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Original Research Article

Venous access in neonates: our experience

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ABSTRACT

Background: The aim of this work was to study various tools for intravenous access in neonates, both short- and long-term, and their feasibility and associated complications.
Methods: Records of 366 neonates who required three or more days of hospital admission were retrieved and included in the study. Their requirements of intravenous fluids, and medications and parenteral nutrition were recorded. The type of intravenous (IV) device, its in-situ duration, any complications and the frequency of need to change it were recorded.
Results: 42 patients needed long-term (more than 7 days) indwelling cannula and central line insertion. The indications were prolonged stay with the need for IV fluids, need for prolonged antibiotics, and parenteral nutrition. Commonest complication was local thrombophlebitis. Other complications noted were fever and local skin necrosis.
Conclusions: Neonatal care has come a long way in last few decades and involves high-end NICUs, advanced ventilators, and other similar gadgets and methodologies. This applies to both, medical as well as surgical neonates. This mandates prolonged admission and various invasive procedures, including surgical operations. Obtaining a secure and long-term venous access automatically becomes an important part of this kind of neonatal care. There are now available a plethora of intravenous cannulas and devices for various indications of intravenous access in neonates. The present article discusses the experience of various options available for intravenous access in neonates including their complications and prevention of the latter.

Keywords: Central venous catheter, Neonate, Thrombophlebitis, Venous access

INTRODUCTION

The need for vascular access in the newborn patient is frequent; however, nothing can be more difficult, time-consuming and frustrating than obtaining a reliable and confident vascular access in the pediatric patient, especially newborn.[1]

Not only this, as the veins in newborns are very tiny and small-caliber, the frequency of cannula change is high as is the incidence of thrombophlebitis. Also, due to miniaturization of the intravenous devices, it is possible to gain access even in the tiniest of newborns. However, it needs considerable experience and skill to achieve this and a good care of the same.

Veins in the newborn are small and fragile which imply low tolerance to pH and osmolality.[2] Because of these factors the extravasations rates are more than 40%; the degree of trauma to the blood vessel during intravenous (IV) access and the dwell affect this outcome.

Up to 91% of peripheral IV lines are removed prematurely due to cannula complications in this population.[3] Peripheral IV dwell time averages only 27-49 hours. Apart from this, the pre-term neonate may

require longer-term parenteral support when compared to the average hospitalized patient.

A technologically specific IV cannula considering the needs of the small neonate may help decrease the number of IV access attempts.

Options available include

- Peripheral IV cannula
- Peripherally-inserted central catheter (PICC)
- Central venous catheter
- Venous cut-down
- Umbilical vein catheter
- Intra-osseous access

METHODS

Hospital records of 366 newborn patients requiring admission were retrieved.

Inclusion criteria

Newborns who needed admission for not less than three days were included. These included both patients referred from outside as well as those born at the present place.

Exclusion criteria

Newborns who already had admission elsewhere for three days or more, as they already must have undergone multiple peripheral cannulation attempts and therefore were more likely to need central venous cannulation, were excluded.

Their need for IV fluids, IV antibiotics and parenteral nutrition were noted. Authors recorded the number of dwell-days as well as various complications. Latter were recorded as local and systemic like sepsis or jaundice. Type of cannulas used, attempts required, and frequency of change were also noted. Cannula was removed at the first sight of any local complication like thrombophlebitis or if any resistance to the free flow of fluid was noted. Tip of the removed cannula was sent for culture if there was any evidence of sepsis. No statistical analysis was needed.

RESULTS

Out of 77 patients, 53 patients were male and 24 were female. Age range was one day till 28 days (mean age 6 days). The indications for admission included various congenital anomalies, intestinal obstruction, spina bifida and/ or hydrocephalus, pneumothorax, and abscesses and soft tissue infections (Table 1).

Table 1: Distribution of patients requiring more than 3 days NICU admission.

	Congenital anomalies	Intestinal obstruction	Spina bifida/ HC	Pneumothorax	Soft-tissue infections/ abscess	Misc	Total
Male	24	11	06	04	02	6	53
Female	12	6	2	1	-	03	24
Total	36	17	8	5	2	09	77

Only seven patients needed parenteral nutrition for prolonged intestinal failure. Rest others required IV access for fluids and antibiotics. PICC was inserted in twelve patients. These were the patients who needed parenteral nutrition or where prolonged course of antibiotics or antifungals was required. Average days of IV access requirement were 10.2±2.3 days. Average dwell time for a peripheral cannula was 2.4±1.2 days while PICC stayed for more than 12 days. In most cases, cannulas were removed electively at the first sign of obstruction or local inflammation. In four patients, central line was inserted through right internal jugular vein. Commonest complication noted was local thrombophlebitis leading to blockade of the cannula. Out of twelve patients who needed PICC, three patients required more than one attempt. On the other hand, out of seven patients who required central line, only one could be put in single attempt. Authors feel this was largely because that the procedure was not very frequently needed. Two patients developed local skin necrosis that was probably due to extravasations. This did not require any intervention as the necrosis was only superficial. In none of the patients did any major complication happen.

DISCUSSION

Peripheral intravenous catheters (PIC) are the easiest and safest means of achieving vascular access. Today, peripheral venous access is preferred except for high volume fluid resuscitation, reliable infusion of irritant drugs and long-term parenteral nutrition.[4] Modern catheters for peripheral access are of smaller caliber, more flexible, more resistant to bacterial colonization and less thrombogenic. This has resulted in significant reduction in the use of invasive procedures, such as intraosseous access and venous cut-down. Advantages of PIC include ease of insertion, low cost, and minimal complications. Disadvantages are easy and early

occlusion, potential for local tissue injury, and that the usage is limited mainly to medications and fluids.

The size of the intravenous cannula to be inserted according to the "INS Standards of Practice" is the smallest gauge, shortest length catheter to meet IV therapy requirements.[5,6] The ideal vein attributes for insertion are that it should be engorged and soft, refills after it has been compressed, be visible, feel round, be well supported by surrounding structures, and be straight and 'free of valves'.

For the purpose of analgesia during the procedure, sucrose as a pacifier can be used or one can use a local anesthetic cream as well. When using topical anesthetic creams, one must plan in advance to allow at least 30-45 minutes for the cream to provide the desired effect. It is important to note that back-flow of blood may not occur in the cannula during insertion in small neonates. Putting the cannula near the joints should be avoided and the cannula should be removed at the first sign of local extravasations or phlebitis.[7] Usually no more than two attempts should be made before allowing the baby to rest, though this will depend upon the urgency of the need for cannulation.[8] If it appears that a further attempt is likely to be unsuccessful, then get another member of the team to try if possible, rather than carrying on.[8]

Peripherally inserted central catheter (PICC), commonly referred to as PICC lines, have become one of the most popular venous accesses in the NICUs. The success of introducing the PICC line is greater if attempts at inserting peripheral lines are limited. Advantages include ease of insertion (bedside), ability to use a variety of medications, and safety and low-cost. Drawbacks are the potential for occlusion/infection, and that it can be difficult to position it accurately in the central vein. Various sites of insertion of PICC include arm (Basilic, Cephalic, Median cubital veins), and leg (Great Saphenous veins).

Lower extremity percutaneously inserted central venous catheters (CVC) have been claimed to have lower rates of catheter-related bloodstream infection, longer time to first complication and lower cholestasis despite longer duration of total parenteral nutrition.[9]

Many kinds of materials such as Teflon, polyurethane and silicone elastomer are available. There is no data to support high rates of infection with any particular catheter material; however, dwell time may be longer for newer materials such as Vialon as compared to Teflon.

The ideal position of the tip of a PICC should be at the superior vena cava-atrial junction or in the inferior vena cava at the level of the diaphragm for lower extremity CVCs. Preferred tip locations include the superior vena cava (above T4) or the inferior vena cava outside the heart shadow and below T9. The tip of the PICC should lie outside the heart, ideally by 1 cm in a baby <1250g and by 2 cm in a baby >1250g.[10] The catheter tip position must be verified with a radiograph and contrast before using the line. For arm insertions, the upper portion of the extremity of insertion, chest and neck should be included in the x-ray. For catheters inserted into a leg vein, the upper leg, abdomen, and chest area should be included in the x-ray.[11] Catheters that are placed via the basilic or axillary veins migrate towards the heart with adduction of the arm, whereas those that are placed via the cephalic vein move away. Flexion of the elbow displaces catheters that are placed in the basilic or cephalic vein below the elbow towards the heart but do not have any effect on catheters that are placed via the axillary vein. For catheters that are placed in the basilic vein, simultaneous shoulder adduction and elbow flexion cause the greatest movement towards the heart (15.11±1.22 mm).[12]

Central venous catheter (CVCs) are inserted at the femoral, subclavian, and internal jugular vein sites. For jugular sites, right IJV is preferred as it has straight descent into the right atrium and there is decreased risk of injury to the thoracic duct. Subclavian vein, in infants, is located more cephalic, meaning that it dives under the clavicle closer to the medial third. Deep to the vessels lays the first rib, which is just superficial to the pleura and lung. The subclavian vein is accessed by means of the infraclavicular approach at a point inferior and lateral to the mid-clavicular bend. The needle is inserted toward the suprasternal notch by guiding the needle posteriorly at an angle of approximately 30° to the chest wall. Femoral vein is also a good choice in neonates. Infection rates are no higher as compared to other sites. The standard procedure for puncturing the femoral vein has a high success rate and a low rate of arterial puncture in pediatric emergency treatment and in the intensive care unit setting, even with inexperienced operators.

Venous cut-down, in the past, was used in cases of difficult access and in emergency situations. However, this technique has fallen out of favor because of its related morbidity, relatively short patency, and technical difficulty. This technique still has a limited role in emergency situations when other peripheral and intra-osseous (IO) attempts fail. Currently, cut-down procedures are regarded as the methods of last resort. In a study the usual time to achieve success by pediatric surgeons was 6 minutes in children aged 6-16 years and 8 minutes in those aged 1 month – 5 years.[13] This time delay makes its use unrealistic for most clinicians, and IO or percutaneous femoral access can be achieved more rapidly[14]. The most preferred cut-down access site is the great saphenous vein above the medial malleolus of the tibia, but antecubital, axillary, cephalic and femoral vessels are also suitable. However, improved procedures using Seldinger technique have been reported.[14]

Umbilical vein catheter (UVC) placed within the first hours of life is a relative easy procedure with a high success rate and can be left in place for up to 14 days with low risk of complications.[15] Indications include

urgent administration of resuscitation drugs such as adrenaline, infusion of hypertonic solutions (greater than 10%), administration of vaso-active drugs, delivery of blood and blood products, measurement of central venous pressure, and exchange transfusion.

However, platelets should not be administered via this route due to risk of inferior vena cava or portal vein thrombosis.[16] Contra-indications for an UVC are omphalitis leading to portal vein thrombosis and later, portal hypertension, necrotizing enterocolitis, and rarely, peritonitis. The UVC should be placed just above the right diaphragm and below the heart in the inferior vena cava. Calculate the desired insertion depth of catheter use by using the formula, 1.5 x weight in kg + 5.5 cm + stump length in cm.[17] An UVC placed properly will not 'bounce back' during its insertion and will usually draw sample blood using a syringe. After insertion, a chest / abdominal x ray should be taken to confirm the catheter tip location.

Intraosseous access was commonly used in the past. Its use has declined with advances in IV catheters and alternative access techniques. ATLS guidelines recommend that intraosseous access should be established in the newborn if umbilical venous access cannot be rapidly achieved. Intraosseous vascular access is based on the anatomic presence of non-collapsible veins in the medullary sinuses in the bone marrow. This venous network drains directly into the central venous circulation by means of emissary veins, resulting in rapid and almost immediate absorption.[18,19]

A variety of drugs (including resuscitation drugs), crystalloid solutions, and even blood products can be given rapidly by means of the intraosseous route. The large bore of these catheters enable the administration of blood without lysing RBCs. The sites of insertion include proximal tibia, distal tibia, distal femur, proximal humerus and distal radius. Correct placement is confirmed with the aspiration of marrow and with the easy infusion of fluid.

Intraosseous catheters are not recommended for long-term use and should be removed within 12-24 hours after their insertion. The most common reported complication is leakage at the insertion site. Other complications include osteomyelitis (<1%), fracture, compartment syndrome, and failure of infusion due to bending of the needle or occlusion of the needle with bone marrow.

Complications are more common with CVC and long indwelling PICC than peripheral cannulas. Early local complications of IV access include thrombophlebitis and local tissue damage, and infiltration and extravasation. The prevalence of extravasation injury resulting in skin necrosis in NICUs is reported to be approximately 4%; 70% of these injuries occurring in infants of 26 weeks' gestation or less.[20] Fragility of the skin, particularly in the first 2 weeks of life, and the lack of subcutaneous tissue in preterm neonates makes them uniquely susceptible to injury and skin loss. Other complications include pneumothorax and/ or pleural effusion, vascular damage (e.g. perforation, dissection), air embolism, aberrant catheter placement, and cardiac complications (e.g. cardiac irritation, cardiac perforation / tamponade). In a large series of 61 CVC-related pericardial effusions in infants, mortality was reported to be 8% in patients who had pericardiocentesis and 75% in patients who did not. Attempts to remove the pericardial fluid by aspirating through the misplaced catheter have not been successful.[21]

Late complications include infection and sepsis, thrombotic complications, occlusion of the cannula, migration and malposition, and phlebitis.

Infection and sepsis are the most common late complications. Incidence increases with the duration of catheter. The incidence is higher in newborns [4.9 episodes of catheter-related bloodstream infection (CRBI) per 1000 catheter days] than in older children (2.4 episodes of CRBI per 1000 catheter days). There is no data to support high rates of infection with any particular catheter material.

Most commonly isolated organism is coagulase-negative Staphylococcus (37%) followed by gram-negative bacteria (25%), enterococci (10%) and candida (9%). In one study, a flush solution containing an antibiotic (vancomycin and ciprofloxacin) and heparin substantially decreased complications, both infectious and thrombotic, compared with heparin alone.[22] The United States centre for disease control and prevention has issued specific guidelines for prevention of infection in IVCs.[23]

Removing the infected catheter eliminates the source of infection. Empiric antibiotics may not be warranted unless the child has signs of sepsis. Commencing broad-spectrum antibiotics is generally warranted in critically ill children after appropriate cultures are obtained. If antibiotics are started, they should cover coagulase-negative Staphylococcus bacteria as well.

About 90% of venous thromboembolic events in neonates are associated with CVCs and include, but are not limited to, deep vein thrombosis, superior vena cava syndrome, intra-cardiac thrombus, pulmonary embolism, and renal vein thrombosis.

To maintain the patency of peripheral and central vascular catheters, Heparin solution of 0.5 -1 u/mL of IVF should be used when the line is not in use. Management of thromboembolism in neonates is controversial. The severity of thrombosis and the potential risk to organs or limbs dictate the degree of intervention required. Heparin 75 u/kg bolus followed by 28 u/kg/h IV should be started. Measure aPTT 4h after initiating therapy, and then adjust the dose to achieve a

PTT of 60-85 seconds. In most cases, cannula removal is indicated.

CONCLUSION

Intravenous access is an important and crucial part of neonatal intensive care. Acquiring and maintaining a patent access is a responsible and skilful job and requires not only technical expertise but a strict vigilance. Timely intervention and appropriate measures will not only prolong the dwell time but will also prevent complications which sometimes can prove serious for these tiny patients.

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