Review Article

Overview on Central Venous Access in Pediatric Patients

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ABSTRACT

Central venous catheters (CVCs) are an intravenous catheter is placed with one end in a wide venous vessel and the other end exteriorized via the skin or implanted beneath the skin for therapeutic administration. It is used for administration of parenteral fluid for nutrition and for delivering medications. The delivery of medication is made easier with the use of a CVC, it also could be used to introduce resuscitation fluid and nutritional fluids into wide veins with high blood flow. The CVC is used in pediatric patients is considered more challenging than that of adults due to anatomical constraints, especially thin and delicate veins, and an in babies, there is an abundance of subcutaneous fat, which may be harmful and causes prohibition of the surgery. The length of treatment, frequency of catheterization, and the accessibility of entry sites are the most important factors to consider when choosing a device. It's critical for members of the healthcare team to talk about which CVC option is best for the patient. Every youngster who requires central venous access has certain requirements to guarantee better results and decrease the risk of any further complications. This narrative review aims to overview and summarize current evidence regarding indications, devices and complications of CVCs.

Keyword: Central venous catheters, parenteral nutrition, venous access, Apheresis, Chemotherapy.

Introduction

In some cases, central venous access is required to provide a conduit for the delivery of medications, fluids, and blood products, such as during surgery. Both long-term parenteral therapy and severe illnesses require parenteral nutrition. The delivery of medication is made easier with the use of a central venous catheter (CVC), it also could be used to introduce resuscitation fluid and nutritional fluids into wide veins with high blood flow. The CVC is used in pediatric patients is considered more challenging than that of adults due to anatomical constraints, especially thin and delicate veins, and an in babies, there is an abundance of subcutaneous fat, which may be harmful and causes prohibition of the surgery [1-3].

In children, CVCs are required for clinical evaluation and interventions. In the United States, CVC insertion is one of the most common operations performed by pediatric interventional radiologists and pediatric surgeons, annually 5 million catheters are inserted [4]. Patients in the critical care unit (ICU) alone are exposed to CVCs for 15 million days every year [5]. Cannulation of a central venous structure is not a new intervention as it goes back to 1929, when Forssmann reported puncturing his arm to advance a plastic tube near the heart. Aubaniac inserted a central venous catheter into the subclavian vein in mid-1950s. Since then, several additional access routes have been identified [6, 7].

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CVADs have become safer and more common as technology has advanced. CVA devices are available in a variety of sizes and brands, allowing the doctor to select the optimum device for each case. The small size of the devices, as well as the size of pediatric patients, can make CVAD treatments more difficult in youngsters [8]. The material utilized in CVADs, as well as methods to prevent any further infections and obstruction, are anticipated to be the focus of future study. The use of ultrasonography (US) in the administration of central lines is becoming more common [9-11]. Teaching and using US for central line insertion will help pediatric and emergency medicine training programs [12]. Children with chronic illnesses, who frequently require extended or recurrent venous access and are at high risk for venous catheter–related problems, which are mostly the result of decisions made during catheterization and ongoing care, are receiving more attention [13, 14]. In hospitalized children, short-term vascular access is necessary for the supply of intravenous fluids, medicine, and supplying blood products. While repeated medicine delivery, chemotherapy, immunization, parenteral nutrition, plasmapheresis, and hemodialysis all necessitate longer-term vascular access devices. The use of vascular access devices is required by routine blood sampling and hemodynamic monitoring. The health state and preferences of the patient, the probable duration and frequency of therapy, and the qualities of the infuscate all influence the vascular access device selection [15]. A multidisciplinary care team composed of surgeons, intervention radiologists, pediatricians, and nurses are ideally suited to care for venous devices in children. Indications, surgical procedures and vascular access devices, as well as the diagnosis and management of problems, are all critical information for a surgeon [16, 17]. This narrative review aims to overview and summarize current evidence regarding indications, devices and complications of CVCs.

Indications

Huge quantities of irritating fluids, such as antibiotics, blood products, parenteral nutrition medium, and sclerosing chemotherapeutic drugs, are delivered using central venous access devices. A CVAD is favored over a peripheral IV line for patients who require prolonged I.V access. When peripheral access is not possible, central access is recommended. At the femoral, subclavian, and internal jugular sites, CVCs are placed. Children who do not have peripheral access or who need a longer IV access should use these devices. For many years, the subclavian method has been the method of choice since it allows the patient the most mobility. In children, the internal jugular vein (IJV) is a frequent site for installation under ultrasonography (US) guidance [18]. CVCs are classified into three categories based on the exteriorized portion of the catheter. Tunneled catheters which are catheters with an exterior segment positioned beneath the subcutaneous plane between the venous puncture site and the skin exit site, non-tunneled catheters are those with a skin exit point right above the venous entry point and the last one is the Totally Implantable Venous Access Device (TIVAD) which is a group of catheters with multiple parts implanted within the body. The opposite end of the venous access component is tunneled beneath the subcutaneous plane and linked to a target chamber covered with a silicone cap once it is put within a great vein [19].

Parenteral nutrition

Children who suffer an intestinal obstruction, intestinal dysfunction due to chronic intestinal pseudo-obstruction syndrome or short bowel syndrome, are all unable to accept enteral feeds. For dryness and replenishment of enzyme or amino acid deficits, children suffering metabolic illnesses frequently need IV fluid therapy in the home. In these kinds of situations, hyperalimentation is recommended, necessitating CVC access. Hyperalimentation and further hyper-osmolality solutions should administer solutions centrally, because the greater blood flow allows for less vessel irritation and faster dilution, to avoid the damage of small capillaries and risk of injury [20].

Venous access

In administering injectable medications, short-term CVCs may also be used, especially when needed to be administered on a regular basis. Patients with restricted or problematic peripheral access, as well as those who require frequent blood collection, might consider CVCs. The main disadvantage of peripheral access is that it becomes more difficult over time and causes chronic illness that affects children both psychologically and physically [20].

Apheresis

Therapeutic apheresis necessitates central venous access. Total plasma exchanges, erythrocytoapheresis, RBCs exchanges, and other apheresis treatments are required for children with Wilson's disease, hemochromatosis, and sickle cell disease. As part of their treatment, people with severe hemophilia get intermittent delivery of the defective clotting factors.

Many of these illnesses require outpatient care for the use of a long-term CVC [21].

Chemotherapy

Chemotherapy must be administered in a continuous way to manage neoplastic disorders. Most chemotherapeutic drugs irritate and injure the vascular endothelium, necessitating administration through a large central vein. Extravasation of these products can harm soft tissues; hence peripheral administration is not recommended.

Devices

The length of treatment, frequency of catheterization, and the accessibility of entry sites are the most important factors to consider when choosing a device. According to researchers compared central venous access device's complications, the most common (51%) are peripherally inserted central catheters (PICCs) and (34.4%) non-tunneled CVCs, followed by (6.3%) tunneled CVCs, (5.2%) totally implantable venous access devices (TIVADs), (1.6%) umbilical vein catheters (UVCs), and (1%) hemodialysis catheters [22].

Umbilical vein catheters

Due to their peripheral veins minor size, umbilical vein catheters are most typically used in preterm neonates. When compared to individuals with multiple peripheral lines, early preterm neonates receiving parenteral nourishment by central venous catheter have been shown to acquire more weight and have reduced infection rates. One of the most important precautions before using the line is making sure that it is in an appropriate position. As insertion in the wrong position of the portal circulations cause serious liver damage with both short- and long-term consequences. Lines are frequently withdrawn or switched for another central access after 5 to 7 days due to high risk of infection [23].

Peripherally inserted central catheter/ epicutaneo-caval catheter. In the U.s, the most widely used central venous access in newborns are PICCs. They are introduced after a peripheral vein has been cannulated. Single-lumen catheters, Epicutaneo-caval catheters (ECCs) that are inserted proximally into a central vein, after being inserted into extremities superficial veins or veins in the scalp. Even though the two types of lines are known as 'PICC', the Epicutaneo-caval catheters can be of extremely small ability, and thus play an essential part in preterm or low birth weight newborns [24, 25].

Though PICCs can be of use to administer vasoactive medicines and parenteral feeding, ECCs have a narrow lumen that makes collection of blood samples and hemodynamic monitoring difficult. PICCs and ECCs have a tiny lumen and are too long for fluid delivery; however, PICCs new generation injectables are available. Since a risk of infection, PICCs are only used for short-term treatment, ranging from four to six months [26].

Tunneled and non-tunneled catheters: Catheters injected right into the subclavian, internal jugular, and femoral veins (central veins) are known as non-tunneled CVCs. Although umbilical vein catheter and PICCs are the primary choice in neonates, recent studies have shown that placement of internal jugular (ultrasound-guided) non-tunneled CVC in low-birth weight, very low-birth weight, and extremely LBW infants has a 95% rate of success [27].

PICCs have to some extent less risk of a central line bloodstream infection than non-tunneled CVCs (2.1 vs. 2.7) but a much higher risk than tunneled lines, according to a systematic analysis. To prevent bacterial infection from the catheter to the blood stream a subcutaneous tunnel between the spot of injection and the venipuncture, also the cuff added to the catheter aids in fixing the device in its place. Broviac and Hickman catheters are the most often utilized devices [28].

Totally implantable venous access device: For long-term, infrequent central venous access, totally implanted venous access devices are recommended. The most important advantage of TIVADs is their reduced infection rates and longer durability. Chemotherapy is the most prevalent application for them. TIVADs are made up of a central venous catheter that is inserted directly into a central vein and coupled to a subcutaneous reserve. A needle is used to reach the reservoir, which has a plastic or metal base with a central silicon bubble. The subclavian vein is the most typical placement location. Because of management in patients, reservoir location varies from surgeon to surgeon. Inframammary placement, parasternal or across anterior axillary line are all possibilities. With ports put on the lateral inframammary site, a retrospective analysis of reservoir placements revealed greater complication rates, mainly the displacement of the line [29].

Complications

Bloodstream Infections: CVC is considered a foreign object that is injected into the bloodstream and can cause infection. S. aureus, coagulase negative staphylococci (particularly S epidermidis), Enterococcus spp., E. coli, C. albicans, and Klebsiella spp. are the most prevalent infecting microorganisms. Microorganisms can enter the bloodstream through the

CVC hub, insertion site, and, less commonly, infusate [30-33]. Central line bloodstream infections are more common in patients who require parenteral nutrition. For children with severe gastrointestinal disease, malfunctioning digestive systems, metabolic disorders, and congenital anomalies; PN is nutrition supplied through a CVC straight into the bloodstream. The high concentration of amino acids, dextrose, and lipids in parenteral nutrition creates an excellent environment for bacteria to thrive, putting patients at risk for CLABSIs [34]. Defined by the Centers for Disease Control and Prevention (CDC), CLABSIs are a laboratory-confirmed bloodstream infection that occurred while a central venous catheter (CVC) was in place for more than two days on the day of the occurrence. One of three criteria defines laboratory-confirmed bloodstream infections which are: Criteria 1: The patient has a known cultivated pathogen from blood cultures, and the cultured organism is not related to an infection at another location. Criteria 2—Patient shows one of the mentioned clinical features: fever (>38°C), chills, or decreased blood pressure with positive laboratory results for two blood cultures or more. Criteria 3—A children under one years old shows at least one of these symptoms: high body temperature (>38°C), hypothermia (36°C), hypoventilation, or bradycardia. In conjugation with positive blood culture results for two successive trials [35]. Risk factors that cause bloodstream infections for neonates are long-term parenteral nutrition, low-birth weight, age less than 3 years, neutropenia, transfusion of blood products, Prematurity and Prolonged duration of catheterization [36-38]. With chronic bacteremia, fungemia, or metastatic infection, CVC excision and replacement should be considered. Replacement is a potential risk factor and therefore the risk of CLABSI following replacement continues. Declined infection risk for ports could be as high as 50% [33].

Venous Thromboembolism: Venous thromboembolism is a potential risk that is linked to a CVC. Most CVC occlusions are thrombotic. With a 2 days dwelling duration, Borow and Crowley examined the formation of platelet and fibrin sheath on silicone catheters and polyurethane, finding silicone over polyurethane and the polyurethane was covered with a hydromer to be the lowest materials that cause thrombosis. Despite the lack of clear clinical evidence, several facilities have adopted heparin infusion and heparin locks as a practice routine. For neonates, the American College of Chest Physicians approves a continuous 0.5 unit/kg/h infusion of unfractionated heparin and washing with heparin, normal saline, or discontinuous recombinant urokinase to ensure stability [39]. VTE risk may be influenced by the location chosen for short-term and long-term CVC access. Due to an increased tendency in VTEs with femoral and subclavian catheters, that's why considering the internal jugular insertion location is mostly recommended. However, because of the clinical manifestations of VTE, such as soreness, pain, edema, and alteration in extremity colour, is more visible in the subclavian and femoral sites, internal jugular VTE occurrences may be underreported. Although VTE is less common in children, it seems to be more frequent with umbilical venous catheters and PICC [39, 40].

External Line Fracture: Tunneled CVCs have the advantage of being repairable if the catheter develops stress, or breakage. Near the distal adjoining junction, the line may break. Fracture of the visible lumen necessitates removing the dressing, restraining between the fracture and exit site, and redressing, as well as emergency medical treatment. During the repair line breakage enables microbial translocation. In the pediatrics population, tunneled CVCs are frequently repaired in order to save the line and prevent surgical removal and replacement. an analysis of 81 children who had their first CVC repair discovered that the mean bacteremia frequency was 9.9/1000 catheter days, which increased to 24.5/1000 CD post-repair, and the risk of CLABSI was 2- to 4-fold higher within repairing in 30 days, which confirms the higher risk of infection due to removal and repair [41].

Multiple Lumens: In a study on 966 PICC lines by Chopra et al, it was observed that duration of hospitalization, ICU condition, and the amount of PICC lumens were all substantially linked with PICC bloodstream infections. Multilumen catheters were linked to a higher infection risk and a shorter time to infection. Multilumen catheters are used in emergency situations to assist effective medical care throughout a crisis; however, it is recommended to use the least lumens possible with rapid removal and replacement of inserted lines within two days to limit the risk of CLABSI [42, 43].

Neonates: It is nearly hard to prevent CVC installation in sick premature and VLBW infants that require parenteral nutrition and further medications. Although part of the skin flora, coagulase-negative staphylococci are considered pathogen that can cause delayed sepsis in newborns, leading to morbidity and mortality [44, 45]. Hemels et al. conducted a randomized experiment with 88 premature newborns.

A peripherally placed central catheter in its arterial location. During the removal of implanted CVCs, the anti-staphylococcal drug cefazolin was given twice. Despite the clinical similarities across the groups, 11% of the untreated control had coagulase-negative staphylococci sepsis two days after the removal of CVC was, which indicates that the presence and elimination of a CVC are both linked risks of CLABSI in the neonatal age [45,46]. Despite decline in CLABSIs by 46% in U.S. hospitals from 2008 to 2013, an estimated 30,100 CLABSIs occur each year in ICU of U.S. facilities. CLABSIs can be avoided with careful installation, care, and maintenance [47].

Conclusion

Central venous catheters (CVCs) are an intravenous catheter placed with one end in a venous vessel and the other end exteriorized via the skin or implanted beneath the skin. It is used for administration of parenteral fluid for nutrition and also for delivering medications. In pediatric patients as their venous are delicate and small this procedure is important and should be done with caution to prevent the rupture of any vessel or need for repeated catheterization which affects the children both mentally and physically. CVC implantation has become easier and safer for numerous practitioners because of ultrasonography. It's critical for personnels of the healthcare team to talk about which option of CVC is finest for the patient.

Conflict of Interest

None

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