VASCULAR ACCESS IN NEONATES – A REVIEW

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Abstract:

Anaesthesiologists are referred to by other professionals for difficult vascular access because they are considered experts in the field. As a result, familiarity with vascular access techniques, including advanced vascular access, is essential. Obtaining vascular access in neonates may necessitate repeated attempts and can be stressful for the infant, family, and caregiver. Access to the neonatal circulatory system can be venous, arterial, or intraosseous. We have tried to elaborate on different types of vascular access including arterial, venous and umbilical. The salient features of different techniques and the use of ultrasound are being discussed.

Key words:

Neonate, intravenous, umbilical, catheter,

Introduction:

Securing a right vascular access is one of the fundamental roles of an anaesthesiologist. What makes it so different in a neonate is that vessels in this subset of population is smaller and more fragile making it hard to pick and cannulate. It is so painful for the performer as well to take multiple attempts to secure the right vascular access in a neonate. Things get more complicated when this happens in an emergency. Despite all this there is a paucity of literature in encompassing vascular access in neonates. This review aims at bridging the gap by bringing in most of the routes to access the vessel in a neonate under one roof.

Achieving vascular access in a neonate can be classified as

1. Arterial access
    a. Peripheral arterial line
    b. Umbilical artery access
2. Venous access
    a. Peripheral venous line
    b. Central venous line
    c. Peripherally inserted central venous catheter
    d. Umbilical venous catheter
3. Intra- osseus access

1. INTRA-ARTERIAL ACCESS

Whatsoever be the age group the patient belongs to, had the need arises to secure an intra arterial line, the procedural risk had to be out-weighted with benefit. Arterial line in neonates poses technical difficulty as the lumen of the vessel is smaller by itself that securing and maintaining the line is difficult. Moreover, more susceptible to complications such as iatrogenic trauma, vasospasm, thrombosis, and thromboembolism with subsequent tissue ischemia and necrosis of the involved anatomical region.

Intra-arterial access shall be classified as

1. Peripheral arterial line
2. Umbilical artery catheterization

Peripheral arterial line

This is the most commonly used technique in securing arterial line across all age groups. Sites frequently employed in neonates being radial, ulnar artery, dorsalis pedis artery and posterior tibial artery, radial artery is most preferred.

It is emperative to know that those sites that has good collateral circulation is preferred because of the risk of thrombosis of the vessel cannulated attributed likely to its small lumen leading to ischemia of the limb. In clinical practise, ischaemic complications in neonates following arterial catheterisation were rare events, but could cause devastating damage. (1) Reports are available on cannulation on brachial artery, yet data is inadequate. (2)

Serious complications of peripheral arterial cannulation include discolouration of digits, blanching of skin or bleeding. Others include swelling of the limb, leakage or extravasation and dislodgement of the catheter. (3)

Umbilical artery catheter

In neonates, cannulation of the umbilical artery is a less frequently performed entity in securing vascular access. Umbilical tie placed around the cord, tight enough to minimize blood loss but loose enough to allow catheters can be passed easily through the vessels. The cord is then cut horizontally 1 cm to 1.5 cm from the skin. The umbilical arteries are identified by their thick walls with a smaller lumen. The cord stump is grasped, and traction applied. The lumen of the artery is probed gently by introducing the closed tips of the iris forceps and then is dilated by allowing the forceps to spring apart, maintaining in this position for about 30 seconds. The catheter is then grasped with the curved iris forceps, or between the thumb and forefinger and inserted into the lumen of the dilated artery. (4) The depth of insertion is calculated using the formula used to calculate the insertion depth in centimeters is 9+ (3 × weight in Kg). (5)

Position is confirmed radiographically by the tip is estimated to lie between T6 and T9. The high position of umbilical artery catheter is between thoracic vertebrae T6 and T9 is preferred over the low position between lumbar vertebrae L3 and L4. This is because renal artery diverges from the aorta at the level of L1 and L2 and placing a catheter at or below this level is likely to disturb the renal flow.

2. INTRA- VENOUS ACCESS

Securing the right venous line is the first and aptly technically difficult task in this subset of population. Vascular access in neonates requires skill, time, patience and the appropriate equipment. Options available in securing venous access shall be headed as

1. Peripheral venous line
2. Central venous line
3. Peripherally inserted central venous catheter
4. Umbilical venous catheter

Peripheral venous line

Peripheral intravenous catheters (PIC) are the easiest and safest means of achieving vascular access. A four variable proportionally weighted rule (known as the difficult intravenous access [DIVA] score) was created (3 points for prematurity, 3 for younger than 1 year, 1 for 1 to 2 years of age, 2 for vein not palpable, and 2 for vein not visible). Those with a DIVA score of 4 or more were more than 50% likely to have failed intravenous placement on first attempt. Still, it lacks external validity. (6)

The common sites preferred are dorsal venous plexus over the hand, those over the cubital fossa, leg veins. The complications with peripheral venous access are the ones we see in day to day practise that include pain, bleeding, bulging, dislodgement, extravasation, nerve injury (example median nerve injury during cannulation over the ante cubital fossa).

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. 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. (7)

In this subset of population, cannulation poses difficulty first because of difficulty in visibility of veins in neonates. The AccuVein® AV300 acts as one of the vein imaging techniques using near-infrared (NIR) light. However now it is shown that it was not able to reduce neither time nor number of attempts until a successful venous cannulation in children using the vein viewer. (8)

Though formal guidelines are lacking, reports suggest using venflon of gauge 20 to 22 is ideal for securing iv access in neonates. Also gestational age and site of cannulation are strong determinants of gauge size and longevity. It is that for preterm size 22 had increased longevity compared to size 20 in terms. (9)

Central venous cannulation

Central venous catheterization is yet another procedure routinely performed for critically ill patients. What different it is from the adult subset is that the neck is smaller in the neonates making the landmark curtailed. This increases the risk of arterial puncture. In addition, central venous cannulation in paediatric patients with congenital heart disease may turn out to be even more difficult due to frequent previous catheterizations, common aberrant vessel anomalies, pre-existent thrombotic occlusion of vessels and preoperative anticoagulant medication, influencing morbidity and mortality. (10)

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. 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 units. (7)

What is more crucial apart from knowing the anatomy is choosing the correct size of the catheter appropriate for the patient's age, height and weight. Literature search showed paucity in available date regarding the size and depth of insertion of central venous catheter in neonates. Selection of a vascular access device is based on the smallest outer diameter with the fewest number of lumens and is the least invasive device required for the prescribed therapy. Currently, subclavian and IJV catheters used in neonates are 22 gauge (G) (22G diameter = 0.9 mm) 4.0 French (F) and 3.0F. (11-13)

For better delineation of anatomical structures, for left internal jugular access, the neonate should be positioned with 30 degrees Trendelenburg position and the head shall be kept in extension and turned away from the site of cannulation. For cannulating the right internal jugular vein, needle is inserted at the apex of the triangle formed by the clavicle and the sternal and clavicular heads of the sternocleidomastoid. For subclavian access, the child should be in trendelenburg with a rolled towel placed between the scapula along the spine to extend the back. Needle puncture should occur at the juncture of the medial and distal third of the clavicle.

From the available studies for cannulating internal jugular vein, tip shall be positioned above the right atrium in 97.5% of patients with an accuracy of 95% with an optimal depth of insertion (cm) = 1.7 + (0.07 x height) in patients whose height is between 40 and 140 cm. (14)

For cannulating IJV, in babies smaller than 5 kg, a depth between 40 and 45 mm for infants 2.0-3.0 kg in weight, 45-50 mm for those 3.0-3.9 kg, and 50-55 mm for those more than 4.0 kg is advocated. But external validation is still underway (15)

The distance from the jugular vein to the heart is relatively short in neonates, and monitoring the guidewire real-time once it is inserted into the body is not possible. If the guidewire is inserted too deeply, it may cause myocardial injury. The most effective way to prevent this complication is to measure the length of the guidewire so that the length of the guidewire inserted into the neonate's body is shorter than that of the catheter eventually inserted. (16)

Also, it is that internal jugular vein is preferred for low complications and ease of ultrasound guidance. The veins are easily located by ultrasound and the puncture can be made with guidance and real time visualisation. The use of ultrasound in neonates needs expertise. For most children, a space - constrained hockey-stick probe with a frequency of 7–10 MHz is sufficient, but probes with higher frequency are effective for small veins and difficult cases.

(Figures 1 and 2)

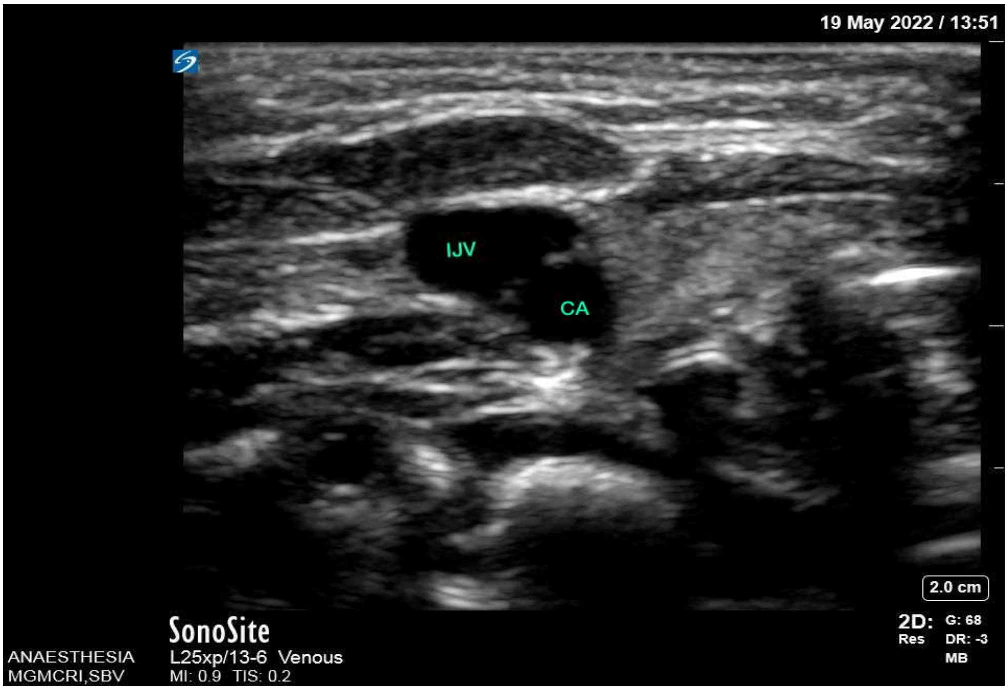

Fig 1 showing neonatal Internal Jugular Vein (IJV) and carotid artery (CA)

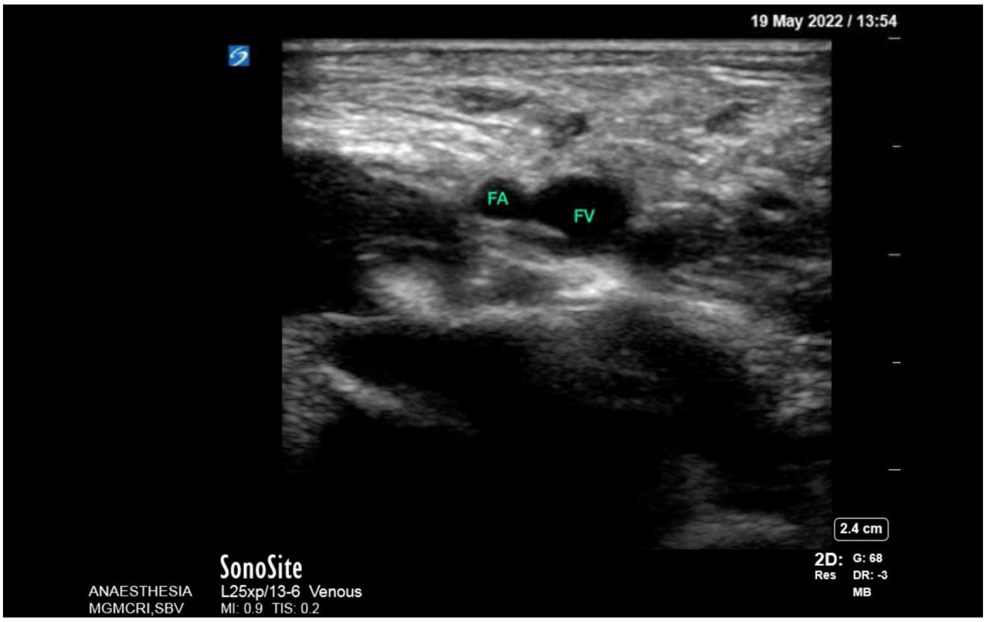

Fig 2 showing femoral artery(FA) and femoral vein (FV) in a neonate

The subclavian vein is alternatively preferred being a non-collapsible vein with fixed landmarks, more comfort, and low infection rates. Femoral vein is less preferred owing to a higher risk of infections. (17) On comparing internal jugular vein and subclavian cannulation, internal jugular vein provides a predictable path for central venous cannulation, although it is more difficult to cannulate infants than adults and even more difficult in smaller newborns.

Peripherally inserted central catheter (PICC)

PICC lines are more popular in current practice as they stay longer in order to provide adequate parenteral nutrition for long periods of time instead of the traditionally used peripheral or central venous access. As the name implies it is a central venous catheter inserted through basilic, cephalic or axillary veins with tip lying at SVC-RA junction like CVCs. In neonates leg veins and scalp veins are also being employed. (18) The PICC should occupy no more than 45% of the selected vessel at its smallest point to ensure there is adequate blood flow through the vessel where the PICC is situated. An easy rule of thumb is a 3Fr PICC requires a 3 mm vessel, 4Fr PICC requires a 4 mm vessel, and so forth. (19)

Several studies have reported a significant number of complications due to PICCs. Some of them were major and potentially fatal, such as thrombosis, extravascular collection of fluid in the thorax, pericardial tamponade and perforation of myocardium, pulmonary embolism, sepsis and death. Mechanical complications of PICCs reported in previous studies included occlusion, accidental removal, leakage or breakage, catheter migration and phlebitis. (20)

Umbilical Venous catheter

Umbilical vein catheterization utilizes the exposed umbilical stump in a neonate as a site for emergency central venous access up to 14 days old.

Under aseptic precautions, thin-walled single umbilical vein at 12'oclock position in the umbilical cord stump is identified. An umbilical tape is applied around the base of the umbilical cord; umbilical vein is dilated with artery forceps and catheterised with gentle caudal stretch up to 4–5 cm. Free backflow of blood is verified and catheter secured to the umbilical cord with tapes. If central venous monitoring is desirable, it is pushed 10–12 cm deep and the position of the tip confirmed radiologically. Two-third of the distance from shoulder to umbilicus correlates with correct placement of tip of the catheter in inferior vena cava just below the right atrium. (17) The desired insertion depth of catheter use by using the formula, 1.5 x weight in kg + 5.5 cm + stump length in cm.(5) For umbilical venous catheters, double lumen 3.5 Fr. catheters are generally used in infants weighing <1.5 kg and 5 Fr. catheters in infants weighing ≥1.5 kg. For umbilical arterial catheters, 2.5 Fr catheters are generally used in infants weighing <1 kg and 3.5 Fr in infants weighing ≥1 kg. (21)

Complications specific to umbilical vein catheters include the risk of placement into the portal venous system, inadvertent umbilical artery cannulation, placement into the right atrium can lead to perforation and subsequent pericardial effusion. In a neonate who becomes hemodynamically unstable following placement of an umbilical vein catheter, cardiac tamponade is a consideration. Overall, the complication rate of umbilical venous catheters similar to that of percutaneously placed central venous catheters. (22)

3. INTRAOSSEUS ACCESS

The use of intraosseous access during resuscitation is widely accepted and promoted in paediatric medicine but features less prominently in neonatal training and shall be considered alternative to umbilical venous catheters. The principle of IO access is to insert a needle into the medullary cavity of a long bone, usually the proximal (at least 10 mm from the tibial tuberosity) or distal tibia, distal femur, or head of humerus. Other sites include the sternum and flat portion of the pelvis, but these are less convenient during resuscitation. According to the device training, care must be taken in infants and young children to avoid the epiphyseal plates. The needle is held perpendicularly and pushed straight into bone. IO needle position may be confirmed by any of the following: aspiration of bone marrow, checking that the device is free-standing in the bone, or infusing a small volume of fluid under direct vision and monitoring for extravasation (aspiration of bone marrow may not always be possible, even in a correctly placed IO device). (23)

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