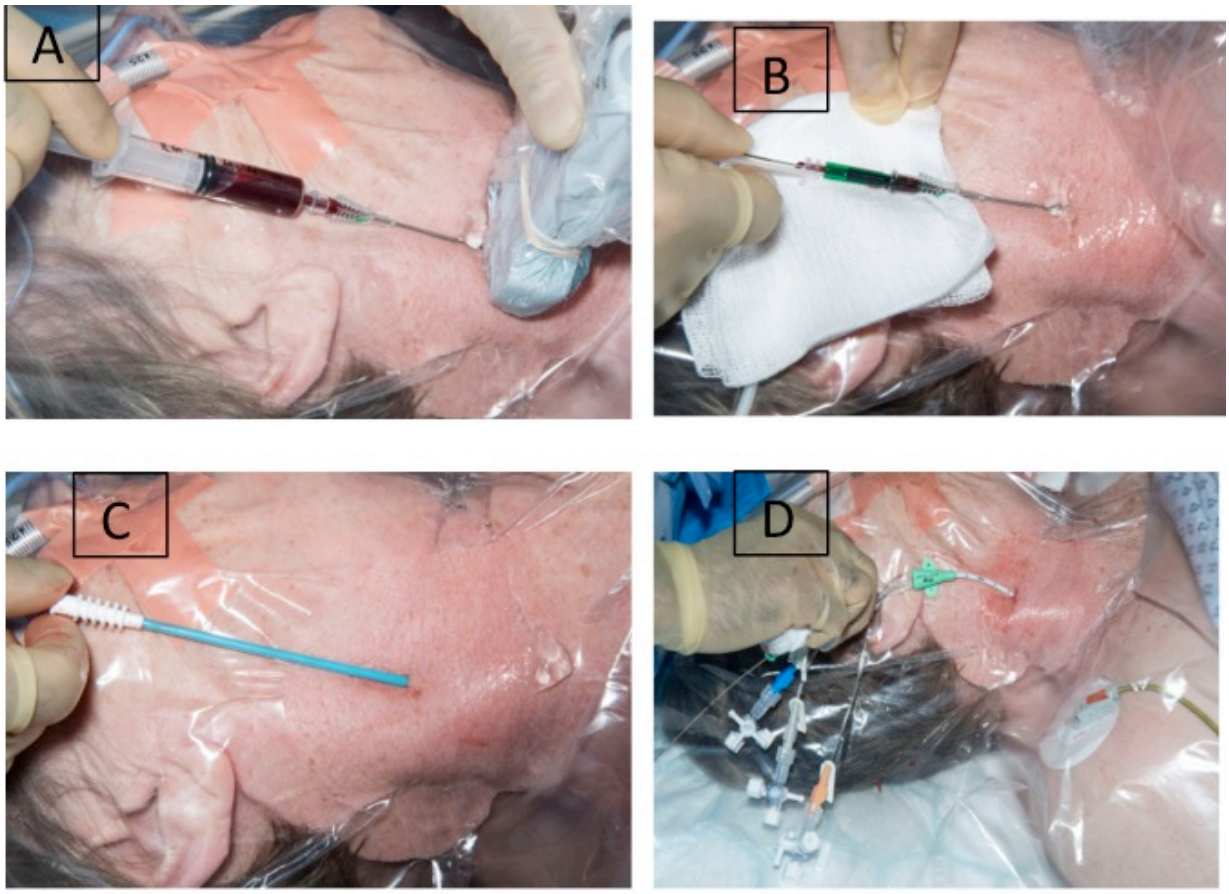

Figure 6: Aspirating blood as the needle enters the vein (A), inserting the guide wire through the needle (B), passing the introducer over the needle (C) and passing the catheter over the guide wire (D).

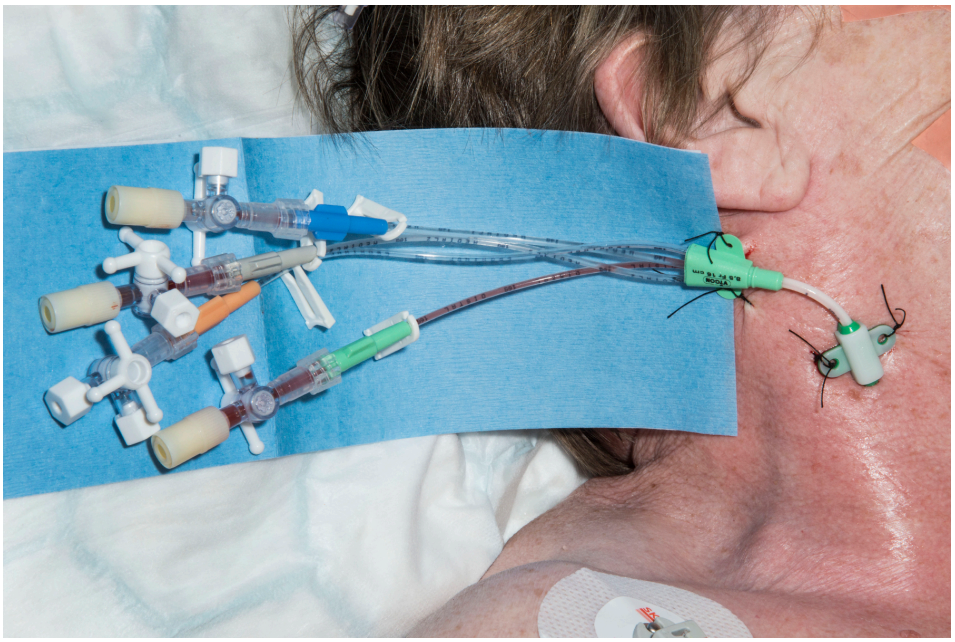

Figure 7: A quadruple lumen catheter insertion via IJV completed. All lumens must be aspirated and flushed with normal saline and three way taps should be correctly in closed.

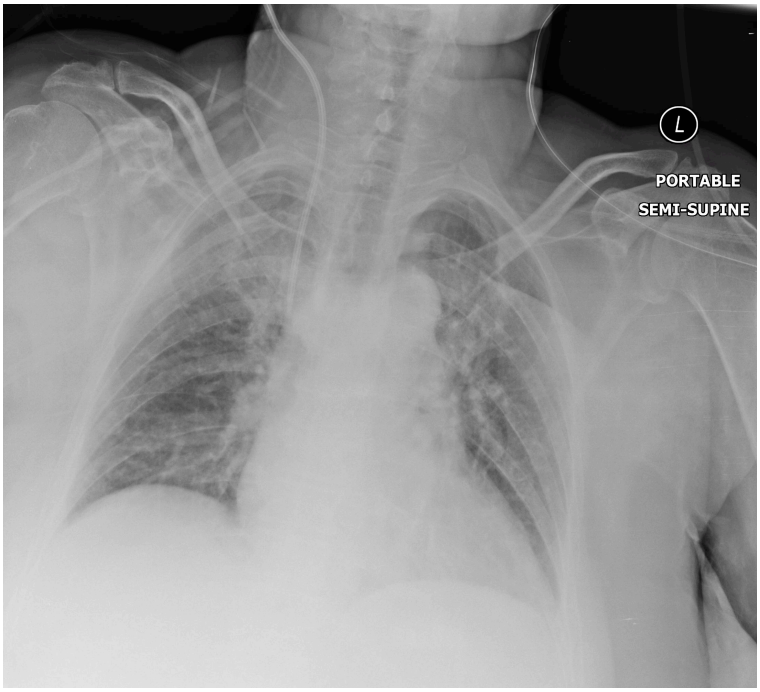

Figure 8: A AP, semi-supine chest x-ray demonstrating the correct position of the tip of CVC via IJV

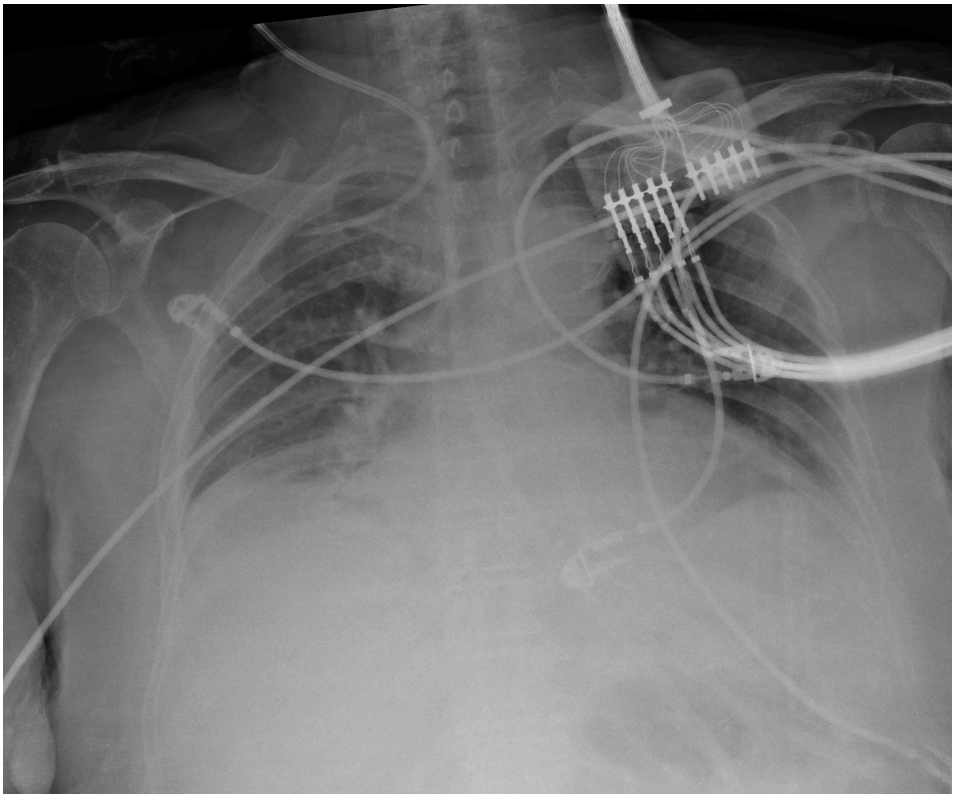

Figure 9: A AP chest X-Ray demonstrating mal position of CVC inserted via IJV entering into the sub-clavian vein.

Post-procedure care

Chest X-ray

A chest x-ray should be performed to ensure that the CVC is in the correct position, and to exclude the presence of a pneumothorax. The tip of the CVC should lie at the level of the carina.

Prevention of catheter related infection

In order to minimise the incidence of catheter-associated infections, aseptic precautions should be used whenever the CVC is handled (i.e. when attaching infusions) and the site should be kept clean and a new dressing should be applied daily.

In the case of a non-tunnelled CVC the need for a CVC should be reviewed on a daily basis and the CVC should be removed as soon as it is no longer required. If the CVC has been in place for more than 10 days and is still required, the clinician should consider inserting a new CVC in a different site and removing the old one.

Catheter-associated infection can lead to sepsis and septic shock if not recognised and treated. The usual pathogens are skin flora such as *staphylococcus* and *streptococcus*. Common signs of catheter-associated infection include erythema or discharge around the insertion site and unexplained pyrexia. Infection should always be considered if the patient has sepsis that is not explained by another cause. The treatment of catheter-associated infection should in the majority of cases include removal of the CVC at the earliest opportunity. Antibiotics such as vancomycin should also be considered.

Further reading

McGee, D. C., & Gould, M. K. (2003). Preventing Complications of Central Venous Catheterisation. *New England Journal of Medicine , 348* (12), 1123-1133.

Smith, R. N., & Nolan, J. P. (2013). Central Venous Catheters. *British Medical Journal , 347*, f6570.

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