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Understanding central venous catheters

By the perioperativeCPD team

Introduction

A central venous catheter (CVC) is one in which the tip or end of the catheter lies in a large vein of the central circulation such as the lower third of the superior vena cava (SVC) or the inferior vena cava. This is often needed in critically ill patients or in those requiring prolonged intravenous therapies that cannot be given orally or through peripheral lines. These catheters are commonly placed in veins in the neck (internal jugular vein), chest (subclavian vein), groin (femoral vein), or through veins in the arms (also known as a PICC line, or peripherally inserted central catheters).

Their insertion and care are specialised skills and should only undertaken by trained practitioners.

Note: this is a module is intended a guide to anaesthetic assistants helping in central line insertion, local policies and procedures will vary and should always be followed.

History

Modern central venous catheterisation started in 1928 when Werner Forssmann, a 25-year-old German surgeon, performed a venous cutdown on his own left antecubital vein, inserted a ureteral catheter to a distance of 65 cm, and then climbed several flights of stairs to the radiology suite to confirm that it terminated in the right atrium. Although the hospital fired Dr. Forssmann for not obtaining permission, he went on to win the 1956 Nobel Prize for his pioneering efforts.

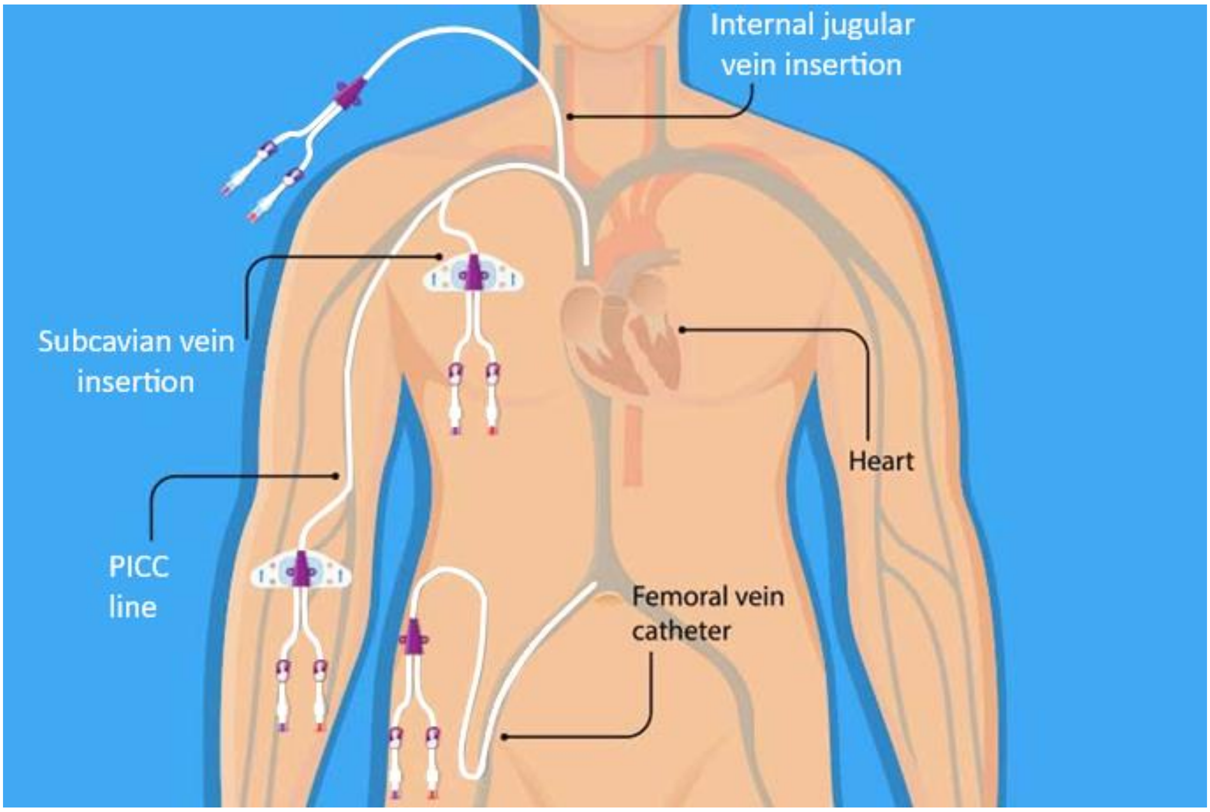
The most important advancement in modern CVC came in 1953 when the Swedish radiologist Sven Seldinger had the idea of advancing large catheters over a flexible wire that was inserted through a percutaneous needle, inventing the Seldinger technique.

Since then, central venous access has become a mainstay of modern clinical practice. Central venous cannulation is a relatively common procedure in many branches of medicine particularly in anaesthesia and intensive care medicine. An estimated 200,000 central venous access procedures are carried out each year in the United Kingdom.

What are central venous catheters?

The term Central Venous Catheter (CVC) refers to an intravenous catheter whose internal tip lies in a large central vein. There are various different types of CVC, but common to all is the concept that the tip of the catheter floats freely within the bloodstream in a large vein parallel to the veins wall. This ensures blood flow around the catheter is maximised, and physical and chemical damage to the internal walls of the vein is minimised. They are also often called central lines, CVP lines or central vein access devices (CVADs)

Common central line sites



Indications for use

The following are the major indications for the insertion of central venous catheters:

1. **Delivery of certain medications or fluids** – medications such as vasopressors (e.g., noradrenaline, vasopressin, etc.), chemotherapy agents, or hypertonic solutions are damaging to peripheral veins and often require the placement of a central line. Additionally, catheters with multiple lumens can facilitate the delivery of several infusions of medication simultaneously.
2. **Specialised treatment** – interventions such as haemodialysis, plasmapheresis, transvenous cardiac pacing, and invasive haemodynamic monitoring (e.g., pulmonary artery catheterisation) require central venous access.
3. **Prolonged intravenous therapies** – medications that must be delivered for extended periods of time such as long-term parenteral nutrition, or intravenous antibiotics are administered through a central line.
4. **Difficult peripheral venous access** – central venous catheters may be placed when it is difficult to gain or maintain venous access peripherally e.g., obesity, scarred veins from prior cannulations, agitated patient.

There are no absolute contraindications to the use of central venous catheters as it may be a lifesaving procedure. Relative contraindications include: coagulopathy, trauma or local infection at the placement site, or suspected proximal vascular injury. However, there are risks and complications associated with the placement of central lines, which are covered later.

*Note: Insertion of a catheter solely to measure central venous pressure is becoming less common. A systematic review found a poor correlation between central venous pressure and intravascular volume; neither a single central venous pressure value nor changes in this measurement predicted fluid responsiveness with any accuracy and CVCs should not be inserted purely for monitoring purposes.

Types of catheters

There are a large range of catheters available and selection should be based on site, reason for insertion and the intended length of use.

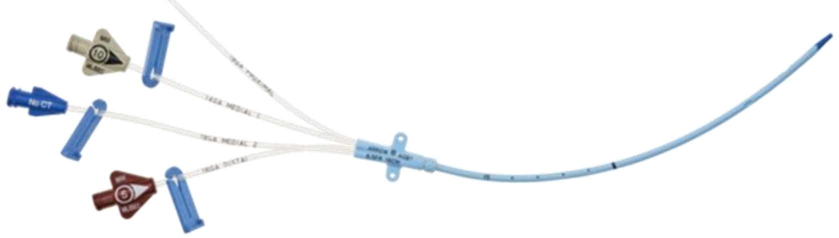
- **Non-Tunnelled central venous catheters** for short term use (the most common type in operating theatres
- **Tunnelled CVC's** intended for long-term use
- **Dialysis catheters** short-term (non-tunnelled) or long-term (tunnelled)
- **Totally Implantable Vascular Access Devices (TIVADs)** also for long term out-patient use
- **Peripherally inserted central catheters (PICC)** for long term out-patient use

Non-tunnelled central lines

Standard multi-lumen central line

These are the most common type of central line in theatres and ITU. They are for short term use, normally less than 3 weeks. Between three and five lumens allow multiple different infusions. Typical adult lengths are 16cm and 20cm with internal lumens of between 14-18G. The lumen exits are placed along the distal catheter body and are rotated 90° around the catheter circumference to minimize mixture of infusions.

As the lumens are long and narrow with a high resistance to flow, they are not effective for rapid infusion. To illustrate, the gravity flow rate of saline through a peripheral 14-gauge (orange) cannula is roughly twice that through a standard multi-lumen 20-cm CVC.



Quad lumen central venous catheter

Large Bore Central Venous Catheter or Introducer Sheath

For rapid infusion of fluids or blood during resuscitation, a shorter wider catheter such as an introducer sheath is better suited. They are available in a variety of sizes from 7.5 to 15 cm in length and 4 to 9F in diameter. Many also allow the introduction of longer devices such as Swan-Ganz catheters, transvenous pacemakers or a pulmonary artery catheter through them.

Due to their large size, sheath introducers should only be inserted into compressible, large veins (as they leave a large hole when removed that will require external compression to achieve post-removal haemostasis). These include the external or internal jugular vein and femoral vein.

Cordis and MAC (multi-lumen access catheter) are examples of introducer sheaths.

Cordis

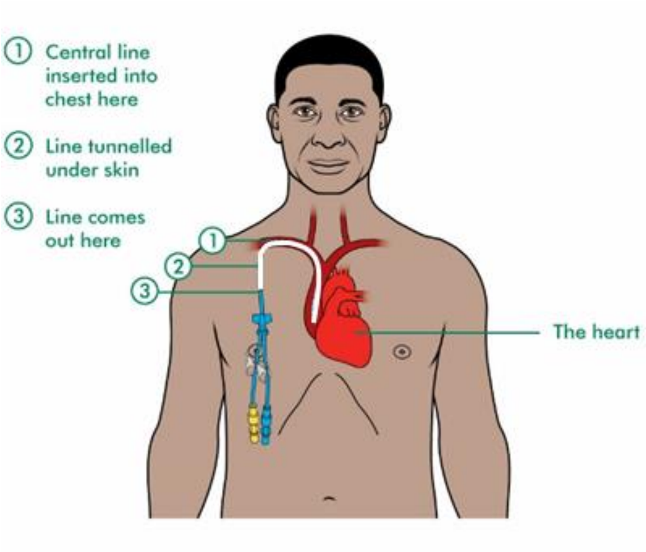
MAC

Tunnelled CVCs

Tunnelled CVCs are for long term administration of irritant drugs such as chemotherapy and typically have 2 or 3 lumens.

Tunnelled catheters are passed under the skin from the insertion site to a separate exit site, as a result they are longer than standard central lines. Passing the catheter under the skin helps to prevent infection and provides stability. The catheter also has a cuff to reduce line colonisation along tract.

Examples: Hickman, Broviac (paediatrics) and Groshong catheters

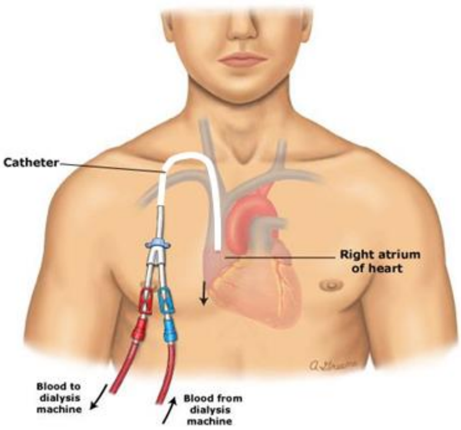


A tunnelled Hickman line

Dialysis catheters short-term (non-tunnelled) or long-term (tunnelled)

Haemodialysis catheters (often called vascaths) are large bore catheters (up to 5.3mm) capable of flow rates of 200–300 ml/min, which is necessary in haemodialysis. There are normally two channels: one is used to carry the patient's blood to the dialysis machine, while the other is used to return blood back to the patient.

Examples: Quinton line (non-tunnelled) or Permacath (tunnelled)

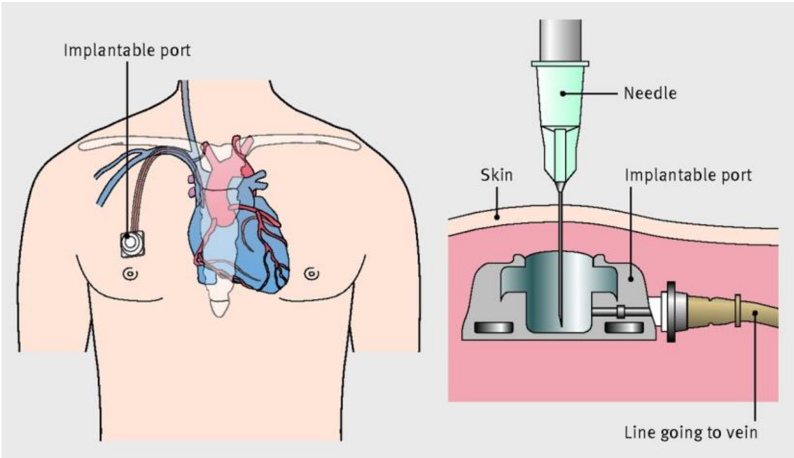


A vascath or Quinton line

Implantable Venous Access Port

A port is similar to a tunnelled CVC but the whole line is entirely under the skin. Medicines are injected through the skin into the catheter. Some implanted ports contain a small reservoir that can be refilled in the same way. After being filled, the reservoir slowly releases the medicine into the bloodstream. Ports are typically used on patients requiring periodic venous access over an extended course of therapy, usually chemotherapy. The port is accessed by a special non-coring needle. An implanted port is less obtrusive than a tunnelled catheter or PICC line, requires little daily care, has lower rates of infection and has less impact on the patient's day-to-day activities. Port access requires specialised equipment and training.

Examples: Portacath, Smartport.

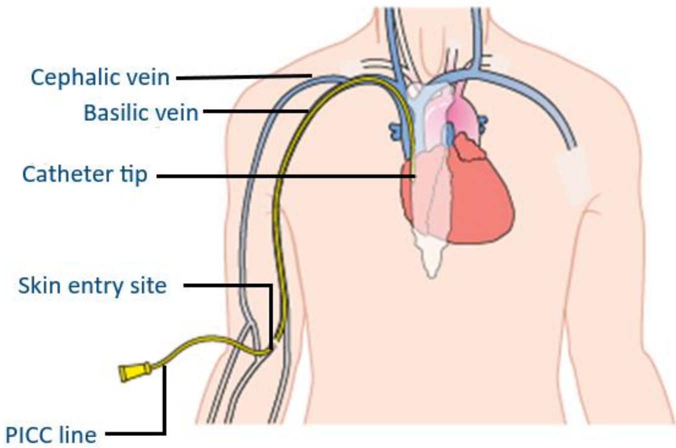


Portacath

Peripherally inserted central catheters (PICC)

The PICC line is not tunnelled but inserted into a peripheral vein. It is much longer than a standard catheter but it still reaches into the great veins. They have a single or double lumen, and are also placed using the Seldinger technique and ultrasound. Most adult PICCs are 60cm in length.

PICCs are usually chosen for patients requiring longer term IV therapy than can be given through a normal central line, for up to one year. They have been shown to be associated with a lower risk of blood-borne infection, especially when they are used on an outpatient basis.



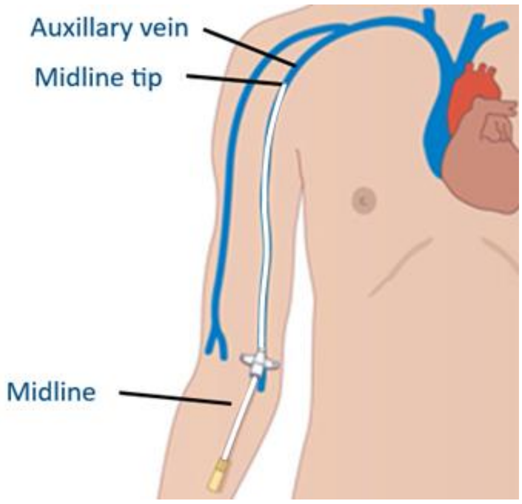
PICC line

What about Midline Catheters?

A midline catheter should not be confused with a PICC line. They are similar to PICC lines in that they have a single or double lumen, use the same access points and both are placed using the Seldinger technique and ultrasound but a midline is a lot shorter at 10cm to 25 cm in length.

Midlines are not central venous catheters because the tip of the catheter is at or below the axillary vein and not in the superior vena cava. For this reason, midlines are considered peripheral devices.

A Midline is can be used for any drug that can be given through a peripheral cannula and is recommended for patients requiring IV therapy for greater 10 days. Midline catheters are about having safe access that is unlikely to be dislodged.



A midline catheter

Equipment required for central venous cannulation

- Patient on a tilting bed, trolley or operating table
- Hat, mask and sterile gown and gloves
- Sterile drapes and gauze swabs
- 2% Chlorhexidine in alcohol solution
- Local anaesthetic with needle and syringe
- Saline flush (prime lines before insertion)
- Appropriate central venous catheter set
- Three-way taps, caps or hubs
- Scalpel blade
- Sutures
- Sterile dressing
- Ultrasound machine (recommended)

Principles of insertion

Confirm a CVC is indeed needed and select the most appropriate route. Explain the procedure to the patient and obtain consent.

The basic preparation and equipment required for CVC insertion is the same regardless of site or technique chosen. A suitable clinical area should be chosen where full aseptic technique can be observed. Sterile gown, gloves and large drapes must be used for the insertion of CVCs. The skin is prepared with a solution of 2% chlorhexidine in 70% isopropyl alcohol. In conscious patients local anaesthetic should be used.

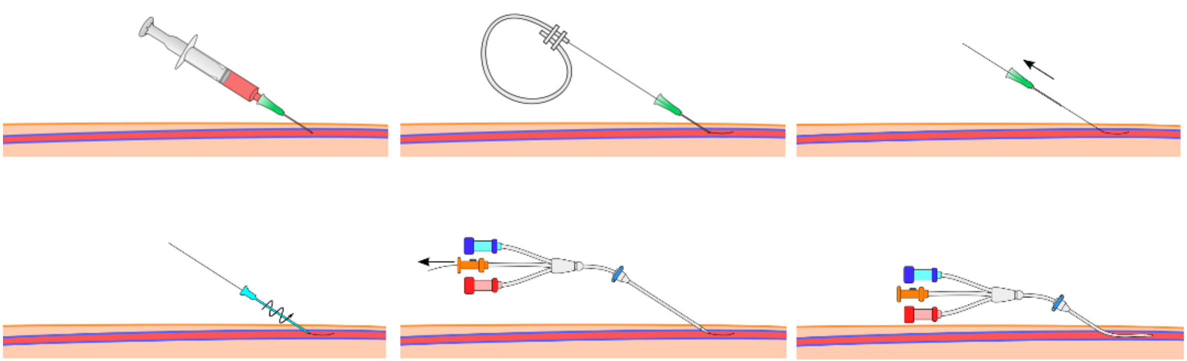
A trained assistant is required and the patient must be monitored with continuous ECG, oxygen saturations and blood pressure measurement. There is evidence that the use of a dedicated 'lines trolley' increases compliance with best practice. The patient is placed head down in the Trendelenburg position.

ECG monitoring is essential because most techniques will at some stage result in the guidewire entering the heart and causing some irritation of the endocardium. Usually, this manifests as ectopics - for example, if the guidewire is in the ventricle, then these will be ventricular ectopics. These arrhythmias are usually consequence-free but the anaesthetist must be informed so they can pull the guidewire back into the SVC.

Ensure all the catheter lumens are flushed with saline and clamp off all except the distal one. It is strongly recommended a needle-free, closed-system hub is connected to the hubs of CVC lumens/3-way taps.

General technique

The most common method of insertion is the catheter over guidewire (Seldinger) technique. The vein is visualised using ultrasound guidance, then punctured with a small gauge needle (18 or 20G) attached to an empty syringe and blood is aspirated easily. If the blood appears bright red, to be at a high pressure or pulsatile, consider the possibility of an arterial puncture.

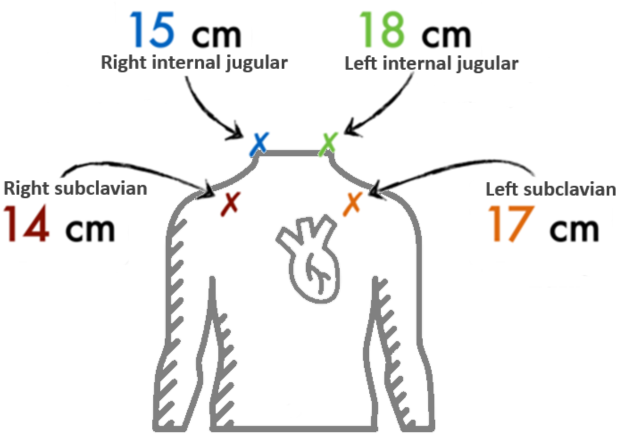


The Seldinger technique

The guidewire is passed down the lumen of the needle into the vein and the needle is removed. The guidewire commonly has a J shaped tip to reduce risk of damage to the vessel wall and help negotiate tortuous vessels. It should advance and withdraw easily at all times.

A dilator is then passed over the guidewire and a small cut made in the skin to allow the dilator to advance into the vein a short distance (further passage along the vein may cause damage to the vessel or distal structures). Gentle skin traction and a twisting motion aids passage of the dilator and prevents kinking of the guidewire. NEVER LET GO OF THE GUIDEWIRE.

The dilator is withdrawn and the catheter is threaded on to the guidewire until the end protrudes from the end of the catheter. The guidewire is held whilst the catheter is advanced to the desired length. External markings on the body of the catheter are used to aid in proper placement of the catheter tip. Care should be taken not to advance the guidewire with the catheter as this may precipitate arrhythmias and there have been cases of guidewires being lost intravascularly.



CVC typical lengths

Remove the guidewire and aspirate and flush all the lumens with sterile sodium chloride 0.9% (plain or heparinised) and secured with a cap or needle-free device according to local policy.

The catheter is secured in place with sutures to prevent it moving and a sterile occlusive dressing applied. Sterile, transparent semi-permeable dressings allow visualisation of the insertion site, and an additional anchor if properly maintained.

The importance of flushing and capping all lumens:

- If you don't flush them, they will clot. *
- All lumens should be capped with a cap or needle-free access device, because: otherwise, the patient will bleed to death, OR a massive air embolism will develop and the patient will still probably die. *
- Follow local policies on flushing and the types of caps as they vary.

In 2016 The Royal College of Anaesthetists published a safety notice following the death of a patient from an air embolism. The coroner's court reported that the patient had died because a nurse had left the CVC port open, which had resulted in an air embolism and cerebral infarction.

* courtesy of https://derangedphysiology.com/main/home

Why are patients positioned head down?

The practice of putting people in a Trendelenburg position is to assist in filling and distending the veins as well as helping prevent air embolus. If the spontaneously breathing patient takes a deep sudden breath during central venous puncture, they could potentially suck enough air into their central veins to fill the right ventricle.

How far head-down do you tilt? The correct answer is probably "enough to get the veins to dilate, but not so much that they fall off the bed" but a more realistic position is a compromise between respiratory function, comfort, intracranial pressure and the upward creep of neck fat and large breasts. Most literature recommends around 15 degrees head down. Reverse Trendelenburg can be used for femoral lines.

Ultrasound

In 2002 the National Institute for Clinical Excellence (NICE) in the United Kingdom recommended the use of ultrasound for the elective placement of CVCs into the IJV. Since this time the use of ultrasound use has increased dramatically. More clinicians are becoming experienced in its use and there is now increasing evidence showing a reduction in number of passes, failure rates, arterial puncture, time to placement and infectious complications using this technique.

Ultrasound guidance is particularly suited to the internal jugular vein, femoral vein as well as peripheral veins. The subclavian vein is not as easy to visualise but recent evidence shows that ultrasound guidance for subclavian vein catheterisation also leads to a reduction in adverse events.

Checks before using the catheter

All CVCs must be checked to confirm intravascular placement of the catheter by aspiration of blood from each lumen.

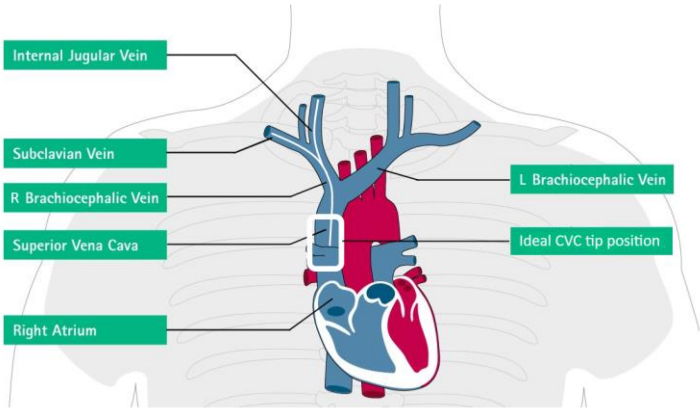
It is also important to ensure the catheter has not inadvertently been placed into an artery. This is ideally done by transducing the pressure waveform as the two waveforms are easily distinguished. Dark blood at low pressure is not always a reliable sign especially in the hypoxaemic, hypotensive patient.

Catheters entering the chest should have a chest x-ray (CXR) taken to confirm correct position of the catheter tip above the level of the carina (not necessary for a femoral line) and not abutting the vessel wall as well as to look for complications such as misplacement or pneumothorax. Misplaced catheters have been reported in almost every possible anatomical position, including the arterial system, mediastinum, pleura, pericardium, trachea, oesophagus and even the subarachnoid space.

As a rough guide a right sided line with the tip showing just above the carina on a CXR will be safe to use.

What is the optimal location for the tip of the central venous catheter?

To reduce the risk of complications and for accurate CVP measurement, the tip of sort term multi-lumen central venous catheters (CVC) should lie within the superior vein cava (SVC), approximately 2–4 cm above the entry to the right atrium and just as importantly be parallel to the vessel walls.



The risk of vessel erosion and perforation is increased if the tip of the CVC is perpendicular to and touching the side wall of a vein. If necessary, the CVC should be withdrawn to achieve a satisfactory position; for left internal jugular and left subclavian approaches this may mean that the CVC tip sits further up in the left brachiocephalic vein.

The tip placement is different for long-term catheters. To reduce rates of thrombosis related to long term catheters, in these patients the catheter tip should lie at the junction of the superior vena cava and right atrium, which is lower than that recommended for other patients

Port designation

The ports in a triple-lumen line are described as proximal, medial and distal - these are the reverse of proximal and distal as regards the patient. In other words, the ports are proximal or distal in relation to the site where the line goes into the patient. So the lumen that opens up at the very tip-end of the catheter - that's the distal port, because it opens the farthest away from the insertion point.

Traditionally the distal port (brown) is used for monitoring the CVP as is the largest lumen and it is closest to the heart although some hospitals now use the proximal (white) port instead for monitoring as it will show if the line has migrated potentially leading to the subcutaneous administration of drugs resulting in significant morbidity and even death. Check your local policy.

The proximal port is often designated for blood sampling. This choice is made because the rapid flow of blood within the large central vein quickly carries the infusions from the more distal lumens, that might affect laboratory tests, away from the proximal sampling port.

Note: Different manufacturers and brands may have different coloured lumens.

Another designation that has gained widespread acceptance is the need to reserve one lumen exclusively for total parenteral nutrition (TPN). The rationale for this designation is the prevention of catheter-related infections. When using a triple lumen catheter, the middle port is often chosen.

Measuring central venous pressure

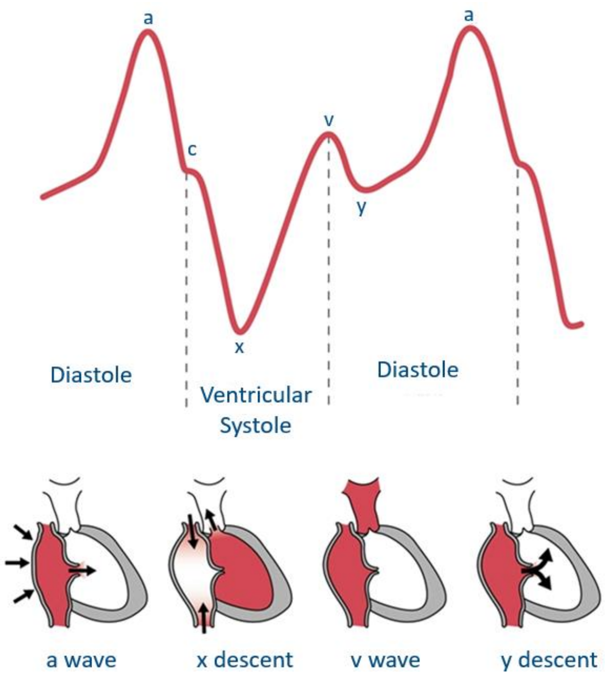
CVP, sometimes referred to as 'filling' pressure, is the pressure of blood returning to, or filling, the right atrium. CVP reflects the amount of blood returning to the heart via the venous system and the ability of the heart to pump the blood into the arterial system.

Normal CVP range is 3-10mmHg. The monitor will display a CVP waveform, which usually 'swings' with each respiration.

There are many other factors that affect the reliability and accuracy of CVP readings. The relationship between CVP, cardiac output, medications and the vascular system is complex, making CVP readings complicated to interpret in relation to general cardiac functioning. For example, in critical care settings, an important influence is mechanical ventilation. Mechanical ventilation or IPPV increases the CVP measurement by approx. 3cmH_2O.

Very roughly:

- Low CVP may indicate hypovolaemia
- Elevated CVP indicates right ventricular failure or volume overload.



Central line trace

Note that the wave has three peaks a, c and v and two descents, x and y.

a – the rise in right atrial pressure caused by atrial systole.

c – the ventricular contraction causes the tricuspid valve to bulge upwards into the right atrium (RA).

x – the decrease in pressure in the RA as the tricuspid valve moves away from the RA during ejection of blood from the right ventricle.

v – the peak in atrial pressure during ventricular systole when the tricuspid valve is closed.

y – the tricuspid valve opens and blood rapidly empties into the right ventricle during diastole.

CVC transducing

The setup and principles of the CVP transducer, including levelling and zeroing is the same as for an arterial line transducer and are covered in our module: *The fundamentals of arterial lines.*

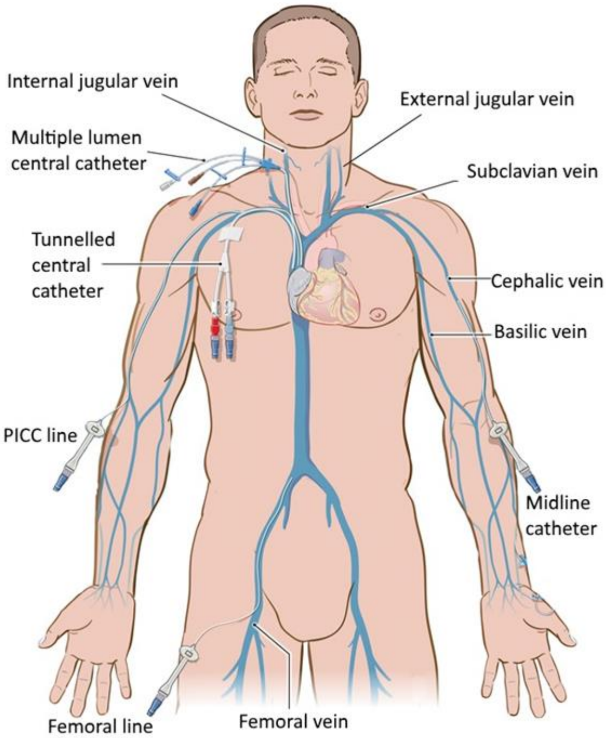
CVC transducers and tubing should always be labelled blue and arterial line transducers and tubing red to prevent inadvertent connections.

Site selection

There are a number of approaches to the central venous system and with exception of the external jugular vein and PICC lines they are generally deep structures often running close to arteries and nerves as well as other structures (e.g., pleura).

The main veins accessed are

- Internal jugular
- Subclavian
- Femoral
- External jugular (only if no other access is obtainable)
- PICC line - Peripheral / Antecubital veins (Basilic or Cephalic).



Catheter insertion sites

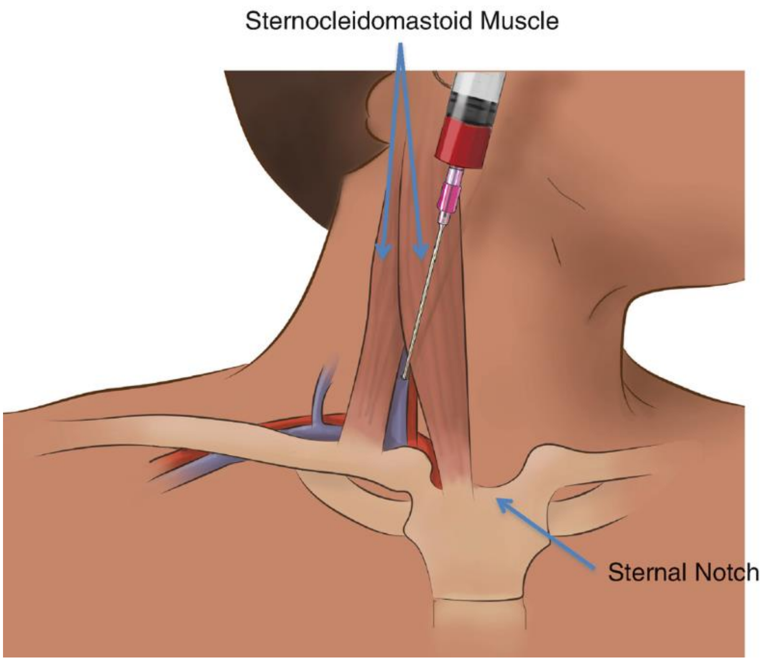
The Internal Jugular Vein

The internal jugular vein (IJV) is most frequently chosen site for CVC insertion in the UK. It is a potentially large vein which is relatively easy to locate, with a lower risk of pneumothorax compared with the subclavian approach. Inadvertent arterial puncture can be easily controlled with manual compression. Many approaches have been described depending on the level of the neck at which the vein is punctured. The central approach the most common, has less chance of arterial puncture and with experience has a low incidence of complications. However, with the IJV occlusion can occur with head movement and it may cause irritation in conscious patients.

Anatomy problems

CVC insertion can be difficult in the morbidly obese as landmarks are often obscured and those patients with very short necks or limited range of movement can be ergonomically challenging.

The right IJV which is most commonly used, offers some advantages in that it tends to be larger and straighter than that on the left, it is more convenient for the right-handed practitioner and avoids the possibility of thoracic duct injury.



Central approach IJV

Positioning

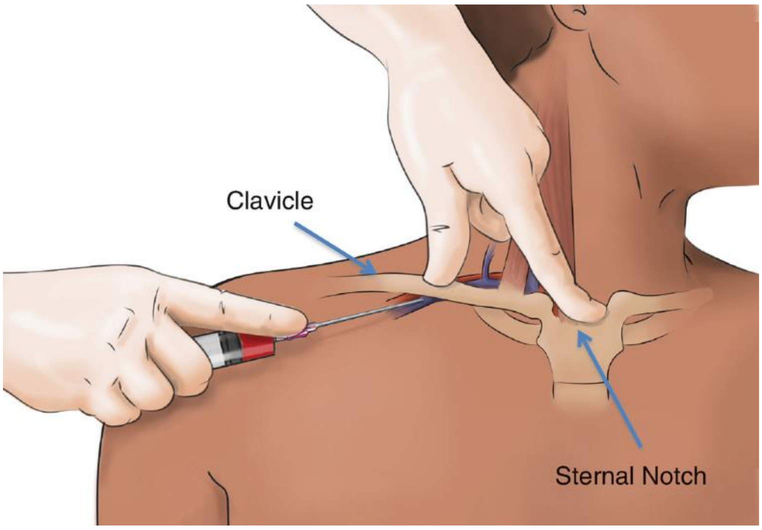
The patient is supine, arms by their sides with a head down tilt (Trendelenburg) to distend the veins and reduce the risk of air embolism. The head should be turned away from the side of cannulation for better access (excessive turning should be avoided as it changes the relationship of the vein and artery and can collapse the vein). The patient’s neck can be extended by removing the pillow and putting a small towel under the shoulders.

Subclavian vein

The subclavian vein (SC) is a continuation of the axillary vein coming from the arm. It has a diameter of 1-2cm in adults and is thought to be held open by its surrounding tissues even in severe circulatory collapse. This site is often preferred as it is generally more comfortable for patients, can be easily tunnelled and has the lowest rate of infection and other long-term complications. This route may also be preferred in trauma patients with suspected cervical spine injury. However, because of its anatomical position below the clavicle, it is associated with a higher risk of pneumothorax. Use of the SCV is more common in Australia and New Zealand.

Positioning

The patient should be positioned as for the internal jugular approach with head down to fill the veins and reduce the risk of air embolism.



Infraclavicular approach SVC

Technique

The right SCV is usually preferred as this approach avoids damage to the thoracic duct. The infraclavicular approach is most commonly used where the needle is inserted into the skin slightly below the clavicle. The needle is kept in the horizontal plane advancing under the clavicle aiming for the sternal notch. The needle should not pass beyond the sternal head of the clavicle.

Access to the SCV during insertion may be helped by downwards traction (5 cm extension) on the relevant arm, or by placing a roll under the shoulder.

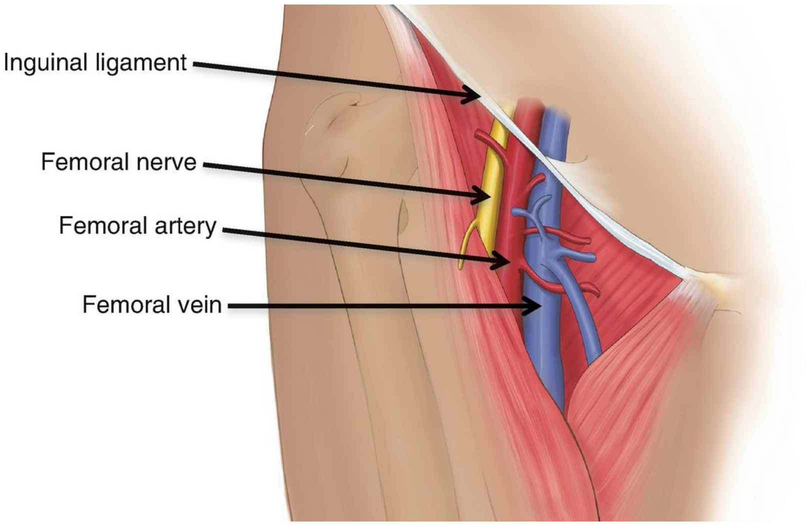
Although technically more difficult, ultrasound guidance of the SCV catheterisation should be utilised. Moving further out to the auxiliary vein gives a better ultrasound image but this is considered an advanced technique.

Femoral vein

The femoral vein is a less frequent site used to insert a CVC. However, this site may be required for patients with acute neurological injuries such as traumatic brain injury, raised intracranial pressure or head trauma, since the femoral vein is furthest away from cerebral blood flow and will therefore not affect intracranial pressure.

Femoral lines have a high risk of infection because of the greater degree of bacterial colonisation found in the groin compared to other sites and are challenging to maintain, partly because they often have to be covered by a sheet to preserve the patient's dignity. This creates a risk that any disconnection of the line may not be immediately identified. There is also an increased risk of thromboembolic complications compared with internal jugular and subclavian approaches.

The large diameter of the femoral vein allows large volumes to be removed and infused and because of this it can be used in the ITU for placement of short-term haemofiltration catheters.



Technique

Palpate the femoral artery 2cm below the inguinal ligament and insert the needle 1cm in from the pulsation and aim up (cephalad) and slightly in (medially) at an angle of 20-30° to the skin. In adults the vein is usually 2-4cm below the skin. Head up position may help in femoral line insertion.

Practical problems

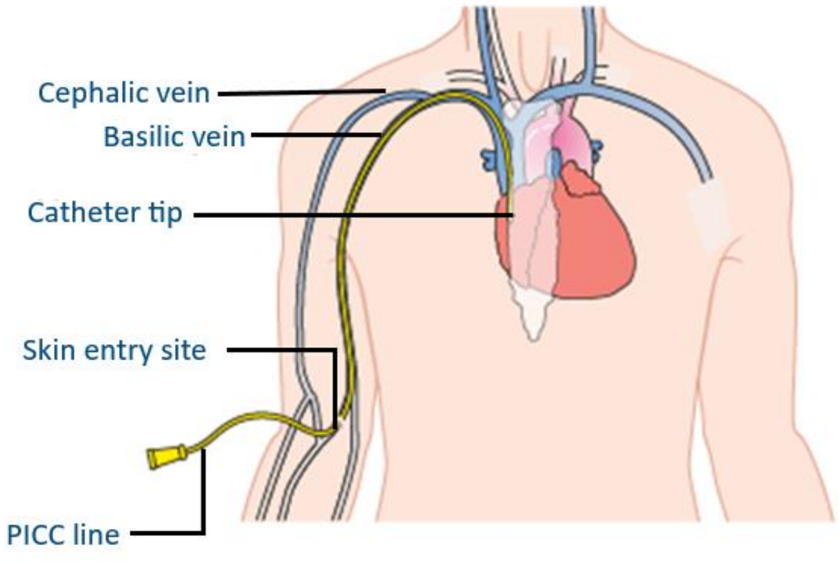
It can be difficult to feel the arterial pulsation especially in obese patients. Get an assistant to retract the abdomen if this is a problem and recheck the landmarks. As with the other approaches' ultrasound, if available can be very useful to assess anatomy and guide the needle.

External Jugular Vein

As the external jugular vein (EJV) lies superficially in the neck it is often visible or palpable which negates many of the complications of the deep vein approaches. It is only used when expertise is lacking, for emergency fluid administration and in cardiac arrests where no carotid pulse is palpable. Due to the anatomy, there is a 10-20% chance the catheter will not thread into the SCV and it has a high failure rate.

PICC lines - The Antecubital Veins

The superficial veins of the antecubital fossa provide a very safe route for central access. Risk of infection is lower than other routes and lines can be used for longer periods (e.g., TPN, prolonged antibiotic courses or chemotherapy). A long catheter is required (around 60cm) to thread the tip into the central veins and for this reason flow rates are low and there is a large dead space making them less useful for resuscitation and inotropes. Tip position is important as migration can occur with movement of the arm (up to 2 cm).



Anatomy

Two main veins are available but the more medial basilic vein has a smoother, more direct route to the SCV. The more lateral cephalic vein turns sharply to pass through the clavipectoral fascia and also has valves at its termination. Both these factors frequently cause difficulty in advancing the catheter.

Technique

Estimate the length of catheter required to reach the superior vena cava. Insert the cannula supplied in the set and remove the needle. Thread the catheter through the cannula and advance it 2-4 cm before releasing the tourniquet. Continue to advance the catheter until the desired length is inserted. The cannula is often designed to tear apart to remove it from the catheter. Other sets contain a guidewire and dilator for a Seldinger technique.

Complications

Complications can occur in up to 10% of CVCs and can be divided into mechanical, infectious and thromboembolic causes, the most common of which are listed below.

Complication rate is dependent on a number of factors including site, patient factors (concurrent illness and variations in anatomy) and operator skill and experience. There are no absolute contraindications to central venous cannulation as it can be a lifesaving procedure but serious complications including death may occur during insertion or ongoing use of CVC.

Anaesthetist training and experience are important factors in reducing complication rates and experienced help should be sought with multiple attempts. The frequency of mechanical complications is six times greater than after a single attempt.

Note: for experienced anaesthetists the route they have the most experience in is the one that will have the lowest rate of complications.

Complications can include:

Arterial puncture:
Accidental puncture of the carotid, vertebral, subclavian, basilic, axillary or femoral arteries can occur during insertion. Arterial blood is bright red and blood flow is substantial.

Perforation of vasculature by a catheter is a potentially life-threatening complication of central lines, especially if it is not immediately recognised and the artery dilated. Fortunately, the incidence of these events is exceedingly rare, especially when lines are placed with ultrasound guidance.

Pneumothorax
Pneumothorax may occur if the catheter punctures the chest wall, allowing air to enter the pleural cavity. The incidence of pneumothorax is highest with subclavian vein catheterisation due to its anatomic proximity to the apex of the lung. The risk of pneumothorax can be minimized by the use of ultrasound guidance.

Cardiac dysrhythmias
Cardiac dysrhythmias can occur during placement if the tip of the guidewire or catheter touches the cardiac wall. The assistant should observe the heart rate and rhythm, and inform the medical practitioner of any. Most dysrhythmias are usually consequence-free.

Air embolism
Entry of air into venous circulation has the potential to cause a venous air embolism. This is a rare complication of CVC placement – however, it can be lethal. The team should ensure that all lines are primed with fluid before connection and that there is no leakage in the system. Manoeuvres that increase central venous pressure, thereby reducing the likelihood of air embolism, include fluid resuscitation, head down (Trendelenburg) position and positive pressure ventilation.

Air emboli of less than 10-20ml rarely cause problems, but a large pulmonary air embolus can cause death.

Air embolism can also occur up to 48 hours after CVC removal.

Occlusion
Venous catheters may occasionally become occluded by kinks in the catheter, backwash of blood into the catheter leading to thrombosis, or infusion of insoluble materials that form precipitates. Thrombosis is the most common cause of central line occlusion, occurring in up to 25% of catheters. However, most cases (more than 95%) of catheter-associated thrombosis go undetected.

Misplacement
During subclavian vein central line placement, the catheter can be accidentally pushed up into the internal jugular vein on the same side instead of the superior vena cava. A chest x-ray is performed after insertion to rule out this possibility. The tip of the catheter can also be misdirected into the contralateral (opposite side) subclavian vein in the neck, rather than into the superior vena cava.

CVC misplacement is more common when the anatomy of the person is different or difficult due to injury or past surgery.

Infection
Infection is the most common complication associated with central venous access devices and one of the most serious. The problem of central line-associated bloodstream infections (CLABSI) has gained increasing attention in recent years. They cause a great deal of morbidity (harm) and deaths, and increase health care costs. In a 2011 UK national point prevalence survey on healthcare associated infections and antimicrobial use, 40% of primary blood stream infections were related to a central venous catheter

The use of a dedicated lines trolley and care bundle is proven to reduce infections.

Antimicrobial-coated catheters are available and have been designed to reduce the incidence of catheter-related bloodstream infection. These can be either antiseptic coated (e.g., chlorhexidine, silver) or antibiotic coated (e.g., minocycline/rifampin) on either the internal or external surface or both. Chlorhexidine coated CVCs have been associated with cases of anaphylaxis.

A Cochrane Review (March 2016) on catheter impregnation, coating or bonding for reducing CVC-related infections in adults found reliable evidence that antimicrobial CVCs are effective in reducing catheter colonisation and catheter-related infections in adults, but they do not appear to reduce clinically diagnosed sepsis or deaths from all causes. There are also cost implications as well as the potential for drug resistance.

It is recommended antimicrobial-coated catheters should only be considered if the expected duration of catheterization is >5 days and if the incidence of catheter-related infections in an ICU is unacceptably high.

Care of the central line

Note: Local training and policies should be followed in all instances.

Hand hygiene must be performed prior to each access e.g., to give a medication or to connect or disconnect administration sets.

Cap off the catheter with a needle-free access device (e.g., smartsafe, safeflow) when not in use. This will minimise interruptions to the closed system and the risk of contamination.

'Scrub the Hub' - all needle-free access devices should be cleaned for 15 seconds using chlorhexidine 2% in 70% alcohol and then allowed to air dry for 15 seconds.

Do not allow air to enter the catheter. All syringes and intravenous administration sets must be carefully primed. The negative pressure within the chest may suck air into the catheter during inspiration especially if the patient is sitting up.

Whenever the bung/access device is removed from the catheter then it must be replaced with a new, needleless access device/bung to prevent infection.

If the catheter possesses an integral clamp, keep it closed whenever the cap is removed and at all other times except when administering or withdrawing fluids. The clamp will prevent air entry and bleeding should the luer lock cap become unattached.

Always take signs of systemic or local infection seriously and refer to a doctor. Infection continues to be one of the most frequent and most serious complications associated with CVC Catheters.

Before it is used for administering therapeutic drugs or fluids, the patency and correct functioning of the catheter should be established. Signs of catheter occlusion, whether partial or complete, should be taken seriously and action should be taken earlier rather than later to restore full patency. Ignoring the early signs may lead to the development of more serious problems which cannot then be easily rectified – e.g. complete blockage or thrombosis.

If using a CVC one can be confident of access if all three of the following apply:

- The catheter can be **flushed with ease**.
- **Blood can be withdrawn** from the catheter.
- The patient experiences **no discomfort** during flushing/infusion and there are no other complications.

After each use flush the catheter with Sodium chloride 0.9%, 5-10mls using the push – pause method (injecting 1ml at a time to create turbulent flow) to minimise the risk of occlusion. The solution will vary depending on the patient's clinical status, speciality, and in line with local policy.

NICE (UK) guidelines state there is no good evidence that flushing short-term central venous catheters (CVCs) with heparin is better than flushing with normal saline solution (sodium chloride 0.9%) but local policies vary.

Note, the volume of a syringe matters. It is significantly more likely for you to fracture the CVC when flushing a blocked lumen with a small syringe, a 10ml syringe is recommended.

Removal

Catheters should be evaluated daily for medical necessity. Local policies vary on how long short-term catheters stay in but 10-15 days is common. Routine catheter replacement is not recommended and the catheter should only be changed when clinically indicated (or within manufacturers guidelines). Removal should only be performed by appropriately trained personal.

To remove internal jugular or subclavian lines, the patient should be placed in Trendelenburg position, which decreases the risk of air embolism. The sterile dressing is removed, the sutures are cut, and the catheter is slowly retracted while applying pressure over the vein.

If appropriate, ask patient to take a deep breath in, hold it, and bear down (Valsalva manoeuvre) to reduce the chances of air embolism.

Pressure should be held on the site for 10 min, and then haemostasis should be confirmed. If the patient is coagulopathic, pressure may need to be held for up to 30 min. A sterile dressing can then be applied.

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