The Egyptian Journal of Hospital Medicine (July 2023) Vol. 92, Page 6488- 6491

Central venous Catheters Indications and Complications: Review Article

Maha Hamed Mohamed Abdelrahim, Waleed Adel Ahmed Salama, Mahmoud Ahmed Mosa Mohamed

Department of Anesthesia, Intensive Care and Pain Management, Faculty of Medicine, Sohag University, Egypt

Corresponding author: Maha Hamed Mohamed**, Mobile: (+20)** 01029012925**, E-mail:** moohaazzahamed@gmail.com

ABSTRACT

Background: Dr. Werner Forssmann used a ureteric catheter to enter the right side of the heart through his cubital vein to create the central line, also known as central venous catheterization, in 1929. Since then, the central line technology has improved steadily and is now required for many critical patient indications, including parenteral nutrition, drug administration, hemodialysis, and rapid fluid resuscitation for the shocked. Central lines come in a wide variety of sizes, locations, and types. Additionally, we should remember that there are a lot of potential issues with the central line.

Objective: Study of the indications and possible complications of central venous catheter.

Methods: CVC, Cannula insertion, Pneumothorax, infection, Bleeding, and Complications were the search phrases utilised in PubMed and Science Direct searches. After meticulous reviewing, references from the applicable literature, including all renowned research and reviews were included as well as the most current or complete study conducted between August 2003 and March 2023.

Conclusion: There are many sites possible for central line insertion, several indications, and the benefit of ultrasound guidance to avoid many possible complications.

Keywords: CVC, Cannula insertion, Pneumothorax, Infection, Bleeding, Complications.

INTRODUCTION

Until its terminal lumen is located within the superior vena cava, inferior vena cava, or right atrium, a central venous catheter (CVC) is placed into a major, central vein (internal jugular, femoral, or subclavian). In 1929, a CVC was positioned for the first time. Central venous access evolved over the ensuing decades into a vital tool for understanding cardiac physiology as well as a vital line for parenteral feeding, haemodialysis, and numerous drugs. The site of catheter insertion should be chosen to have a low risk of thrombosis, infection, and mechanical issues. Since the femoral vein has a higher likelihood of thrombosis and infection compared to other sites, it should be avoided [(1)].

Catheter types:

The kind and length of the proposed therapy determine the catheter's choice and selection.

1- Non-tunneled catheters

The majority of the time, untunneled catheters are utilised and observed in emergency and urgent circumstances. As it's straightforward and simple to insert. Non-tunneled catheters are only effective for a brief period of time. They need to be removed as soon as possible to avoid issues like thrombosis or infections [(2)].

2- Tunneled catheters

When intravenous access is required more than once over the course of a month, tunneled catheters are utilised. Compared to non-tunneled catheters, they had a decreased infection rate [(2)].

3- Implanted ports

They are favoured for long-term usage because they produce superior aesthetic outcomes and are less prone to infection than both tunneled and non-tunneled

catheters. The issue with implanted ports is that they need to be installed surgically, which involves more time and expertise [(2)].

4- Dialysis catheters

Hemodialysis and continuous renal replacement procedures both use dialysis catheters [(3)]. Both are utilised for blood filtration, often in cases of acute renal damage, fluid overload, or sepsis. Metabolic acidosis, hyperkalemia, the use of certain medications (salicylates, lithium, isopropanol, and ethylene glycol), uremia, and when the serum creatinine is more than 10 mg/dL are some other reasons for dialysis [(4)].

Heparin is needed to prevent clots from forming in the big bore central lines used for hemodialysis, which can also be tunneled for long-term usage [(2)].

5- Peripherally inserted central catheters (PIC)

An upper arm vein is used to enter a peripherally inserted central catheter, which is subsequently directed into the superior vena cava on the right side of the heart. It can stay in place for several weeks to months [(2)]. They are recommended when a patient requires intravenous administration of antibiotics or chemotherapy medications while maintaining the integrity of the peripheral vascular system [(4)].

Received: 01/03/2023
Accepted: 02/05/2023

Sites of a central line placement:

There are three usual places for central line implantation. The femoral vein, subclavian vein, and internal jugular vein are these places. Establishing central venous access while being guided by ultrasonography is currently standard practice [(2)].

1- The Subclavian Vein

One of the most popular locations to insert a central line is the subclavian vein. The axillary vein, which continues the brachial vein, is carried on by the subclavian vein. The axillary vein will change its name to the subclavian vein near the lateral edge of the first rib. After there, the vein travels down the sternal notch and beneath the collarbone until it reaches the medial border of the anterior scalene muscle. The internal jugular vein and subclavian vein join to form the brachiocephalic vein [(5)].

The infraclavicular approach is typically used to insert a central line. The skin is then punctured caudally with the needle pointing towards the sternal notch about a centimeter distant from the point where the medial and middle thirds of the clavicle meet [(6)]. Subclavian central lines on the right side appear to malfunction less frequently than those on the left do [(7)].

2- The Internal Jugular vein

Another typical location for the insertion of central lines is the internal jugular vein. The sigmoid sinus in the posterior cranial fossa is where the internal jugular vein begins, and it eventually leaves the skull through the jugular foramen [(8–9)]. The subclavian vein joins it as it continues to descend, creating the brachiocephalic vein, at the intersection of the neck and thorax. The internal jugular vein is situated before the vagus nerve and is surrounded by a number of significant structures along its morphological length. Additionally, it is situated lateral and anterior to the internal and common carotid arteries [(8–10)]. Every participant should use caution during insertion to lessen the possibility of harming these structures.

In a previous operation, a central line was introduced into the internal jugular vein by puncturing the apex of Sedillot's triangle with a needle pointing to the ipsilateral nipple [(6)]. The installation of ultrasonic guiding has simplified and lessened the difficulty of the central approach procedure. Because the right jugular vein empties directly into the superior vena cava whereas the left does not, the right jugular vein is used more frequently than the left. The left lung's apex is also higher than the right lung's. The left jugular central line may be more vulnerable to pneumothorax as a result of this mismatch [(6)].

3- The Femoral vein

The femoral vein is one of the most often used sites to implant central lines. The superficial and deep femoral veins converge in the upper thigh where it empties into the body. When the femoral vein rises above the inguinal ligament, it becomes the external iliac vein. The internal and external iliac veins join to form the common iliac vein, which eventually joins with the vein on the other side to form the inferior vena cava (IVC). The right atrium receives the IVC's discharge. The femoral vein, which is situated inside the femoral triangle, is encircled by the adductor longus, sartorius muscle, and superior inguinal ligament. You should first be able to feel the femoral artery, inguinal ligament, and anatomical point midway between the anterior superior iliac spine and the pubic tubercle. Once the pulse is noticed, the femoral vein is always located medial to the femoral artery inside the femoral triangle [(10)]. An ultrasound can be used as guidance if the results need to be validated before continuing.

Indications of central venous catheter [(11)]:

- Blood component transfusions.
- Chemotherapy.
- Fluids especially in hypovolemic.
- Frequent blood tests as ABG.
- Hemodialysis.
- Long-term treatment as antibiotics.
- Total parenteral nutrition.
- Air embolism aspiration.

Contraindications of central venous catheterization [(13)]:

- Coagulopathy (DIC), or other inherited or acquired coagulopathy.
- An abscess-like infection at the insertion site.
- Previous manipulation during surgery or injury around the insertion site.
- Damage to nearby structures that are close to the place of insertion.

The potential complications connected to inserting a central line [(7)]:

Using a central line can result in a number of problems, however ultrasound guidance has been proven to reduce this risk at all central line access sites [(2, 7)].

Immediate Complications:

- Vascular problems include bleeding, hematoma development, and arterial or venous damage. The majority of instances involving femoral vein central lines include arterial damage [(14)].
- Cardiac complications**:** Premature atrial and ventricular contractions as a result of the guide wire touching the right atrium [(14)], and arrhythmias. Consider the depth of the wire, another cardiac problem brought on by placing a pulmonary artery catheter that will result in a cardiac tamponade, is right ventricular perforation. This requires an immediate diagnosis and rapid pericardiocentesis removal [(14)].

- Catheter misplacement.
- It is possible to experience a pneumothorax, a pneumomediastinum, a tracheal injury, recurrent laryngeal nerve damage, and an air embolus with the insertion of a central line [(14)]. Pneumothorax or pneumomediastinum development will result from injury to the parietal pleura during insertion. They are most frequently observed with subclavian vein central lines and are present in 1% of instances [(15)]. The risk of pneumothorax will grow with a bigger catheter and more insertion attempts.

Delayed Complications:

Infection and equipment malfunction are examples of the delayed effects of central line insertion. These issues can develop weeks or months following the installation of a central line and have a considerably more gradual start [(14)].

- Infections**:** Central line infections have the potential to result in sepsis, shock, and even death. From 80 to 189 central line-associated infections occur every 100,000 patients/year [(17)]. Reports state that between 12% and 25% of patients die [(17)]. Staphylococcus aureus and Staphylococcus epidermidis bacteria are the two most frequent pathogens, and infections are connected to the development of biofilm on the venous catheter [(14, 17)]. Prior to beginning a course of broad-spectrum antibiotics, two blood cultures should be acquired from different locations if a central line bloodstream infection is suspected [(14)]. Depending on the sensitivity of the culture, broad-spectrum antibiotics should be administered [(17)].
- Device malfunction**:** A device dysfunction occurs when the central line's mechanical components aren't working properly. A malfunction of one of them may cause later consequences like an infection, thrombosis, stenosis and fibrin sheath, or catheter fracture. The central line site, the length of time, and the underlying patient comorbidities all have a direct impact on the rate of device dysfunction. Within the first week following a central line's insertion, a fibrin sheath can form, which can obstruct the distal apertures. The ability to take blood from the line will be lessened as a result. To remove the fibrin sheath, fibrinolytic medications like alteplase can be provided as a kind of treatment. If those medications are unsuccessful, line stripping can be tried [(15, 16)].
- Another problem that was found most frequently with subclavian lines after a catheter has been in place for a long time is a central line venous catheter fracture [(14)]. A catheter fracture might result in the development of potentially fatal diseases such as sepsis, endocarditis, heart perforation, or arrhythmias [(16)]. Pinch-off syndrome leads to the fracture [(15)]. The catheter is crushed by the subclavius-costoclavicular complex, which is made up of the clavicle and the first rib, leading to the development of pinch-off syndrome [(15)]. This compression will cause the catheter to malfunction, raising the possibility of a catheter fracture [(15)]. All catheter components must be swiftly and carefully removed in order to avoid further harm.
- The risk of venous thrombosis is also increased with long-term central lines. Patients will experience paresthesia, edema, and erythema in their ipsilateral extremities [(14)]. Patients may develop superior vena cava (SVC) syndrome as a result of the thrombosis. One in 1000 patients will develop SVC syndrome, according to studies [(15-17)]. The rate of thrombosis is lowest in subclavian central lines and highest in femoral vein central lines. In addition, 41% of patients with cancer have the highest risk of thrombosis [(15)].
- Venous stenosis may develop as a result of an old central line. 41% of people are at risk for venous stenosis. Although, it normally has no symptoms, stenting might be used to treat the patients if they do [(16)].

Complications associated with peripherally inserted central catheters:

Previous investigations raised the hypothesis that PICC had lower rates of infection than central lines, but current research has not confirmed this. Similar problems are observed with both PICC and central lines, despite the lack of clinical trial data to compare them. Prior research investigations have reported venous catheter fracture, embolisation, cardiac perforation, cardiac tamponade, arrhythmias, and pneumothorax [(17)].

CONCLUSION

There are many sites possible for central line insertion, several indications, and the benefit of ultrasound guidance to avoid many possible complications.

- **Sponsoring financially:** Nil.
- **Competing interests:** Nil.

REFERENCES

1. **Bell T, O'Grady N (2017):** Prevention of central line-associated bloodstream infections. Infect Dis Clin North Am., 31: 551–559.
2. **Bannon M, Heller S, Rivera M (2011):** Anatomic considerations for central venous cannulation. Risk Manag Healthc Policy, 4: 27–39.
3. **Claure-Del Granado R, Mehta R (2016):** Fluid overload in the ICU: evaluation and management. BMC Nephrol., 17:109-13.
4. **Hanafusa N (2015):** Application of continuous renal replacement therapy: what should we consider based on existing evidence? Blood Purif., 40: 312–319.

5. **Deere M, Singh A, Burns B (2023):** Central Venous Access of the Subclavian Vein. Treasure Island (FL): StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK 482224/
6. **Taylor R, Palagiri A (2007):** Central venous catheterization. Crit Care Med., 35: 1390–1396.
7. **Vascular Access 2006 Work Group (2006):** Clinical practice guidelines for vascular access. Am J Kidney Dis., 48:176–247.
8. **Mumtaz S, Singh M (2019):** Surgical review of the anatomical variations of the internal jugular vein: an update for head and neck surgeons. Ann R Coll Surg Engl., 101: 2–6.
9. **Garner D, Kortz M, Baker S (2019):** Anatomy, Head and Neck, Carotid Sheath. Treasure Island (FL): StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK 519577/
10. **Yigit E, Dursun E, Omeroglu E *et al.* (2018):** The course of lower cranial nerves within the neck: a cadaveric dissection study. Eur Arch Otorhinolaryngol., 275 (10): 2541-2548.
11. **Song Y, Messerlian A, Matevosian R (2012):** A potentially hazardous complication during central venous catheterization: lost guidewire retained in the patient. J Clin Anesth., 24 (3): 221-6.
12. **Hind D, Calvert N, McWilliams R *et al.* (2003):** Ultrasonic locating devices for central venous cannulation: Meta analysis. BMJ., 327: 361-65.
13. **Pillai L, Zimmerman P, d'Audiffret A (2009):** Inadvertent great vessel arterial catheterization during ultrasound-guided central venous line placement: A potentially fatal event. J Vasc Surg., 53: 74-79.
14. **Matsushima H, Adachi T, Iwata T *et al.* (2017):** Analysis of the Outcomes in Central Venous Access Port Implantation Performed by Residents via the Internal Jugular Vein and Subclavian Vein. J Surg Educ., 74 (3): 443-449.
15. **Guilbert M, Elkouri S, Bracco D *et al.* (2008):** Arterial trauma during central venous catheter insertion: Case series, review and proposed algorithm. J Vasc Surg., 48: 918–25.
16. **Teichgraber U, Nibbe L, Gebauer B *et al.* (2003):** Inadvertent puncture of the thoracic duct during attempted central venous catheter placement. Cardiovasc Intervent Radiol., 26: 569–71.
17. **Centers for Disease Control and Prevention (CDC) (2011):** Vital signs: Central line-associated blood stream infections--United States, 2001, 2008, and 2009. MMWR Morb Mortal Wkly Rep., 60: 243–8.