Central Venous Pressure

(CVP)

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Definitions

- **Central venous pressure (CVP) describes the pressure of blood in the thoracic vena cava, near the right atrium of the heart.**
- **CVP reflects the amount of blood returning to the heart and the ability of the heart to pump the blood into the arterial system.**
- **Central Venous Pressure is a more accurate and reliable way of monitoring the patient's fluid balance and cardiac status.**

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CVP

- **A central venous access device is a single or triple lumen catheter which is passed via direct entry into the subclavian, jugular or anticubital vein.**
- **The tip of the catheter is placed into the vena cava or right atrium of the heart.**

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When should CVP be measured?

- **Paients with hypotension who are not responding to basic clinical management.**
- **Continuing hypovolaemia secondary to major fluid shifts or loss.**
- **Patients requiring infusions of inotropes.**

Function of Central Venous Pressure:

The CVP is often used to make estimates of circulatory function, in particular *cardiac function* and *blood volume*.

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Various values of CVP

The CVP catheter is an important tool used to assess right ventricular function and systemic fluid status.

- **Normal CVP is 2-6 mm Hg.**
- CVP is **elevated** by :
  - **Decreased cardiac output .**
  - **Increased blood volume.**
  - **Venous constriction.**
  - **Changing from standing to supine body posture.**
  - **Arterial dilation.**
  - **Forced expiration (e.g., Valsalva).**
  - **Muscle contraction (abdominal and limb).**
- CVP **decreases** with:
  - **hypovolemic shock from hemorrhage, fluid shift, dehydration**
  - **negative pressure breathing which occurs when the patient demonstrates retractions or mechanical negative pressure which is sometimes used for high spinal cord injuries.**
  - **Deep inhalation .**

Assisting with CVP placement:

- Adhere to institutional Policy and Procedure.
- Obtain history and assess the patient.
- Explain the procedure to the patient, include:
  - local anesthetic
  - trendelenberg positioning
  - draping
  - limit movement
  - need to maintain sterile field.
  - post procedure chest X-ray

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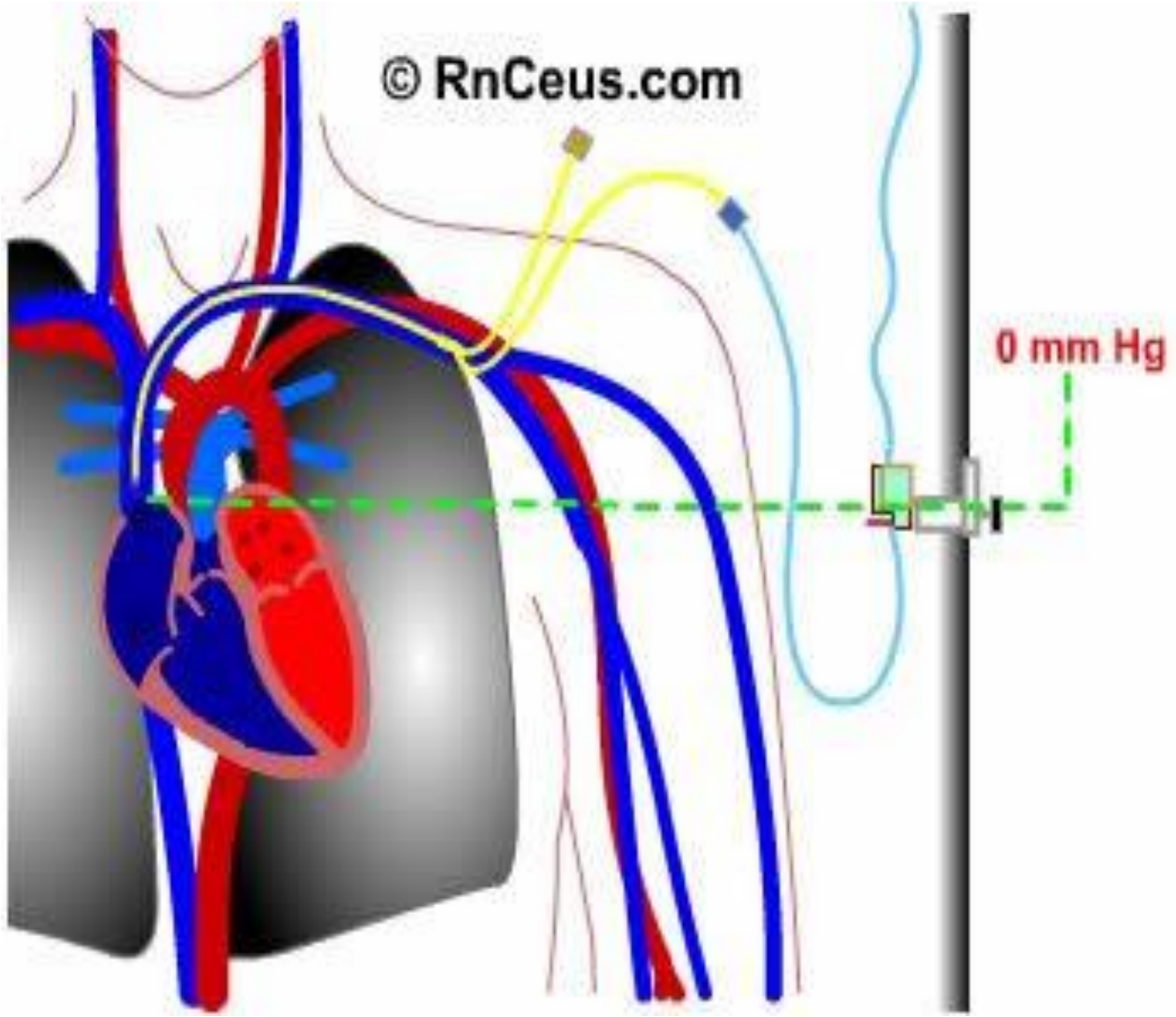
Assisting with CVP placement*: (continue..)*

- Obtain a sterile, flushed and pressurized transducer assembly
- Obtain the catheter size, style and length ordered.
- Obtain supplies:
  - Masks
  - Sterile gloves
  - Line insertion kit
  - Heparin flush per policy
- Position patient supine on bed capable of trendelenberg position
- Prepare for post procedure chest X-ray



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Indications for using CV catheter

Central venous access is the placement of a venous catheter in a vein that leads directly to the heart. The main reasons for inserting a central venous catheter are:

- **measurement of central venous pressure (CVP) .**
- venous access when no peripheral veins are available .
- administration of vasoactive/inotropic drugs which cannot be given peripherally .
- administration of hypertonic solutions including total parenteral nutrition (TPN) .
- haemodialysis/plasmapheresis.
- Provide long term access for :
  - a) Hydration or electrolyte maintenance
  - b)Repeated administration of drugs such as antibiotics or cytotoxic drug.
  - c)Repeated transfusion of blood or blood products
  - d)Repeated Specimen Collection

Contraindications for using CV catheter

- ***absolute***

a) SVC syndrome.

Superior vena cava syndrome (SVCS) is obstruction of blood flow through the superior vena cava (SVC). It is a medical emergency and most often manifests in patients with a malignant disease process within the thorax

b) Infection at the site of insertion .

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Contraindications for using CV catheter

- ***Relative***:

a) Coagulopathies .

b) Newly inserted pacemaker wire .

c) Presence of carotid disease .

d) Recent cannulation of the internal jugular vein.

e) Contra lateral diaphragmatic dysfunction .

f) Thyromegaly or prior neck surgery.

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General preparation to obtain central venous access

- **The basic preparation and equipment that is required for central venous cannulation is the same regardless of the route or technique chosen.**
- **Clinicians who insert central venous lines should be taught the technique by an experienced colleague.**
- **If this is not possible then the access routes associated with the fewest complications are the basilic vein or femoral vein.**

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Equipment required for central venous access.

1)Patient on a tilting bed, trolley or operating table
2)Sterile pack and antiseptic solution
3)Local anaesthetic - e.g. 5ml lignocaine 1% solution
4)Appropriate CV catheter for age/route/purpose
5)Syringes and needles
6)Saline or heparinised saline to prime and flush the line after insertion
7)Suture material - e.g. 2/0 silk on a straight needle
8)Sterile dressing
9)Shaving equipment for the area if very hairy (especially the femoral)
10)Facility for chest X-ray if available
11)Additional equipment required for CVP measurement includes: manometer tubing, a 3-way stopcock, sterile saline, a fluid administration set, a spirit level and a scale graduated in centimeters.

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General technique for all routes

- **Confirm that central venous access is needed and select the most appropriate route.**
- **Explain the procedure to the patient.**
- **Shave the needle insertion area if very hairy**
- **Using a strict aseptic technique, prepare and check all the equipment for use. Read instructions with the catheter.**
- **Sterilize the skin and drape the area**
- **Infiltrate the skin and deeper tissues with local anaesthetic. In cases where difficulty is anticipated use the small local anaesthetic needle to locate the vein before using the larger needle. This reduces the risk of trauma to other structures.**
- **Position the patient as for the specific route described - avoid long periods of head down, particularly in breathless patients**
- **Identify the anatomical landmarks for the chosen route and insert the needle at the recommended point.**
- **After the needle has penetrated the skin, aspirate gently whilst advancing the needle as directed until the vein is entered.**
- **If the vein is not found, slowly withdraw the needle whilst gently aspirating; often the vein has been collapsed and transfixed by the entry of the needle.**

Technique of CL inserting

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Checks before using the line:

- Ensure fluid runs in freely and that blood flows freely back. To observe the latter place the infusion bag below the level of the bed .
- If available, take a chest X-ray (ideally erect) to check the position of the catheter tip and to exclude a ***pneumo***, ***hydro*** or ***haemothorax***. An early radiograph may not show up abnormalities and it may be best to wait 3-4 hours unless symptoms develop. The tip of the CVP line should lie in the superior vena cava just above its junction with the right atrium.
- Ensure that the patient will be nursed where their CV line can be supervised. Give appropriate written instructions regarding how, and what it is to be used for, and who to contact if there is a problem.

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How to measure the CVP?

- **The CVP is measured using a manometer filled with intravenous fluid attached to the central venous catheter.**
- **It needs to be 'zeroed' at the level of the right atrium, approximately the mid-axillary line in the 4th interspace supine.**
- **Measurements should be taken in the same position each time using a spirit level and the zero point on the skin surface marked with a cross.**
- **Check that the catheter is not blocked or kinked and that intravenous fluid runs freely in, and blood freely out.**
- **Open the 3-way tap so that the fluid bag fills the manometer tubing (check there is no obstruction to fluid flow and that the cotton wool in the top of the manometer is not blocked or wet).**
- **Turn the tap to connect the patient to the manometer. The fluid level will drop to the level of the CVP which is usually recorded in centimeters of water (cmH_2O).**
- **It will be slightly pulsatile and will continue to rise and fall slightly with breathing - record the average reading.**

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How to measure the CVP?

- **An alternative to the manometer and 3-way tap is a butterfly needle inserted into the rubber injection port of ordinary intravenous tubing.**
- **In Intensive Care Units or theatres, electronic transducers may be connected which give a continuous readout of CVP along with a display of the waveform.**
- **Useful information can be gained by studying the electronic waveform.**
- **The CVP reading from an electronic monitor is sometimes given in mmHg (same as blood pressure).**
- **The values can easily be converted knowing that 10cmH20 is equivalent to 7.5mmHg (which is also 1kPa) .**

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How to measure the CVP?

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Care of the Central venous Catheter:

- **Use an aseptic technique when inserting the catheter and any subsequent injections or changing fluid lines**
- **Keep the entry site covered with a dry sterile dressing**
- **Ensure the line is well secured to prevent movement (this can increase risks of infection and clot formation)**
- **Change the catheter if there are signs of infection at the site.**
- **Remember to remove the catheter as soon as it is no longer needed. The longer the catheter is left in, the greater the risks of sepsis and thrombosis**
- **Some people suggest changing a catheter every 7 days to reduce the risks of catheter related sepsis and thrombosis.**
- **However, providing that the catheter is kept clean (sterile injections and connections) and there are no signs of systemic sepsis, routine replacement may not be necessary.**
- **Repeated cannulation to change lines on a routine basis, rather than based on clinical need, can increase the risks to the patient.**

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Complications

The main complications that can arise from central venous cannulation are listed in table 2. The incidence of each complication varies for each route described.

Table 2. Potential complications.	
Early	**Late**
1)Arterial puncture **2)Bleeding** **3)Cardiac arrhythmias** **4)Injury to the thoracic duct** **5)Injury to surrounding nerves** **6)Air embolism** **7)Catheter embolus** **8)Pneumothorax**	**1)Venous thrombosis** **2)Cardiac perforation and tamponade** **3)Infection** **4)Hydrothorax**

Practical problems common to most techniques of insertion

Table 3 lists some problems that can occur with any of the routes for central venous access.

Table 3. Problems during CV cannulation	
Arterial puncture	**Usually obvious but may be missed in a patient who is hypoxic or hypotensive.**
Suspected pneumothorax	**If air is easily aspirated into the syringe (note that this may also occur if the needle is not firmly attached to the syringe) or the patient starts to become breathless. Abandon the procedure at that site. Obtain a chest radiograph and insert an intercostal drain if confirmed. If central access is absolutely necessary then try another route ON THE SAME SIDE or either femoral vein. DO NOT attempt either the subclavian or jugular on the other side in case bilateral pneumothoraces are produced.**
Arrhythmias during the procedure	**Usually from the catheter or wire being inserted too far (into the right ventricle). The average length of catheter needed for an adult internal jugular or subclavian approach is 15cm. Withdraw the wire or catheter if further than this.**

Practical problems common to most techniques of insertion: (continued…)

Air embolus	**This can occur, especially in the hypovolaemic patient, if the needle or cannula is left in the vein whilst open to the air. It is easily prevented by ensuring that the patient is positioned head down (for jugular and subclavian routes) and that the guidewire or catheter is passed down the needle promptly.**
The wire will not thread down the needle	**Check that the needle is still in the vein. Flush it with saline. Try angling the needle so the end of it lies more along the plane of the vessel. Carefully rotate the needle in case the end lies against the vessel wall. Reattach the syringe and aspirate to check that you are still in the vein. If the wire has gone through the needle but will not pass down the vein it should be very gently pulled back. If any resistance is felt then the needle should be pulled out with the wire still inside, and the procedure repeated. This reduces the risk of the end of the wire being cut off by the needle tip.**
Persistent bleeding at the of entry	**Apply firm direct pressure with a sterile dressing. Bleeding should usually stop unless there is a coagulation abnormality. Persistent severe bleeding may require surgical exploration if there is an arterial or venous tear**

Some of the risks of central venous catheterization

Table 4. Some of the risks of central venous catheterization include:	
Pain during placement	**Discomfort can result from the needle stick and placement of the catheter at the time it is inserted. Doctors try to lessen the pain with a local numbing medicine (anesthetic like novocaine). The discomfort is usually mild and goes away once the catheter is in place.**
Collapsed lung	**This is called a pneumothorax. The lung is very close to the veins of the neck or chest. If the needle passes through the vein, it could pierce the lung causing it to leak and collapse on that side. If this happens, the doctor can place a tube between the ribs into the chest to suck out the air that is leaking from the lungs. This complication is particularly dangerous when a patient is on a breathing machine. Rarely, collapse of the lung can cause death. This complication can even happen when everything is done correctly.**
Infection	**Any tube (catheter) entering the body can make it easier for bacteria to get in and infect the patient. The longer a catheter remains in the body, the more likely it is to become infected. Special care in bandaging the skin at the needle site and changing the connecting tubes and fluids help to decrease this risk. With great care, these catheters can remain in the body for several weeks without becoming infected.**

Some of the risks of central venous catheterization

cont...)

Bleeding	**Bleeding around holes in the veins is usually mild and seals on its own. Since the major arteries run alongside the major veins, the arteries can be punctured by accident. Even bleeding from an artery can stop on its own before serious problems occur. Rarely, the chest fills with blood, which can be life-threatening. In that situation, it may be necessary to place a tube between the ribs to drain out the blood .**
Clotting around the catheter	**Blood clots can commonly form in and around these catheters inside the veins. Such clots usually do not cause problems. Once the catheter is removed, the body can often dissolve the clot over time. Sometimes, clots can break off and travel out into the lungs. This is called a pulmonary embolism. A blood clot in the lungs can cause breathing problems and, very rarely, death.**
Air entering through the catheter	**Rarely, air enters the catheter as it is being inserted. The air bubbles can travel through the heart and cause lung injury and low blood pressure. This problem is called an air .embolism. Special care is taken to avoid air entry**

Interpretation of the CVP:

- As previously stated, the CVP does not measure blood volume directly and is influenced by right heart function, venous return, right heart compliance, intrathoracic pressure and patient positioning.
- It should always be interpreted alongside other measures of cardiac function and fluid state (pulse, BP, urine output etc.).
- The absolute value is not as important as serial measurements and the change in response to therapy.

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Interpretation of the CVP:

- A normal value in a spontaneous breathing patient is 5-10cm water cmH2O, rising 3-5cmH2O during mechanical ventilation.
- The CVP measurement may still be in the normal range even with ***hypovolaemia*** due to ***venoconstriction***.
- A guide to interpretation is shown in table 4.

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Interpretation of the CVP: (continued…)

Table 4. Guide to interpretation of the CVP in the hypotensive patient			
CVP reading	***Other features that may be present***	***Diagnosis to consider***	***Treatment***
Low	Rapid pulse Blood pressure normal or low Low urine output Poor capillary refill	Hypovolaemia	Give fluid challenges* until CVP rises and does not fall back again. If CVP rises and stays up but urine output or blood pressure does not improve consider inotropes
Low or normal or high	Rapid pulse Signs of infection Pyrexia Vasodilation/constriction	Sepsis	Ensure adequate circulating volume (as above) and consider inotropes or vasoconstrictors
Normal	Rapid pulse Low urine output Poor capillary refill	Hypovolaemia	Treat as above. Venoconstriction may cause CVP to be normal. Give fluid challenges* and observe effect as above.

Interpretation of the CVP: (continued…)

High	Unilateral breath sounds Assymetrical chest movement Resonant chest with tracheal deviation Rapid pulse	Tension pneumothorax	Thoracocentesis then intercostal drain
High	Breathlessness Third heart sound Pink frothy sputum Oedema Tender liver	Heart failure	Oxygen, diuretics, sit up, consider inotropes

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Interpretation of the CVP: (continued…)

Very High	Rapid pulse Muffled heart sounds	Pericardial tamponade	Pericardiocentesis and drainage

Fluid challenge. In hypotension associated with a CVP in the normal range give repeated boluses of intravenous fluid (250 - 500mls). Observe the effect on CVP, blood pressure, pulse, urine output and capillary refill. Repeat the challenges until the CVP shows a sustained rise and/or the other cardiovascular parameters return towards normal. With severe blood loss, blood transfusion will be required after colloid or crystalloid have been used in initial resuscitation. Saline or Ringers lactate should be used for diarrhoea/bowel obstruction/vomiting/burns etc.

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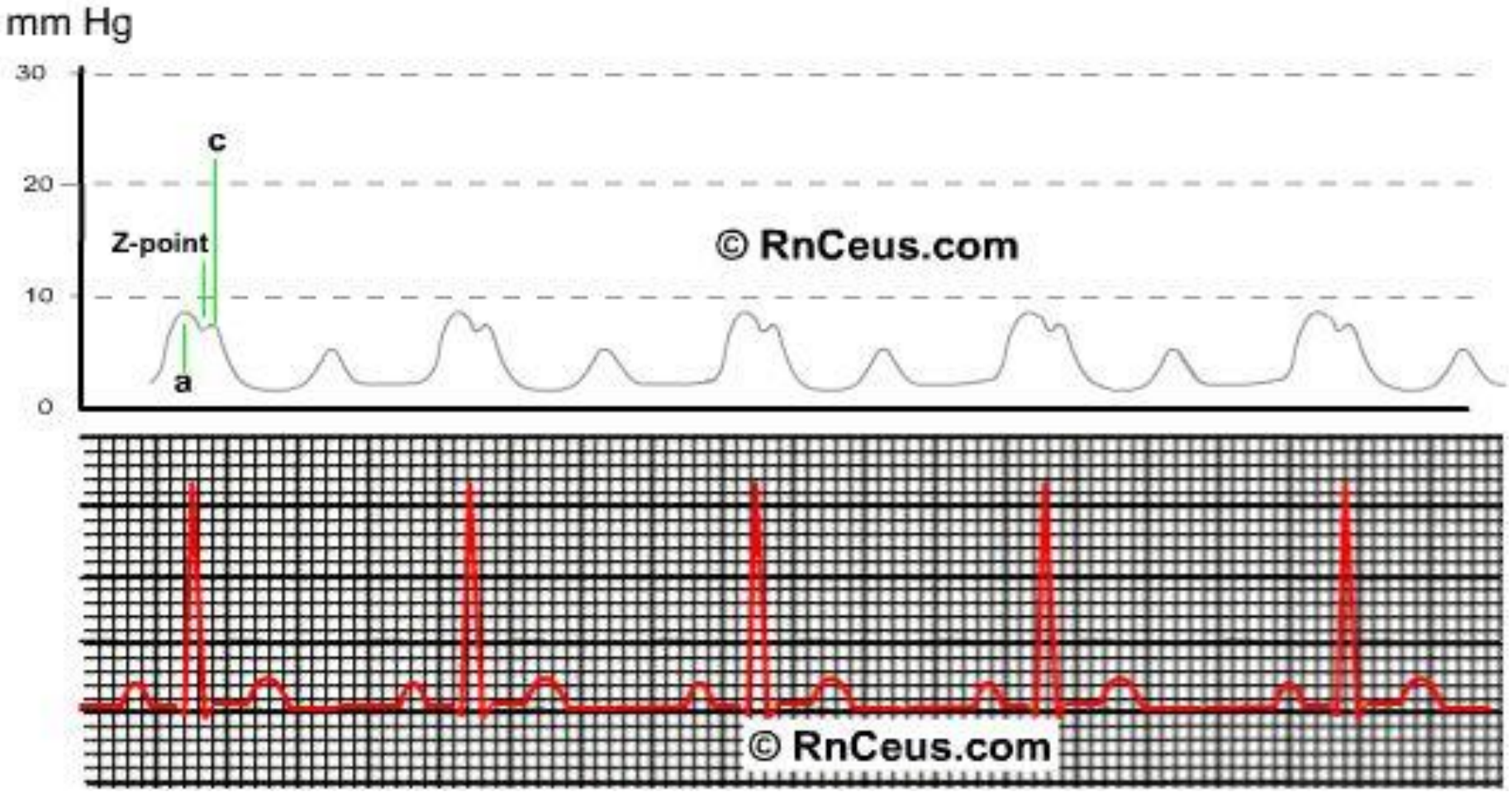
Central Venous Pressure waveform:

There are two ways to read a CVP waveform:



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Central venous Insertion

The aim is to place a catheter into the superior or inferior vena cava, just above the right atrium.

The sites of choice are the:

- Subclavian vein
- Jugular vein.

These allow easiest access and impede patient mobility least. Other potential sites are the:

- Brachial vein
- Femoral vein
- Median basilic vein.

For these sites, catheters of varying lengths must be used to achieve the final position.

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Hazards of CVP line insertion

1. Sepsis
2. Hydrothorax
3. Brachial Plexus injury
4. Catheter embolism
5. Air Embolism
6. Haemorrhage
7. Thoracic duct trauma
8. Thrombosis
9. Pneumothorax
10. Haemothorax
11. Misdirection or kinking of the catheter
12. Cardiac Tamponade
13. Cardiac Arrythmias.

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✓Access To The Subclavian Vein :

Preparation and positioning: The patient should be supine, both arms by the sides, with the table tilted head down to distend the central veins and prevent air embolism. Turn the head away from the side to be cannulated unless there is cervical spine injury. Normally the right SCV is cannulated since the thoracic duct is on the left and may occasionally be damaged during SCV cannulation.

Technique: Stand beside the patient on the side to be cannulated. Identify the midclavicular point and the sternal notch. The needle should be inserted into the skin 1cm below and lateral to the midclavicular point. Keeping the needle horizontal, advance posterior to the clavicle aiming for the sternal notch. If the needle hits the clavicle withdraw and redirect slightly deeper to pass beneath it. Do not pass the needle further than the sternal head of the clavicle.

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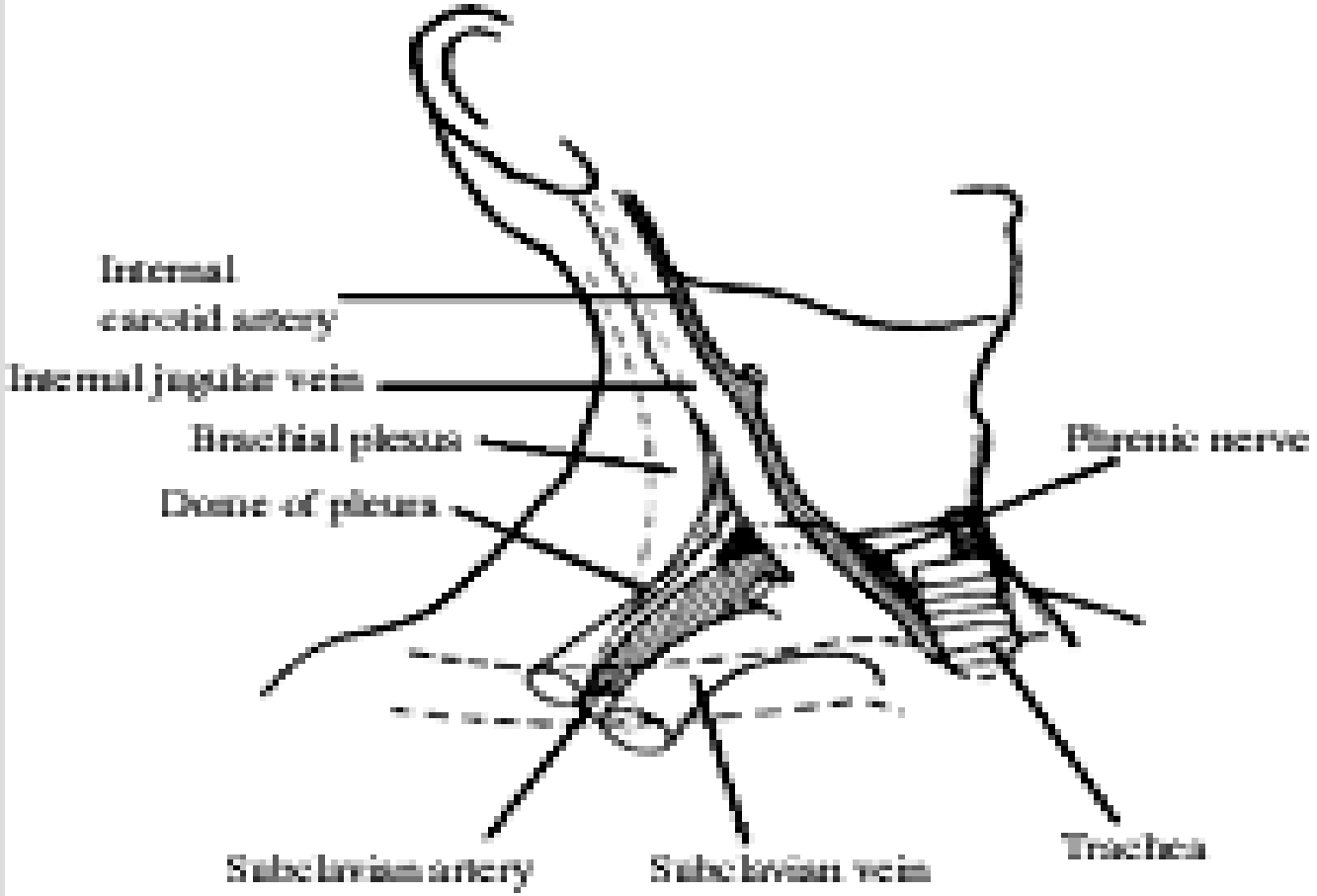
Complications: Any of the complications described above can occur but pneumothorax (2-5%) or rarely haemothorax or chylothorax (fatty white fluid in the pleural cavity due to leakage of lymph from thoracic duct) are more common with this route than the others.

Practical problems specific to the subclavian route:

- **Keep hitting the clavicle**.
- **Cannot find the vein**: direct the needle a little more cephalad
- **Fail after repeated attempts**: DO NOT PERSIST since the likelihood of complications increase. Try an alternative route ON THE SAME SIDE unless chest radiography is available to exclude any possible pneumothorax.
- **The catheter tip is not in the chest:** Usually detected on chest X-ray, or if the fluid level in the CVP manometer does not rise and fall with breathing. A simple test that may increase the suspicion of jugular placement is to rapidly inject 10ml of fluid into the catheter whilst listening with a stethoscope over the neck. An audible 'whoosh' or thrill under the fingers suggests the catheter has entered the jugular vein. If this is positive, in the presence of a CVP reading which does not change with respiration, then the position of the cannula must be questioned.



Anatomy of the root of the neck

Fig 2

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✓Access To The Femoral Vein:

Preparation and positioning: Abduct and externally rotate the thigh slightly.

Performance of the technique: Identify the pulsation of the femoral artery 1-2 cm below the inguinal ligament. Insert the needle about 1cm medial to the pulsation and aim it towards the head and medially at an angle of 20-30° to the skin. In adults, the vein is normally found 2-4cm from the skin. In small children reduce the elevation on the needle to 10-15° since the vein is more superficial.

Complications: Arterial puncture is possible if the needle is directed too lateral. Femoral nerve damage may follow incorrect lateral insertion of the needle. Infection is the commonest problem with femoral catheters and they are not recommended for long-term use.

Practical problems:

- **Cannot feel the artery**: Try the other side. Check the blood pressure. Treat any hypotension and retry. If there is no other venous access then it may be acceptable to try to locate the FV with a small needle starting medially to avoid the femoral nerve. Once found, change to the normal needle and continue the procedure. If the artery is accidentally punctured, apply direct pressure with your fingers and insert the normal needle medial to the puncture site.

- **Cannot locate the vein**: Recheck the anatomical landmarks. It is possible for the femoral vein to be compressed by the fingers on the artery. Release pressure but leave the fingers resting on the skin over the artery and retry. Cautiously redirect the needle closer to the artery and in a more lateral direction.

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✓Access To The External Jugular Vein:

Preparation and positioning: The patient should be supine, both arms by the sides, with the table tilted head down to distend the central veins and prevent air embolism. Turn the head away from the side to be cannulated for better access.

Technique: Stand at the head of the patient and identify the EJV as it crosses the sternocleidomastoid muscle. If it is not palpable or visible (see problems) then choose an alternative vein for catheterisation. Insert the needle in line with the vein where it is most easily seen or palpated. Thread the guidewire and then the catheter.

Complications: If the vein is easily seen or palpated this route carries a very low risk.

Practical problems:

- **Cannot see the vein**: Ask the patient to take a big breath in and strain as if trying to go to the toilet (Valsalva manoeuvre). If mechanically ventilated briefly hold the lungs in inspiration. Press on the skin above the midpoint of the clavicle where the vein enters the chest. If none of these make the EJV visible then use a different vein.
- **Catheter will not pass into chest**: Press on the skin where the vein enters the chest. Try rotating the catheter or flushing it with saline as you insert it. If using a guidewire, rotate the wire when it reaches the bottom of the vein. Try slowly turning the head in either direction. It may be useful to insert a normal plastic cannula into the vein first, then thread the guidewire down this. By doing this, the wire can be pushed, pulled and rotated without the risk of it being cut which could occur if the wire is manipulated through a needle.

✓Access To The Internal Jugular Vein :

Preparation and positioning: The patient should be supine, both arms by the sides, with the table tilted head down to distend the central veins and prevent air embolism. Slightly turn the head away from the side to be cannulated for better access (turning it too far increases the risk of arterial puncture).

Technique: Stand at the head of the patient. Locate the cricoid cartilage and palpate the carotid artery lateral to it at this level. Keeping a finger gently over the artery, insert the needle at an angle of 30-40^{o} to the skin and advance it downward towards the nipple on the same side (in a woman guess where the nipple would be if she were a man). Always direct the needle away from the artery under your finger. The vein is usually within 2-3cm of the skin. If the vein is not found, redirect the needle more laterally.

Complications: With experience this route has a low incidence of complications. Arterial puncture is easily managed by direct pressure. Pneumothorax is rare providing the needle is not inserted too deeply.

Practical problems:

- **Cannot feel the artery**. Check the patient! Try the carotid on the other side. It is safer to consider a different approach rather than 'blindly' try to find the jugular.
- **Arterial puncture**. Remove needle and apply firm pressure over the puncture site for 10 minutes.
- **Cannot find the vein**. Recheck your position. Ensure that you are not pressing firmly on the artery as this can compress the vein next to it. Try tipping the patient further head down if possible. If the patient is hypovolaemic, and central venous access is not immediately required to correct it, give intravenous fluids and wait until the veins are fuller. Try inserting the needle a little closer to the artery but beware of puncture.

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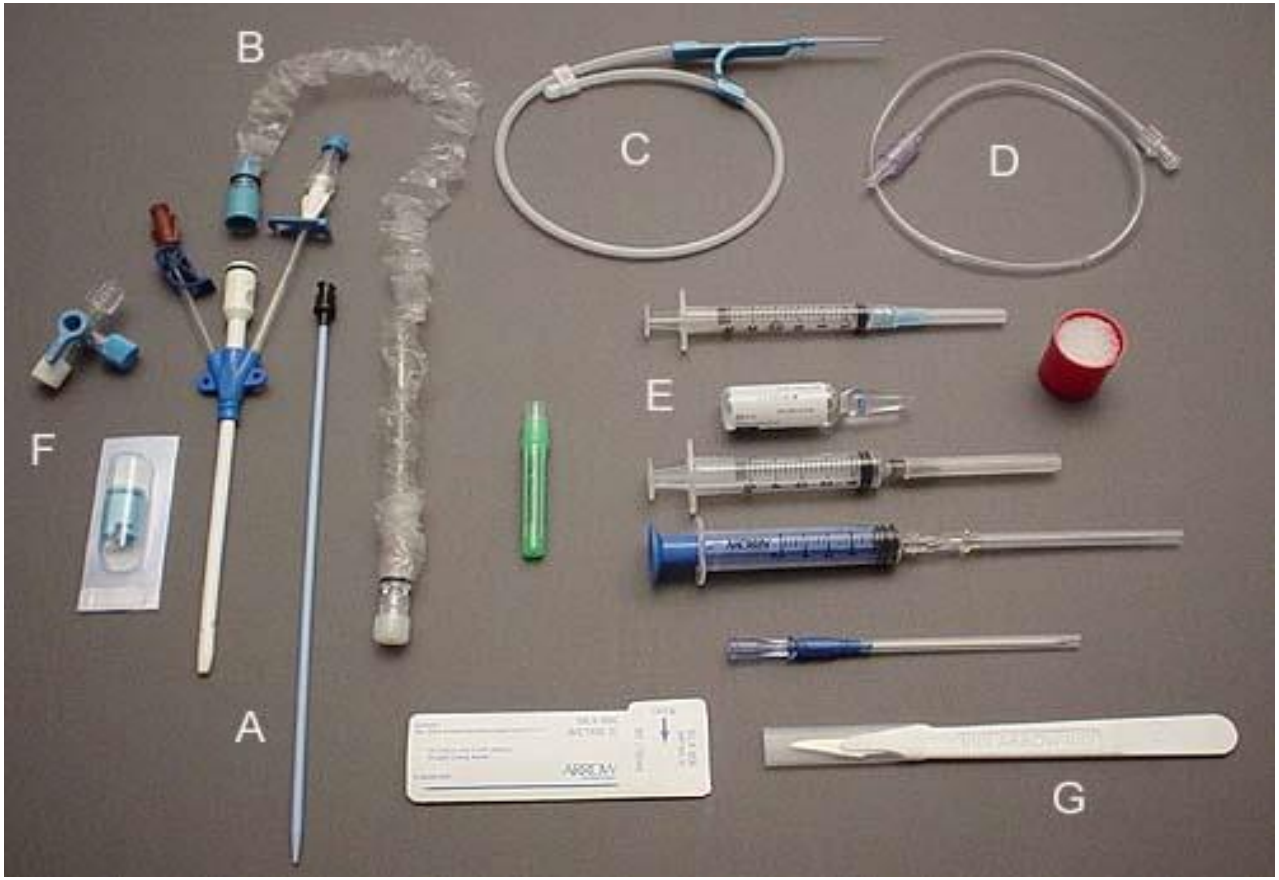
EQUIPMENT USED FOR PLACING OF CENTRAL VENOUS CATHETER IN THE RIGHT INTERNAL JUGULAR VEIN

Central Venous Catheter Kit:



Most of the instruments and materials needed for placing a central venous catheter come in a prepackaged, sterile "kit." Opening one of these kits for the first time can be overwhelming – there are many different needles and hubs and tubes, and knowing what each piece in the kit does what may help for describing the exact technique.

Drapes: These are to keep the site of cannulation sterile and clean, and to provide a sterile field to place instrument on.

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- **Sharps holder (E, below) :** This provides a place to stick the needles when you are done using them, thus lessening the chance of sticking yourself with a contaminated needle, and without having to go to the sharps box every time a needle has been used. Note that once a needle has been stuck into the "foam" of the holder, it should not be used again, because the plastic reside can stick to the needle and lodge inside the needle tip.
- **A 25 or 26 gauge (remember bigger numbers mean smaller needles!) needle with a small syringe attached and a vial of 1% lidocaine (A, below)** : This smallest needle is used with the lidocaine to numb the area to be cannulated.
- **A 22 gauge "finder needle" with 5ml syringe (B, right)** : This needle does just that; it is used to find the internal jugular vein initially- its small size makes it safer to use when in the process of locating the vein. If the carotid artery is inadvertently punctured with this needle, there is a decreased risk of a large hematoma forming, and other complications arising.
- **An 18 gauge IV needle with a catheter hub attached to a 10 ml syringe (syringe C with catheter D, right)** :This is basically an IV set that is used to create an opening in the vein large enough to pass the guide-wire through. The soft plastic IV catheter around the needle is left in the vein while the needle is withdrawn.

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- **Tubing ("D" in main photo at top of page)**: This long clear tubing is used to test the venous access. The tubing is filled with sterile saline, attached to the IV catheter lying within the vein and is lifted straight up. If the column of water drops, the hub is successfully within the vein.

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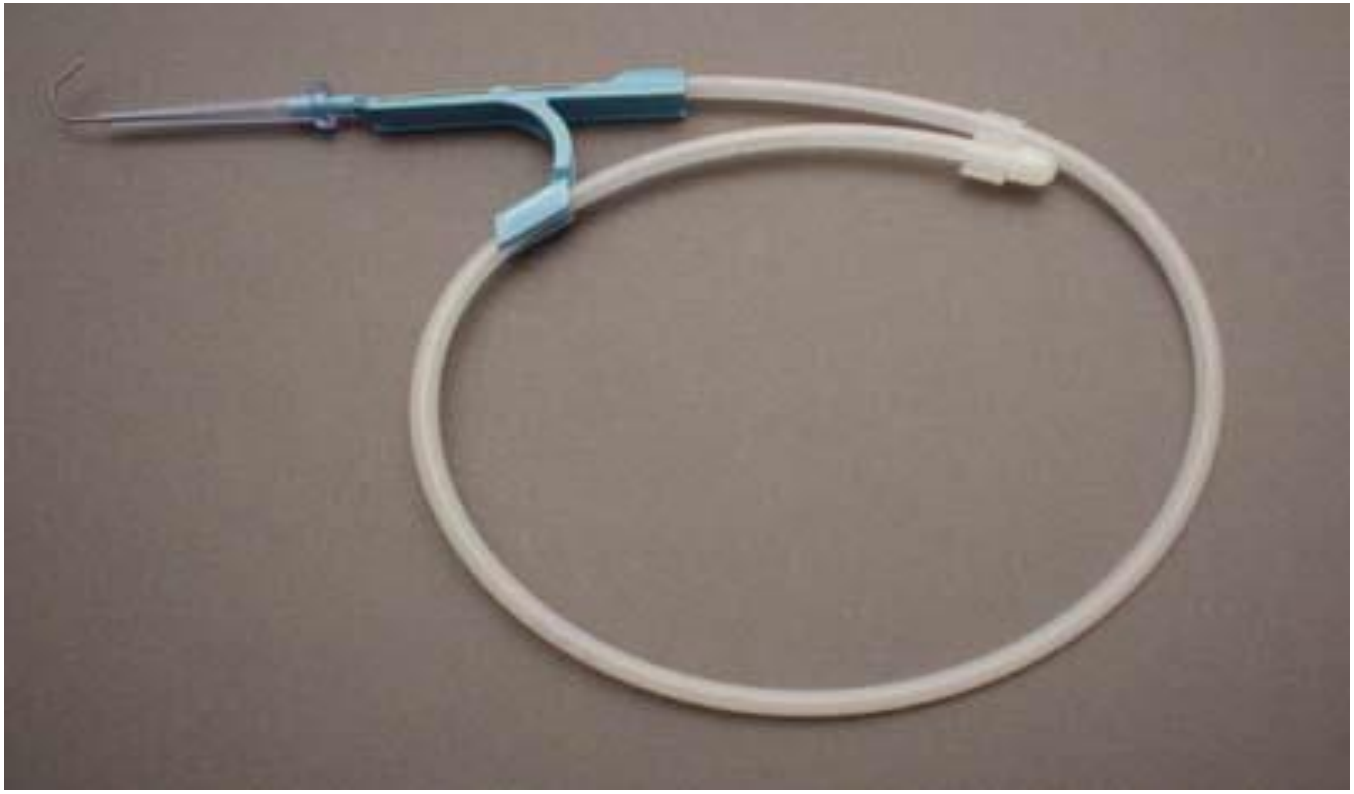
Guide wire (below) : This is a long, soft, flexible wire that is mounted in a plastic loop in order to ease the insertion into the hub of the IV catheter; the wire helps to direct the central venous catheter the vein. It has a "J" shaped bend on one end to protect the vein once it is inserted. The central venous catheter will be fed into the vein using this wire as a lead.



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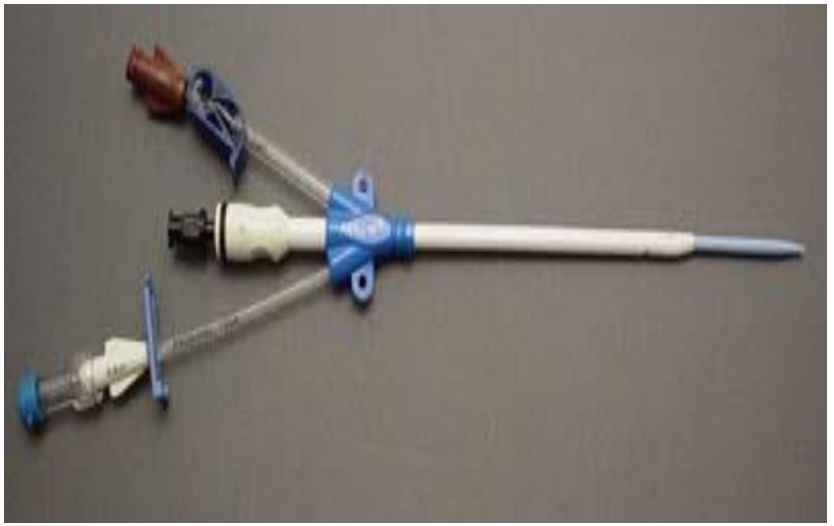
- **A #11 scalpel (below)** : This is used to enlarge the entry into the vein while the guide wire lies within the vein.
- **Suture (below)**: This is used to attach the body of the catheter to the skin after insertion. It acts as an added safety measure to prevent the catheter from being inadvertently pulled out.

Multiple lumen catheter (below on left, top device): This is the catheter that will be inserted into the vein. This catheter has three ports, two that open on the side of the cathter tip, and one that opens at the very end of the catheter.



- **Vessel dilator (above on left, bottom device):** This is the blue length of firm plastic that is part of the body of the catheter while the catheter is being inserted. As its name implies, it dilates the vein and helps the catheter pass smoothly into the vein. It is removed after insertion.

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