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Small Hands, Sharp Focus: Masterclass in Paediatric Vascular Access

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ABSTRACT
Vascular access is a core pillar of safe paediatric anaesthetic practice. Establishing reliable peripheral or central venous access in neonates, infants, and young children presents unique physiological, anatomical, and psychological challenges that differentiate it from adult care. This comprehensive guide details the nuances of paediatric vascular access, addressing site-specific anatomy, appropriate cannula sizing, and the integration of point-of-care ultrasound (POCUS) through in-plane and out-of-plane approaches. Furthermore, it outlines precise securement strategies engineered to survive emergence delirium and establishes a systematic monitoring protocol for early detection of extravasation, phlebitis, and dislodgement. By blending meticulous anatomical knowledge with modern ultrasound techniques, the paediatric anaesthetist can minimize procedural attempts, optimize clinical efficiency, and guarantee patient safety.

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Introduction

In the theatre suite, few procedures carry the potential to shift an anaesthetic plan as rapidly as the placement of an intravenous (IV) line. For adult patients, peripheral cannulation is standard protocol. For the paediatric patient, however, establishing vascular access is a high-stakes intervention that dictates induction strategies, determines the safety margin during critical airway management, and forms the lifeline for intraoperative resuscitation.

Children present with narrow vessel diameters, a generous layer of subcutaneous fat that obscures visible or palpable landmarks, and a heightened physiological vulnerability to fluid fluctuations and distress. A crying, uncooperative toddler undergoing an awake inhalation induction or an infant with profound vasoconstriction demands a high level of technical precision. If an IV fails or "tissues" during a critical surgical moment, the physiological reserve of a child can deplete within minutes.

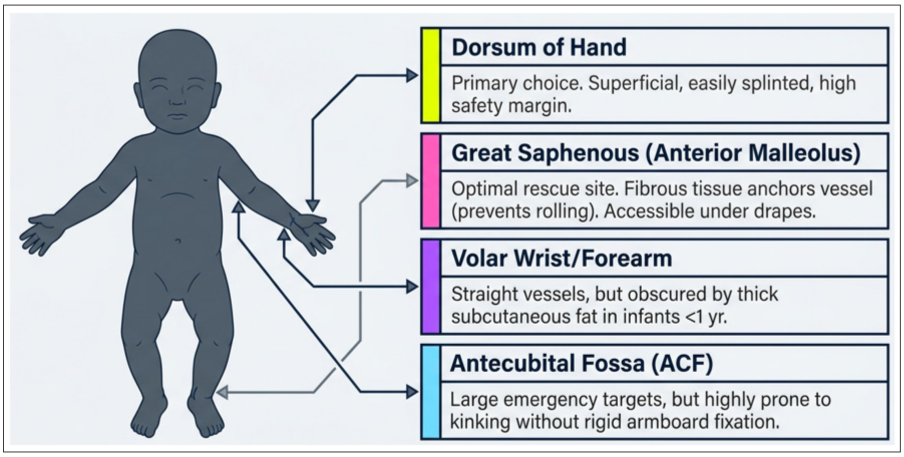
Historically, paediatric vascular access relied heavily on tactile feedback, surface landmarks, and luck. The evolution of point-of-care ultrasound (POCUS) has transformed this landscape, turning a blind procedure into a precise, visual science. This masterclass serves as a guide to mastering both peripheral and central access, detailing advanced techniques, equipment selection, ultrasound mechanics, and strict post-insertion monitoring protocols.

Anatomical Considerations and Site Selection

Navigating the paediatric venous network requires an intimate understanding of age-dependent anatomy. An ideal site must balance accessibility, vessel diameter, and stability during the intraoperative and postoperative phases.

Peripheral Venous Anatomy

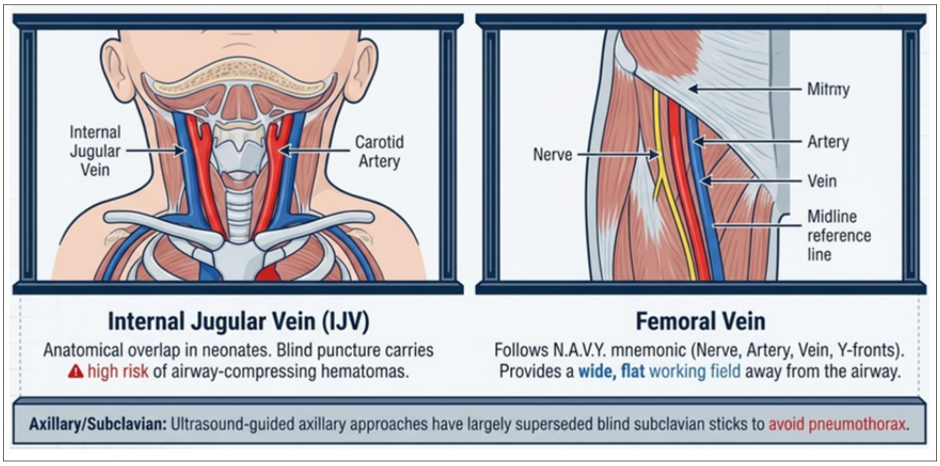
- **Dorsum of the Hand:** The dorsal venous network remains the primary choice for paediatric peripheral intravenous (PIV) access. These veins are superficial, relatively fixed by surrounding connective tissue, and easily splinted. Because they lie well away from major arteries and nerves, they offer a high safety margin.
- **Volar Aspect of the Wrist and Forearm:** The cephalic and basilic veins as they course along the forearm provide straight segments suitable for longer catheters. However, in infants under one year, a thick layer of subcutaneous fat frequently obscures these vessels, rendering them virtually unpalpable. The volar aspect of the wrist contains superficial veins, but cannulation here requires strict joint immobilization to prevent catheter kinking.
- **Great Saphenous Vein (Anterior Malleolus):** Located predictably anterior to the medial malleolus of the ankle, the saphenous vein is an excellent rescue site, particularly during inhalational inductions when the upper extremities are covered or inaccessible. It is anchored by dense fibrous tissue, which prevents the vessel from rolling away from the needle tip.
- **Antecubital Fossa (ACF):** The median cubital, cephalic, and basilic veins in the ACF are large and easily accessible in emergencies. However, they are highly prone to kinking and occlusion when the child flexes the elbow. Consequently, the ACF is less desirable for maintenance fluids or intraoperative monitoring unless fixed with an arm board.



Central Venous Anatomy

When central venous catheters (CVCs) are indicated—such as in major cardiac, craniofacial, or neonatal abdominal surgeries—three primary anatomical sites are utilized:

- **Internal Jugular Vein (IJV):** The IJV is located lateral and slightly superficial to the carotid artery within the carotid sheath, running deep to the sternocleidomastoid muscle. In neonates and small infants, the IJV frequently overlaps the carotid artery anteriorly. This anatomical overlap means that blind landmark-guided punctures carry a high risk of inadvertent arterial puncture or airway-compressing hematomas.
- **Femoral Vein:** Positioned medial to the femoral artery in the femoral triangle, immediately inferior to the inguinal ligament. The anatomical relationship follows the NAVY mnemonic (Nerve, Artery, Vein, Y-fronts/midline) from lateral to medial. The femoral site is useful for intraoperative resuscitation because it provides a wide, flat working field well away from the shared airway space of the anaesthetist.
- **Subclavian and Axillary Veins:** The subclavian vein runs beneath the clavicle, crossing superior to the first rib. While it offers a stable exit site on the chest wall with low rates of contamination, its proximity to the pleura increases the risk of pneumothorax or chylothorax in small children. The more lateral axillary vein approach under ultrasound guidance has largely superseded the blind subclavian stick.



Equipment: Paediatric Cannula Sizing

In paediatric anaesthesia, matching the catheter gauge to the vessel diameter is a critical safety consideration. Over-sizing a cannula can occlude the vessel lumen, stopping surrounding blood flow and rapidly leading to mechanical phlebitis, thrombosis, or early catheter failure.

Cannula Gauge	Color	Ideal Patient Population	Common Clinical Applications
26G	Violet	Neonates, micro-preemies (<2.5 kg)	Low-flow maintenance crystalloids; minimal medication administration.
24G	Yellow	Infants, toddlers, young children	Standard choice for routine paediatric surgeries; induction line.
22G	Blue	Older children, school-aged kids	Major paediatric general surgery, minor blood transfusions.
20G	Pink	Adolescents, adult-sized teenagers	Rapid fluid resuscitation, trauma, contrast-enhanced CT scans.

Poiseuille's Law states that fluid flow rate (Q) through a cylindrical tube is directly proportional to the fourth power of the radius (r) and inversely proportional to the length (L):

$$Q = (\Delta P \cdot \pi \cdot r^4) / (8 \cdot \eta \cdot L)$$

Where ΔP is the pressure gradient and η is fluid viscosity. Because flow is highly sensitive to radius, a small increase in cannula size dramatically increases flow capacity. However, because flow is also inversely proportional to length, a short, relatively wide peripheral catheter (e.g., a short 22G) can achieve rapid fluid bolus delivery faster than the long, narrow lumen of a multi-lumen central venous catheter [1-5].

Cannulation Techniques: Landmark vs. Ultrasound-Guided

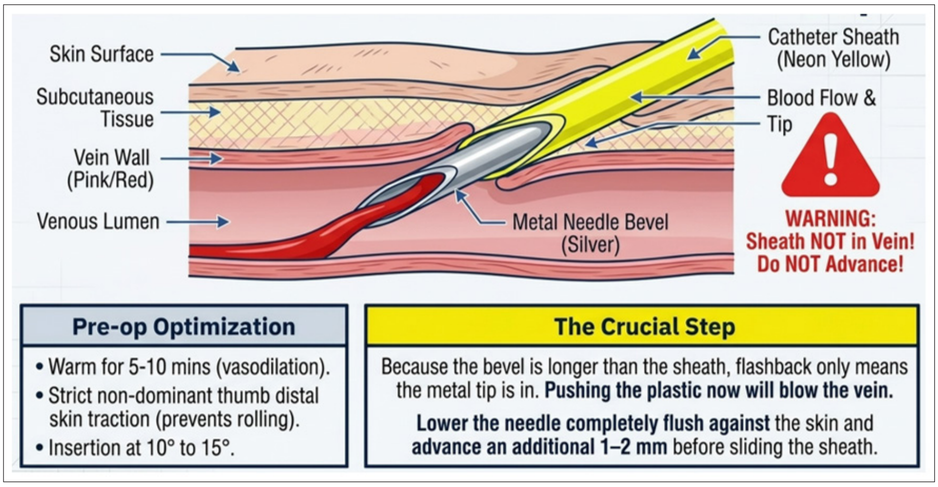
Successfully entering a small, fragile vein requires careful technique and precise motor control.

The Traditional Landmark Approach

The landmark approach relies on visual inspection, tactile palpation, and transillumination.

- **Pre-procedural Optimization:** Ensure the extremity is warm. Applying a warm blanket or a chemical warming pack for 5–10 minutes causes vasodilation.
- **Skin Traction:** Secure strict counter-traction on the skin distal to the insertion site using your non-dominant thumb. This flattens the skin and prevents the vein from rolling or sliding sideways away from the needle bevel.
- **The Insertion Angle:** Enter the skin at a shallow angle (10° to 15°), with the needle bevel facing upward.
- **The 'Flashback' Transition:** Watch for the first flash of blood in the flashback chamber.

Crucial Paediatric Step: *Because the needle bevel is longer than the tip of the surrounding plastic catheter, seeing blood means only the metal needle tip has punctured the vein. If you advance the plastic sheath immediately, you will push the vein wall away or blow the vessel. Upon getting a flash, lower the needle completely flush against the skin and advance the entire needle-catheter assembly an additional 1–2 mm into the vessel. This ensures that the outer plastic sheath is safely inside the lumen before you slide it forward off the needle.*

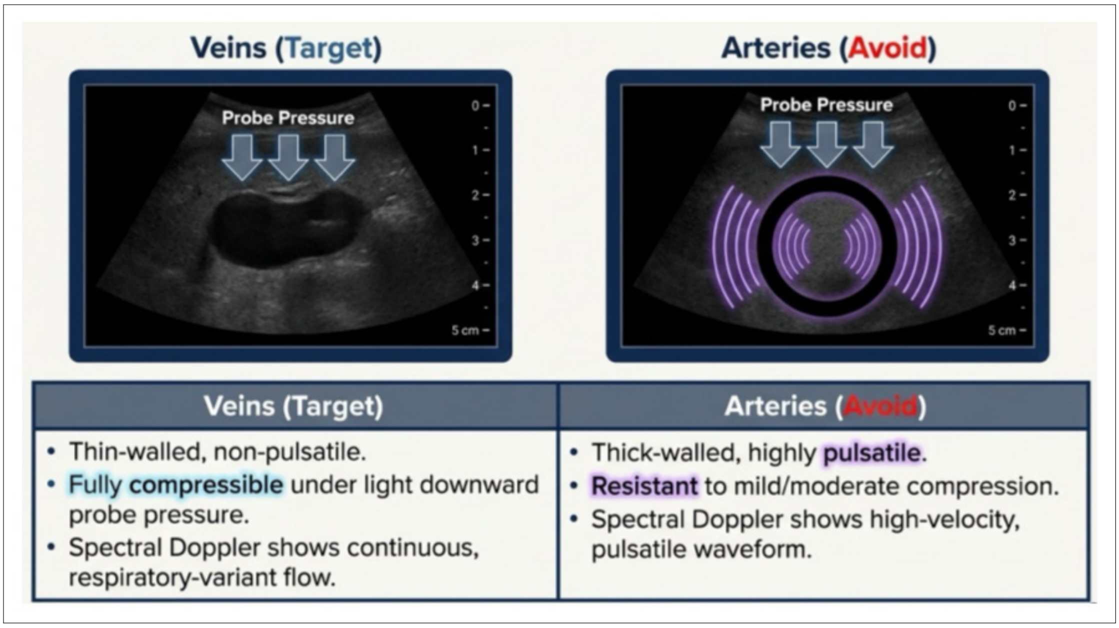


Ultrasound-Guided (USG) Techniques

Point-of-care ultrasound has modernized paediatric vascular access, reducing the number of needle punctures and lowering complications like hematomas or inadvertent arterial cannulation. High-frequency linear array transducers (12 to 18 MHz) provide the crisp, high-resolution images required to visualize tiny, deep-lying structures.

Differentiating Arteries and Veins on screen:

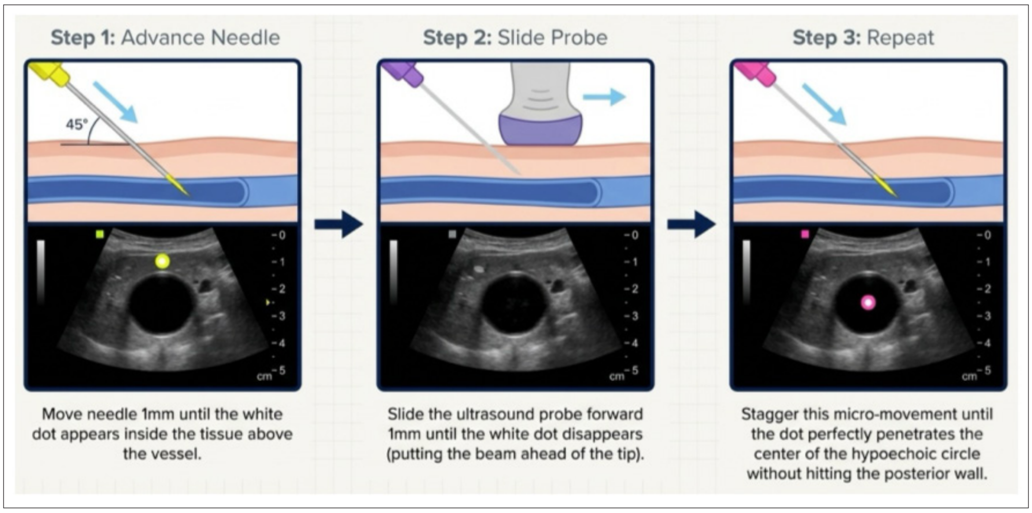
- **Veins:** Thin-walled, non-pulsatile, and fully compressible under light downward pressure from the ultrasound probe. They demonstrate a continuous, respiratory-variant flow profile under spectral Doppler.
- **Arteries:** Thick-walled, highly pulsatile, and resistant to mild or moderate compression. They demonstrate a high-velocity, pulsatile waveform under spectral Doppler.



• **Out-of-Plane (OOP) Short-Axis Technique:** In the out-of-plane approach, the ultrasound probe is oriented perpendicular to the path of the vessel. The vessel appears on screen as a circular, hypoechoic (black) structure. Center the vessel on the screen. Insert the needle at the midpoint of the probe, perpendicular to its face, at a 45° to 60° angle. The needle is visualized only as a single hyperechoic (bright white) dot representing its cross-sectional tip.

The Dynamic Walk-Down: *Because a needle shaft looks identical to the needle tip in a short-axis view, it is easy to overshoot the vessel's posterior wall. To prevent this, use a dynamic 'walk-down' technique: advance the needle a millimeter until the white dot appears, then slide the ultrasound probe a millimeter ahead until the dot disappears. Repeat this sequence until the dot penetrates the center of the black circle.*

• **In-Plane (IP) Long-Axis Technique:** In the in-plane approach, the ultrasound probe is aligned perfectly parallel to the course of the vessel, displaying the vein as a long, continuous longitudinal tube. Insert the needle at one end of the probe, tracking down the long axis of the acoustic beam. The advantage is that the entire length of the needle, including the shaft and the tip, remains fully visible throughout the procedure. This allows you to watch the needle bevel pierce the anterior wall of the vessel in real-time, completely avoiding posterior wall puncture. The challenge is that keeping a 24G needle aligned within a razor-thin ultrasound plane requires steady hand-eye coordination.



Securing the Line: Engineered to Survive Emergence

In paediatric anaesthesia, securing the line is just as important as placing it. A cleanly inserted IV can be instantly lost during emergence delirium or when moving the patient from the operating table to the recovery trolley.

Skin Preparation: Ensure all blood, ultrasound gel, and antiseptic solutions (e.g., 2% chlorhexidine gluconate in 70% isopropyl alcohol) are completely dry. Adhesive dressings will not stick to wet skin.

Mechanical Anchoring (The Chevron Method): Place a strip of sterile adhesive tape or a dedicated adhesive border beneath the hub of the cannula, crossing it over the top in a chevron pattern. This anchors the hub firmly to the skin and limits side-to-side translational movement.

Transparent Semi-Permeable Membrane: Place a transparent adhesive dressing over the insertion site. Crucially, leave the hub-to-catheter junction completely visible. Covering this connection point with opaque tape prevents early detection of fluid extravasation or local skin blanching.

Joint Immobilization (Splinting): If the IV is located near a joint (such as the dorsum of the hand, wrist, or ankle), apply a padded, appropriately sized splint. Restricting joint flexion prevents the catheter tip from scraping against the internal vessel wall, reducing the risk of mechanical phlebitis and catheter failure.

The Extension Tubing Loop: Loop the integrated extension tubing smoothly back toward the limb and secure it with a secondary piece of tape. This loop acts as a strain relief; any accidental tugs pull against the looped tubing rather than directly on the catheter hub. Secure the entire extremity with a lightweight, breathable cohesive bandage (e.g., Coban), ensuring it is wrapped loosely enough to avoid any tourniquet effect.

Vigilant Monitoring: Tissueing, Phlebitis, and Dislodgement

Because paediatric patients may be non-verbal, sedated, or paralyzed under general anaesthesia, they cannot report pain or burning at an IV site. The responsibility for continuous, proactive surveillance rests entirely on the anaesthesia and nursing teams.

- **Extravasation / Tissueing:** Occurs when fluid or medication leaks into the surrounding subcutaneous tissue, either due to partial catheter dislodgement or vessel wall rupture. Signs include localized swelling, firm skin, coolness to the touch, and skin blanching. System indicators include a sudden increase in the pressure readings of an automated infusion pump.
- **Phlebitis:** Inflammation of the endothelial lining of the vein. It can be mechanical, chemical, or infectious. Signs include erythema, localized warmth, swelling, and a palpable indurated 'cord' along the path of the vein proximal to the insertion site.
- **Dislodgement:** Occurs when the catheter slides out of the venous lumen. Signs include a wet dressing, blood tracking down the patient's skin, or an inability to aspirate blood or flush the line smoothly.

The Mandatory 15-Minute Surveillance Protocol:

• ***LOOK:*** *Inspect the insertion site through the transparent window. Is the dressing clean, dry, and intact? Is there any local swelling, redness, or skin blanching?*

• ***FEEL:*** *Lightly palpate the skin over and immediately proximal to the catheter tip. Does the tissue feel soft and compliant, or is it firm, cool, or boggy?*

• ***TEST:*** *Verify that the IV flushes easily without resistance or swelling. Check the infusion pump to ensure pressures remain low.*

Conclusion

Mastering paediatric vascular access requires combining a solid grasp of neonatal and infant anatomy with technical precision and modern technology. Ultrasound-guided techniques should no longer be seen as an exceptional rescue method, but rather as a core competency that improves first-stick success and enhances safety. By pairing careful anatomical site selection and appropriate cannula sizing with robust securement and strict intraoperative monitoring, the anaesthetist can safeguard the patient's venous health and ensure a smooth, stable perioperative course [6-10].

References

1. Brescia F (2021) International evidence-based recommendations on indwelling vascular access devices in paediatric neonates: An institutional consensus. Pediatric Anesthesia 31: 1152-1167.
2. Gauger VT (2022) Peripheral intravenous catheter longevity in the pediatric population: Factors influencing infiltration and phlebitis rates. Journal of Clinical Anesthesia 78: 110645.
3. Heins J (2020) Ultrasound-guided vs. landmark-guided peripheral intravenous cannulation in pediatric patients with difficult venous access: A systematic review and meta-analysis. Pediatric Emergency Care 36: e520-e526.
4. Lamperti M (2023) International evidence-based recommendations on ultrasound-guided vascular access in pediatric patients. British Journal of Anaesthesia 130: 212-225.
5. Meyers C (2021) Anatomy and selection of central venous access sites in neonates and infants: A practical review for the clinician. Journal of Pediatric Surgery 56: 789-796.
6. Olsson M (2022) The out-of-plane vs. in-plane approach for ultrasound-guided vascular access in small children: A randomized controlled simulation trial. Acta Anaesthesiologica Scandinavica 66: 341-348.
7. Riker MW (2020) Securing pediatric peripheral intravenous catheters: A randomized trial comparing standard clear dressings with integrated securement devices. Annals of Emergency Medicine 75: 488-497.
8. Schults MA (2021) Peripheral intravenous catheter line failure in pediatric patients: A prospective cohort study of risk factors. International Journal of Nursing Studies 116: 103720.
9. Ullman AJ (2020) Global vascular access in children: An international cross-sectional study of prevalence, device type, and management. THE LANCET Global Health 8: e1321-e1330.
10. Wilder RT (2023) Complications of central venous catheters in pediatric surgical patients: A ten-year institutional review. Journal of Pediatric Anesthesia and Critical Care 10: 85-92.