Central Venous Catheterization

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A Central Venous Catheter (CVC) is an indwelling intravenous device that is inserted into a vein of the central vasculature.
Uses

1. Difficult Peripheral Vascular Access

Ex-patients with burns, previous vein injuries (such as IV drug use)

2. Volume Loading
   - Time-consuming to insert and are associated with high complication rates.
   - Flow rate is determined by the calibre and length of the catheter (Poiseuille’s law)
   - Shorter and greater calibre catheters delivering greater volumes over equivalent amounts of time
3. Provision of Caustic Medications or Solutions
- Vasoactive medications (vasopressors or inotropes)
- Irritant substances (chemotherapeutic agents, cytotoxic drugs or high concentration solutions)
- Total parenteral nutrition
4. Central Venous Pressure Monitoring

The central venous pressure (CVP) is the pressure measured in the central veins close to Right atrium.

It indicates mean right atrial pressure and is frequently used as an estimate of right ventricular preload.

Being used as a guide for fluid management, though some researches suggest otherwise (http://www.ncbi.nlm.nih.gov/pubmed/18628220)
5. Repeated Blood Sampling

6. Introduction of Pacemakers or Pulmonary Artery Catheters

7. For haemodialysis/haemofiltration - For acute and chronic haemodialysis access
Contraindications

Absolute
- Overlying skin or soft tissue infection
- Thrombophlebitis
Contraindications cont

Relative

1. Distorted Anatomy – Trauma, deformity, burns.
2. Infection at the Site of Access – cellulitis
3. Uncooperative patients
4. Proximal Vascular Injury
5. Bleeding disorders & anticoagulation or thrombolytic therapy.
   - 3% complication rate as long as there are no arterial punctures (Mumatz et al)
   - Absolute contraindication for subclavian access
   - Ultrasound guidance is recommended
Central venous access devices in COVID patients

- PICC (peripherally inserted central catheters)
- CICC (centrally inserted central catheters)
- FICC (femorally inserted central catheters)
Principles

- Preferably u/s guided with wireless ultrasound probes
- Avoid radiology after central venous cannulation

- Catheter tip location-intracavitary electrocardiography (IC-ECG) and transthoracic echocardiography (TTE).

- Consider the use of subcutaneously anchored securement, which will make the dislocation less likely especially in the agitated patient or in the patient undergoing periodic pronation.
PICC (peripherally inserted central catheters)

- No risk of pleuropulmonary complications (pneumothorax, hemothorax)
- PICC can be given in any position. (supine / sitting / pronated)
- PICC is theoretically safer for the operator than the insertion of a CICC, where the operator dangerously close to the patient's face and to his oral, nasal and tracheal secretions
- **Risk**-thrombosis
Can be useful

- In patients on non-invasive ventilation (with mask or helmet), keeping the neck free
- In the pronated COVID-19 patient, the dressing is comfortable, easy to monitor the exit site, the connection/disconnection of the infusion lines and not flooded by the patient's oral and tracheal secretions
- In tracheostomized patients
- In heavily anticoagulated patient
- PICCs offer longer life expectancy
Central insertion catheters (CICCs)

- In case of specific contraindications and as an alternative to PICCs
- In the absence of specifically trained personnel
- Indication - preferential use of CICCs is the need for a central route with more than three lumens.
  - Supraclavicular/ an infra-clavicular approach
  - In the presence of helmets, face masks, tracheostomies, etc., (ultrasound-guided puncture and cannulation of the axillary vein) provide greater protection and stability of the catheter at the exit site.
  - Use U/S to verify the absence of pneumothorax
FICC (femorally inserted central catheters)

- Minimizes the risk of operator contamination by the patient's oral, nasal and tracheal secretions
- The exit site can be
  (a) by puncturing the common femoral vein and then tunneling to mid-thigh, or
  (b) by directly puncturing the superficial femoral vein at mid-thigh;
- For CVP - tip must be in atrium
- For others - in the middle tract of the inferior vena cava (above the bifurcation of the iliac veins and below the renal veins).
COVID-19 patient - due to his hyper-coagulability status - may have a high risk of catheter-related thrombosis (either after PICC, CICC or FICC insertion).

In the absence of contraindications, then, for all central venous catheters in COVID-19 patients, subcutaneous administration of low molecular weight heparin at prophylactic (100 units/kg/24h) or even therapeutic (100 units/kg/12h or 150 units/kg/24h) dose should be considered.
Types Of Central Venous Catheters

1. Non-tunneled central catheters
2. Tunneled central catheters
3. Peripherally inserted central catheters (PICC)
4. Implantable ports
Types Of Central Venous Catheters .cont

- Single & multi-lumen catheters are available in all catheter types
- Each lumen must be treated as a separate catheter
Open-ended

- The catheter is open at the distal tip
- The catheter requires clamping before entry into the system
- Clamps are usually built into the catheter
- Requires periodic flushing
Closed-ended

- A valve is present at the tip of the catheter (eg. Groshong®) or at the hub of the catheter (eg. PAS-V®)
- Clamping is not required as the valve is closed except during infusion or aspiration
Types Of Central Venous Catheters

Composition
- Silicone
- Polyurethane

Coatings
- Antimicrobial or antiseptic coating
- Heparin coating
- Radiopaque to confirm tip placement
The type of CVC inserted depends on the

- Type of therapy to be administered
- Length of therapy (Short term or Long term)
- Previous devices and complications
- Patient preference
Non Tunnelled Catheters
Polyurethane

Single or multiple lumens

Flow varies depending on size and ID

Inserted percutaneously

- Internal jugular vein
- Subclavian vein
- Femoral vein
Advantages

- Easier placement, removal and replacement
- Economical

Disadvantages

- Highest risk of infections
- Unused ports must be routinely flushed with heparin solution and clamped
- Dislodged more easily
- Temporary - requires frequent exchanges
The insertion of a central venous line is potentially life-saving as, in emergent situations, it allows rapid administration of high-volume isotonic fluids and medications that would otherwise be caustic to peripheral veins.
Anatomy

- In the leg, popliteal vein drains to the *superficial femoral vein*. The superficial femoral vein is joined by the *deep femoral vein* in the upper thigh becoming the *common femoral vein*.
- The *great saphenous vein* then joins the common femoral vein near the inguinal ligament.
- Superior to the inguinal ligament, the *common femoral vein* becomes the *external iliac vein*.
- The internal iliac vein drains into the external iliac vein becoming the common iliac vein, and the common iliac veins join to become the inferior vena cava.
- The *common femoral vein* is the ideal vein to puncture when performing central venous access at the femoral site.
- The common femoral vein lies within the “femoral triangle” in the inguinal-femoral region which is bordered by the inguinal ligament superiorly, the adductor longus medially, and the sartorius muscle laterally.
- Mnemonic “NAVEL.” Moving laterally to medially, (N) femoral nerve, (A) femoral artery, (V) femoral vein, (E) empty space, (L) lymphatics.
In most instances, central venous access with ultrasound-guidance is considered the standard of care.
Indications

- Peripheral access is unobtainable
- Medication to be infused is known to induce peripheral phlebitis
- High volume fluid and/or parenteral nutrition administration is required
- Emergency resuscitation is warranted
- Monitoring of central venous oxygen saturation and central venous pressure is indicated
- Frequent blood sampling needs to be performed
- Access is required to perform hemodialysis, hemofiltration, or apheresis.
Contraindications

Potential contraindications to central venous access via the femoral vein are the following:

- Thrombosis
- Skin infection at the site of needle puncture
- Trauma
- Distorted anatomy
- Coagulopathy
Equipment

- Central venous catheter
- Introducer needle and a slip-tip syringe
- Guidewire
- Dilator
- Scalpel
- Gauze (4x4)
- Hubs for access ports on catheter
- Normal saline for flushing catheter
- Facemask and hair cap
- Chlorhexidine gluconate (e.g., chloraprep) or povidone-iodine solution for topical cleaning
- Topical anesthesia (e.g., 1% lidocaine)
• 25-gauge needle and a syringe for administration of topical anesthesia

• Sterile gown and gloves
• Sterile drape that is long enough to cover patient from head to toe
• Needle holder and silk sutures
• If using ultrasound-guidance: ultrasound, sterile ultrasound probe cover, sterile and non-sterile ultrasound gel
• For line dressing: Transparent dressing to allow for visualization of the insertion site (e.g., Tegaderm).
## Equipments needed

<table>
<thead>
<tr>
<th>Central line kit containing:</th>
<th>Additional items:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• needle or a cannula over needle</td>
<td>• suture</td>
</tr>
<tr>
<td>• central venous catheter</td>
<td>• scalpel</td>
</tr>
<tr>
<td>• guidewire</td>
<td>• appropriate dressing</td>
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<tr>
<td>• dilator</td>
<td>• syringes</td>
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<tr>
<td>• anchoring clips.</td>
<td>• blue and green needles</td>
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<tr>
<td></td>
<td>• three-way taps, one for each lumen</td>
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<td></td>
<td>• drapes</td>
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<td></td>
<td>• cleaning fluid (2% chlorhexidine gluconate in 70% isopropyl alcohol is recommended)</td>
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<tr>
<td></td>
<td>• swabs</td>
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<tr>
<td></td>
<td>• Gallipot or similar</td>
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<td></td>
<td>• sterile ultrasound probe sheath</td>
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<td>• 0.9% normal saline</td>
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</tbody>
</table>
Preparation

- Informed consent of the patient by explaining the risks and benefits of the procedure
- Choose an appropriately sized central venous catheter for the patient. This decision may be influenced by the clinical indication, patient size and/or vessel caliber.
- Consider the following:
  - Catheter size in French (F) (e.g., 4F, 7F)
  - Catheter length (in centimeters)
  - Number of lumens required
Positioning

- The patient can be placed in a reverse Trendelenburg position to engorge the femoral vein which could potentially increase the vessel’s caliber.
- The patient’s leg can be positioned in one of three ways: frog-leg position, external rotation at the hip with full leg extension, abduction of a fully extended leg with external rotation at the hip.
- Operator washes hands with soap and water.
- Operator dons sterile personal protective equipment (PPE) (i.e., cap, facemask, sterile gown and gloves).
- European Centre of Disease Prevention and Control (ECDC) strongly recommend the use of a double mask (N95mask + surgical mask) for the insertion of vascular access devices, considering the high risk of aerosol in the environment,
Sterile prepping of the skin at the site of insertion with chlorhexidine gluconate or povidone-iodine solution
Place a sterile drape over the patient ensuring coverage from head to toe
Administer local anesthetic as an effort to minimize the use of systemic analgesia/sedation
Flush all lumens of the central venous catheter with normal saline.
Seldinger technique

- Use introducing needle to locate vein
- Wire is threaded through the needle
- Needle is removed
- Skin and vessel are dilated
- Catheter is placed over the wire
- Wire is removed
- Catheter is secured in place
landmark technique

- Use your index finger to locate the arterial pulsation along the inguinal ligament at the midpoint between the anterior superior iliac spine and the pubic symphysis.
- Then move 1 cm to 2 cm inferior to this position as the needle puncture must be performed below the inguinal ligament. Next, move 1 cm to 2 cm medially as the vein lies medial to the artery.
- Puncture just medial to your index finger in a direction just medial to your middle finger.
Complications

- **Early**
  - Arterial puncture which could result in formation of a hematoma
  - Hematoma formation could also result from routine placement
  - Bladder puncture. At our institution, we catheterize or insert a foley catheter prior to placement of a femoral central line
  - Hemorrhage
  - Catheter fragment resulting in a guidewire embolism
  - Cardiac dysrhythmias, particularly from high-lying central lines
Central Line Associated Bloodstream Infection (CLABSI)
Phlebitis
Thrombosis
Erosion/perforation
The following are not complications, per se, but can lead to complications:
Uncooperative patient
Lack of experience/supervision
<table>
<thead>
<tr>
<th>Site</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
</table>
| Femoral | • Safest vein to place large lines, for example for veno–veno haemofiltration because there are fewer important structures nearby.  
• Puncture of femoral artery can usually be treated with pressure | • Femoral artery puncture leading to retroperitoneal bleed  
• Femoral nerve damage  
• Difficult to nurse and keep clean  
• Highest likelihood of infection |
Internal Jugular Approach

• **Positioning**
  - Right side preferred
  - Trendelenburg position
  - Head turned slightly away from side of venipuncture

• **Needle placement: Central approach**
  - The triangle formed by the clavicle and the sternal and clavicular heads of the SCM muscle is located
  - Three fingers of left hand are gently palced on carotid artery
  - Needle should be placed at 30 to 40 degrees to the skin, lateral to the carotid artery
  - Aim toward the ipsilateral nipple under the medial border of the lateral head of the SCM muscle
  - Vein should be 1-1.5 cm deep, deep probing in the neck should be avoided.
Internal Jugular Central Approach

Internal jugular vein
Subclavian vein
Clavicle
Sternocleidomastoid muscle
<table>
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<tr>
<th>Site</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal jugular</td>
<td>• Anatomy readily visible with ultrasound</td>
<td>• Puncture of internal carotid or misplaced line in the internal carotid</td>
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<td>• Can be adapted to accommodate patient size and position</td>
<td>• Pneumothorax is a recognised complication</td>
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<td>• Easily accessed surface of patient</td>
<td>• Difficult to nurse long term.</td>
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Subclavian Approach

• Positioning
  – Right side preferred
  – Supine position, head neutral, arm abducted
  – Trendelenburg (10-15 degrees)
  – Shoulders neutral with mild retraction
  – Right side preferred

• Needle placement
  – Junction of middle and medial thirds of clavicle
  – At the small tubercle in the medial deltopectoral groove
  – Needle should be parallel to skin
  – Aim towards the supraclavicular notch and just under the clavicle
<table>
<thead>
<tr>
<th>Site</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subclavian</td>
<td>• Lower risk of infection</td>
<td>• Highest chance of pneumothorax</td>
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<td></td>
<td>• Does not require movement of patient’s head and can be accessed during c-spine immobilisation</td>
<td>• Puncture of tracheostomy or ET tube cuff</td>
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<td></td>
<td>• Useful in emergencies</td>
<td>• Cannot apply pressure to stop bleeding</td>
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<td></td>
<td>• Vein does not collapse fully in hypovolaemic states</td>
<td>• Can be painful even with good skin anaesthesia</td>
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<td>• Less easy to visualise with USG</td>
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</tbody>
</table>
Figure 3: Postinsertion chest X-ray displaying normal position of CVC tip (arrow) in relation to carina
Maintenance of CV line

- Hepsol flush 8 hourly
- Central Short channel is used for measuring CVP
- Rest two channels are used for medication and TPN
- The dressing should be changed at regular interval
- Catheter should not be kept for more than 3 weeks
Complications

- Acute
- Chronic

Complication rate depends on
- Site
- Patient factors (illnesses, variations in anatomy)
- Operator skill and experience.
Acute complications

Cardiac Dysrhythmias
- Due to cardiac irritation by the wire or catheter tip.
- Withdraw the line into the superior vena cava.
- Always use a cardiac monitor.

Haematoma formation – Arterial/Venous puncture

Mechanical injury to nearby structures
- Pneumothorax/Haemothorax
- Atrial wall puncture - pericardial tamponade.
- Bowel penetration, Bladder puncture, Femoral nerve injury

Air embolus

Malposition

Lost Guide-wire
Chronic complications

- Infections
- Catheter fragmentation
- Non-function/Blockage - fibrin builds on and around the catheter and vessel, drug precipitates, lipid deposits
- Thrombosis/Thromboembolism
Air embolism

Deadly complication associated with CVC’s

Signs and Symptoms

- Respiratory changes: sudden shortness of breath, cyanosis
- CVS changes: sudden onset of chest pain, ↑HR, ↓BP
- CNS changes: altered neurological signs, dizziness, confusion, loss of Consciousness
Management

- Left lateral decubitus with head low Position (Durant maneuver and Trendelenburg position)
- Clamp the Central Venous Catheter
- 100% O2
- Direct removal of air from the venous circulation by aspiration from a central venous catheter in the right atrium may be attempted
To minimize the chance of air entering the system:

- Ensure the lumen is clamped prior to opening the system
- Position the patient so that the insertion site is at or below the level of the heart during insertion and removal of catheter
Infections

Most frequent and serious complications.

Types

- Local infection – Cellulitis
- Central Line-Associated Bloodstream Infections (CLABSI)
Causative Organisms

- Staph epidermidis 25-50%
- Staph aureus 25%
- Candida 5-10%

Risk Factors

- Cutaneous colonization of the insertion site
- Moisture under the dressing
- Prolonged catheter time
- Technique of care and placement of the central line
Evidence-Based Strategies Selected to Reduce CLA-BSIs

1. Hand hygiene
2. Maximal sterile barriers
3. Chlorhexidine for skin asepsis
4. Avoid femoral lines
5. Avoid/remove unnecessary lines
Care of central line

Maintenance bundle
Daily assessment of whether catheter is needed
Catheter site care
  No iodine ointment
  Chlorhexidine scrub to site with dressing changes (30-s scrub and 30-s air dry)
  Change gauze dressings every 2 d unless soiled, dampened, or loosened (CDC recommended)
  Change clear dressing every 7 d unless soiled, dampened, or loosened (CDC recommended)
  Prepackaged dressing change kit (each unit to define package contents)
Catheter hub/cap/tubing care
Dressing changes per protocol

- Use sterile technique
- Change when damp, soiled or loosened
- Change every 7 days if transparent
- Change every other day if gauze is used
- Clean skin around insertion site with alcohol in a circular motion. Also clean cath with alcohol
- Flushing of lines
  - Each lumen is treated as a separate cath
  - Injection caps are vigorously cleaned with alcohol
  - Use 10cc or larger syringe for administration of meds or flush
  - Turbulent flush technique is recommended
The infusion lines are changed every 24 hours.

Disinfect the infusion lines with sterile guaze and 70% alcohol daily.

When blood samples are collected flush the lines with heparinised saline to keep patent and prevent it from blocking or patient is on 24 hours Heparin infusion (0.9% normal saline)

Clean the cap with 70% alcohol before connecting the 3 ways valve.
• The CVC must be handled with sterile gloves
• The Hickman’s catheter comes either in one, two or three lumens in three different colours.
• The red cap is for blood and blood components and Chemotherapy drugs.
• Blue cap for drugs that are not compatible with intravenous fluids.
• White cap for total parenteral nutrition (TPN), if patient is not on TPN, it is plugged.
• All these are done under Aseptic techniques.
<table>
<thead>
<tr>
<th>Category</th>
<th>Type of bag/container</th>
<th>Type of waste</th>
<th>Treatment disposal options</th>
</tr>
</thead>
</table>
| Yellow   | Non chlorinated colour coded bags in coloured bins | • Human anatomical waste  
• Animal anatomical waste  
• Soiled waste  
• Expired or discarded medicines  
• Chemical waste  
• Micro, biotech & clinical lab waste  
• Chemical liquid waste | Incineration/deep burial |
|          | Separate collection system leading to ETP | | |
| Red      | Non chlorinated plastic bags in coloured bins, containers | Contaminated waste (recyclable) tubing, bottles, urine bags, syringes (without needles) and gloves | Auto/micro/hydro and then sent to recycling |
| White    | Translucent, puncture, leak & tamper proof | Waste sharps including metals | Auto/dry heat sterilization followed by shredding/mutilation/encapsulation |
| Blue     | Water proof card board boxes/containers | Glassware waste | Disinfection or auto/micro/hydro then sent to recycling |

*Disposal by deep burial is permitted only in rural or remote areas where there is no access to common biomedical waste treatment facility. This will be carried out with prior approval from the prescribed authority*
Thank You So Much!