Vascular access in pediatric interventions: Science or skill?

Three papers are being published in this issue of the journal, which focus on vascular access in small neonates for different types of procedures.[1-3] These procedures include balloon dilation of pulmonary valve stenosis, aortic coarctation, and general pediatric cardiac interventions. The theme is similar for all of these papers, and the main focus is performance of the interventions in critically ill neonates. Vascular access may be a huge challenge, especially in very low birth weight babies. In the distant past, vascular access was a skill that was learned with practice. Teachers took a considerable amount of time to teach their trainees the skills in interventions. However, it did not matter how skillful the teacher or the trainee was; in small babies with low weights at the time of cardiac catheterization or intervention, it could take a considerable amount of time to obtain access. Generally, access was obtained from the femoral veins or arteries. If percutaneous access was difficult, then it was obtained by cut-downs. Access was taken on as a challenge and failure was taken badly by the operators! Having gained access, a variety of interventions were performed using equipment (such as guide-wires, catheters, and balloons), which was designed for adult patients but was being used in babies and children. This resulted in many unwanted difficulties, such as procedures taking longer times, complications such as vascular occlusions because of large profiles, and even avulsion of vessels.

It took pediatric cardiologists a considerable amount of time to venture into performing interventions using alternative routes, such as axillary arteries, carotid arteries, jugular veins, and transhepatic approach. This was because of a lack of training in these routes for both the skilled operators and therefore the trainees. Such a diversion required operators to work with anesthetists, who were more familiar and skilled in access from the internal jugular veins, radiologists, who were more familiar with transhepatic access, and vascular surgeons, who were more familiar with carotid and axillary artery access. This helped to develop the concept of a collaborative and supportive team approach for interventions generally, which has become more prevalent in our specialty nowadays.

The paper by Polat, reporting on a single-center experience of pediatric cardiac interventions using carotid artery access, is a valuable addition to the literature.[1] Polat emphasizes the fact that previously surgical cut-down was used for carotid arterial access, but in this paper, percutaneous carotid access was obtained using ultrasound guidance. A variety of complex interventions were performed. The paper highlights the complications, despite ultrasound guidance for access, such as nonocclusive thrombus in the vessel and either hematoma formation or pseudoaneurysm formation, which required further surgery to the access site. The paper further emphasizes the need for training in ultrasound-guided access before applying it more widely for complex interventions.

The paper by Hoetama *et al.* focuses on balloon dilation of critical pulmonary valve stenosis in neonates by femoral or jugular venous access.[2] They compared the procedure by the two access sites, in a small series. In their series, procedure duration, crossing the valve, and the fluoroscopy times were all shorter using the jugular venous approach. The authors did not use ultrasound guidance, and therefore, the approach was determined by prior training and acquired skills. There are some babies, with dilation of the right atrium and right ventricle, with additional tricuspid regurgitation, in whom the femoral venous approach may present many technical problems, and so, interventional pediatric cardiologists may wish to start the procedure from the jugular venous approach from the outset. This immediately identifies a subgroup needing a different approach from the conventional one.

The paper from Meliota *et al.* deals with balloon angioplasty in eight critically ill neonates, who were clinically unstable, using axillary artery access.[3] Procedures were attempted in 10 neonates, but in two, the axillary access failed and the babies needed a cut-down on to the carotid arteries. The authors accept that they may have succeeded in all the babies if ultrasound guidance had been used. In modern practice, this is a very important message.

A few additional considerations merit specific attention in obtaining vascular access in neonates and small infants. They include the following:

1. Appropriate positioning: An extremely important aspect of obtaining vascular access relates to taking the time and effort to position the baby. This can be particularly challenging when cardiac catheterization is undertaken using conscious sedation without general anesthesia. For femoral access, it helps

greatly to elevate the pelvis and hips of the child using a small roll. The limbs should be abducted slightly and laterally rotated. For babies undergoing catheterization using conscious sedation, it is often useful to straighten and comfortably restrain the knees with a broad and relatively strong adhesive tape [Figure 1]. For the axillary artery, the positioning is well described by Meliota *et al.* The positioning should straighten out the axillary artery and enable easy palpation of the axillary artery over the head of the humerus. Similarly, it is important to pay attention to positioning in carotid, internal jugular, and subclavian access. The time invested in positioning is often well worth it because it saves a considerable amount of time by enabling quick and easy access

2. Assembling the right hardware for access: It is vital to plan and assemble the hardware for vascular access carefully. This is especially important in many catheterization laboratories in low-resource environments, where appropriate dedicated pediatric introducer sheaths are unavailable.[4] Many of these facilities are shared with adult cardiology facilities, and a variety of common improvisations are frequently used to obtain access to small babies. For example, radial artery introducer sheaths are often used to obtain femoral or axillary access in babies.

Figure 1: This picture showing a child undergoing cardiac catheterization under conscious sedation. The roll of cloth is placed under the buttocks to enable easy femoral vascular access. Note the restraints over the knee to ensure stability of the position

It is important to assemble all the items on the table before the puncture is actually made. This is because the vessels in neonates and infants are small and the needle or cannula has very little space available inside the vessel lumen, and a good position may be lost very quickly. Time is of the essence here. As soon as the needle or the cannula is in the vessel, the appropriate wire should be introduced. It may be necessary to keep two wires on the table. Often, this includes a small caliber (0.014 inch) coronary wire. Another critical aspect of successful cannulation with the least potential trauma to the vessel wall is in ensuring that there is a perfect fit between the wire and the dilator of the introducer sheath. This is critical in axillary artery access, where the skin is soft and lax and does not allow easy passage of the dilator of the sheath unless there is a perfect fit. The accompanying table [Table 1] presents a simple checklist of items that need to be assembled on the table before obtaining vascular access. Careful planning of the size of the vascular sheaths is dictated by the size of the catheters to be used for the catheterization procedure. In general, effort is made to use the smallest possible caliber for neonates and small infants. Some vessels are more forgiving than others. Veins allow 1–2 Fr-sized larger introducers; among arteries, axillary arteries and carotids tend to be more accommodating. For example, a 5 Fr sheath can be used in the axillary artery in a 2.5 kg neonate requiring patent ductus arteriosus (PDA) stenting, whereas the femoral artery may not accommodate anything larger than 4 Fr sheath.

Table 1: Checklist of items needed to be assembled on table before obtaining vascular access

Item required for vascular access	Comment
Local anesthesia	In babies undergoing procedures under conscious sedation; Using small amounts of xylocaine with a 26-gauge needle does not usually distort vascular landmarks
Puncture needles or cannula	While the smallest possible caliber needle or cannula should be used, it is necessary to ensure that the guidewire used for the vascular sheath passes freely through the cannula or needle used to puncture. Furthermore, it is important not to flush a cannula to enable visualization of the small droplet (flash) of blood in the hub of the needle
Guidewires	The guidewires that are placed within the packaging of introducer sheath kits may not always be ideally suited for initial cannulation of the vessel in a neonate. It may be useful to keep an alternative. This is usually a low-profile, soft-tipped wire (such as the 0.014-inch coronary wire) on the table. If the coronary wire is used, it will need to be replaced by the appropriate guidewire (0.018/0.021 or 0.025 inch) that fits best with the dilator of the introducer sheath. This may necessitate the use of larger cannulas or micro-puncture vascular systems
Introducer sheath	The smallest possible sheath that allows passage of the catheters chosen for the procedure should be used. The dilator should fit the wire perfectly
Items for ultrasound-guided vascular access	These include vascular access probes, appropriate machine, sterile camera covers, and clasps to enable fastening of the cover over the probe. The positioning of the ultrasound monitor in relation to the operator is an important consideration in catheterization laboratories that have additional equipment

Obtaining access in a small baby is challenging even for the most experienced operators. Seeing a magnified ultrasound image of the vessel provides a far more reliable, accurate guide and a scientific method for vascular access compared with relatively crude, tactile perception of vascular pulsations through latex gloves. In the last couple of decades, more and more interventional pediatric cardiologists have taken a leaf out of the radiologists' books and have familiarized and trained themselves in using ultrasound-guided access. This has turned the procedures from being a skill learned by practical work and teaching from seniors into a "science," in which machines train the trainees. This has gone a long way in reducing the complications related to blind vessel puncture, resulting in thrombosis, occlusion, and rarely avulsion, and development of arteriovenous fistulas at the access sites, because of overlying veins and arteries. It is necessary to acknowledge that there is a learning curve associated with ultrasound-guided vascular access. The skillset needed involves the development of "hand–eye coordination" between the movements of the puncture needle or cannula and images are displayed on the ultrasound screen. Often, the operator needs to obtain a steady high-resolution image of the vessel with one hand and puncture with the other.

While we expect that over the next decade, ultrasound guidance will be routinely used for pediatric vascular access for children in all catheter laboratories, it is necessary to acknowledge that many units in low-resource environments do not, as yet, have the facility or the expertise. In these situations, "wire-guided" access may be helpful in selected circumstances, where the initial "blind" access fails. Here, a small-caliber wire is previously placed across the vessel to be accessed from separate access. For example, if right axillary artery access is needed to stent an arterial duct, the puncture of this vessel may be guided by placing a coronary guidewire in the right axillary artery via one of the femoral arteries. This technique can be used to obtain internal jugular or subclavian venous access in selected circumstances.

Hence, successful interventions in small babies, which are determined by obtaining vascular access, have now been turned from skills learned by repeated procedures to a "science" by using machines.

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