

Section 10

Diagnostic modalities and procedures

40. Central vascular access
41. Arterial blood gases- interpretation
42. Hearing screening
43. Neonatal chest X-ray
44. Cranial ultrasonography
45. Point of care echocardiography
46. Umbilical arterial blood gas sampling



Central venous access commonly used in neonatal practice include umbilical venous catheterization (UVC), umbilical artery catheterization (UAC) and peripherally inserted central catheter (PICC).

Umbilical artery catheterization (UAC)

Indications

1. Continuous monitoring of arterial blood pressure in sick and ventilated babies
2. Need to perform frequent arterial blood gas (ABG) analysis in ventilated babies
3. Exchange blood transfusion (isovolumetric)

Estimating length of insertion

The length of insertion (cm) is determined by the following methods:

1. By measuring shoulder-umbilical length (SUL; Distance from the tip of the shoulder/ lateral end of the clavicle to a point vertically below at level of the umbilicus; Figure 1A, 1B)¹ and adding umbilical stump length to it.
2. Alternate method for UAC
 - Infants ≥ 1500 g = (birth weight in kg \times 3) + 9 cm + umbilical stump length
 - Infants <1500 g = (birth weight in kg \times 4) + 7 cm + umbilical stump length

Always confirm the position of the catheter by performing an X-ray of the chest and abdomen including thighs. UAC can be identified by its looping course in the abdomen on X-ray.

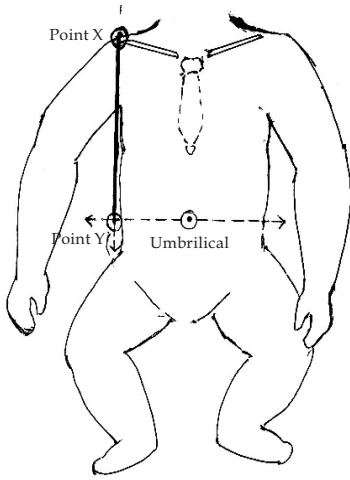


Figure 40.1A: Shoulder umbilical length : the distance from the tip of the shoulder/lateral end of the clavicle (point x) to a point vertically below at the level of the umbilicus (point y).

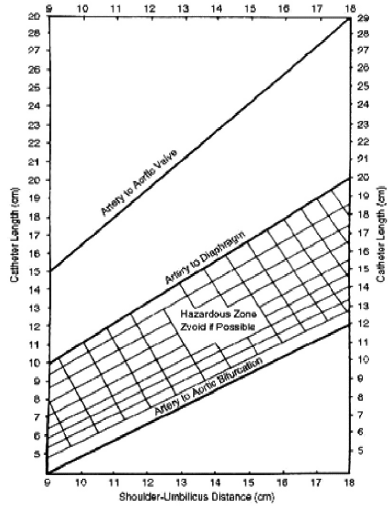


Figure 40.1B: Shoulder-umbilical length normogram (reproduced with permission from dunn pm. Localization of the Umbilical catheter by post-mortem Measurement. Arch dis child. 1966;41:69.)

Either of following two positions is used for UAC

1. High position - Tip of catheter lies between T6 and T9 vertebrae. High position is preferred due to lower incidence of vascular complications.
2. Low position - Tip of catheter lies between L3 and L4 vertebrae

High position of UAC: What is the evidence?

A Cochrane review (2010)² on effects of position of catheter tip stated that high position (as compared to low position of UAC) is associated with:

- Lower incidence of clinical vascular complications (RR 0.53, 95% CI 0.44 to 0.63)
- No difference in rates of intraventricular hemorrhage, death and necrotizing enterocolitis

Recommended catheter size

Infant's birth weight 1.2 kg	3.5 F
Infant's birth weight > 1.2 kg	5 F

Catheter type and material

End-hole catheters are preferred over side hole due to decreased risk of complications. Studies have shown no clinically relevant differences in outcomes between standard polyvinyl chloride (PVC) catheter and other materials like polyurethane.

Practical tips

- Attempt UAC insertion first (followed by UVC, if required) unless it is an emergency
- Dilate the artery lumen for around 60 seconds using iris forceps³ before attempting insertion of the catheter
- Maintain patency of arterial catheter using low-dose heparin infusion (0.25-1.0 U/mL). Total heparin dose (25-200 U/kg/d)
- If catheter on radiological examination is too low for a high position, do not advance it to high position. It is better to adjust the catheter in low position.
- Document the date and time, indication, number of attempts, depth of insertion and position on X ray.

Recommended duration: 7 days**Complications⁴**

1. Blanching of leg – the most common complication. In such a situation, rewarm the opposite leg with a warm (*not hot*) towel this will cause reflex vasodilatation. If there is no return of normal color within 5 minutes in the affected limb, consider removal of the catheter.
2. Trauma during insertion (creation of a false passage, hematoma, peritoneal perforation, vessel perforation)
3. Vascular complications- Thromboembolism involving renal, mesenteric, iliac and other vessels this may presented as NEC, hypertension, hematuria, renal failure, pallor/coldness of extremities. Catheter should be removed in all such cases.
4. Line migration
5. Catheter breakage
6. Infection (cellulitis, omphalitis, sepsis)

UAC removal

1. Stop heparinized fluids 30 min prior to removal. Remove slowly with gentle traction over 30 to 60 seconds. Remove the last 5 cm of line over several minutes to minimize bleeding
2. Remove the catheter as soon as it is no longer required for the clinical condition. Appearance of complications may also mandate earlier removal of the catheter.

Umbilical venous catheterization (UVC)**Indications**

1. Emergency vascular access during resuscitation in birthing room
2. Central venous pressure (CVP) monitoring (the UVC must pass through the ductus venosus and positioned in inferior vena cava)
3. Exchange transfusion
4. Administration of TPN, blood products and hyperosmolar solutions

Estimating length of insertion

1. By measuring shoulder-umbilical length (SUL) and estimating depth of insertion. (Figure 40.2).¹
2. Based on birth weight ($[3 \times \text{birth weight in kg} + 9] / 2$) + 1 + umbilical stump length (cm)
3. Shoulder-umbilical length (cm) \times 0.66 + umbilical stump length (cm)
4. For exchange transfusion and emergency vascular access, catheter is advanced only until the point of good blood flow (usually 2-5 cm)

Always confirm the position of catheter tip radiologically. Preferred position of catheter tip is 0.5 to 1.0 cm above the level of diaphragm.⁵

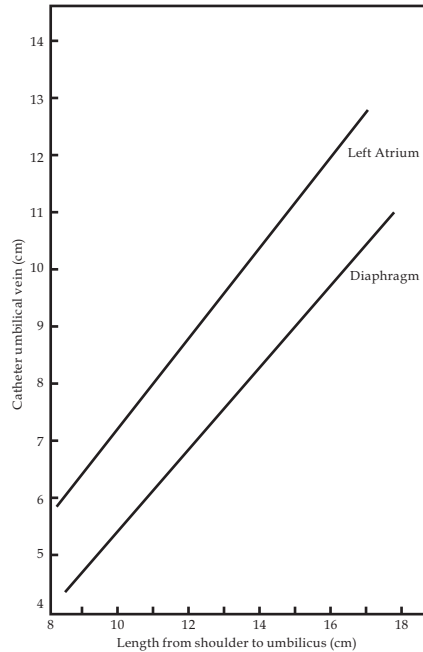


Figure 40.2: Catheter length for umbilical vein catheterization. (reproduced with permission from Dunn PM. localization of the umbilical catheter by post-mortem measurement. Arch dis child.1966;41:69.)

Recommended catheter size

Infant's birthweight 1.5 kg	3.5 F
Infant's birthweight >1.5 kg	5 F

Practical tips

- Identify the umbilical vein by its location in the umbilical cord cut section (12'O clock) and by its thinner wall and wider lumen
- Never advance the catheter once placed and secured. You can withdraw the catheter if it is too far in.
- Document the date and time, indication, number of attempts, depth of insertion and position on X-ray.

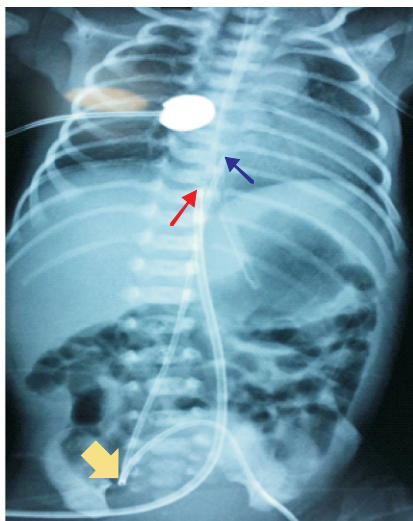
Recommended duration of UVC: 14 days

Complications

1. Infection (most common): Sepsis, cellulitis, omphalitis, endocarditis, septic emboli, liver abscess. Any evidence of central line associated blood stream infection (CLABSI) warrants catheter removal.

2. Line malposition - Cardiac arrhythmia, pericardial effusion, cardiac tamponade, portal vein thrombosis, NEC, hepatic necrosis.⁶ Cardiac complication is a rare, but life threatening complication.
3. Blood loss
4. Vascular complications (Thrombosis / embolism): Emboli can be in lungs, liver or systemic circulation. Can present as pulmonary edema, pulmonary hemorrhage, hepatic necrosis, abscess, calcification. Removal of catheter is indicated in all these as well as in thrombosis.
5. Catheter breakage

Figure 40.3: Anteroposterior radiograph of chest and abdomen showing satisfactory position of UAC (red arrow) and UVC (blue arrow). UAC can also be identified by its looping course (block arrow).



Percutaneously inserted central catheter (PICC)

Indications

1. Preterm neonates needing parenteral nutrition when UVC is contraindicated (omphalitis, peritonitis, necrotizing enterocolitis, absent/reversed end diastolic flow (A/REDF), beyond day 1 of life)
 - a) All neonates < 1000 g not on significant feeds
 - b) Birth weight 1000 to 1499 g and not likely to receive significant feeds for three or more days
 - c) Birth weight more than 1500 g and not likely to receive significant feeds for 5 or more days
2. Prolonged intravenous access (usually more than 5-7 days) in conditions like gastrointestinal/surgical disorders,

- congenital cardiac conditions etc
3. Hyperosmolar intravenous fluid / medication (dopamine, dobutamine, calcium gluconate) administration
 4. Difficult intravenous access

Vein selection

There are different veins available for insertion in both upper and lower limbs. The most commonly used veins in upper limb are basilic vein (preferred due to shorter and direct course to central vein) and cephalic vein. In lower limb, long saphenous vein and popliteal vein are usually preferred. Other sites which can be used in rare circumstances are scalp veins (temporal vein, posterior auricular vein), axillary vein and external jugular vein.

Estimating distance of insertion	Tip position
Upper limb - Measure distance from the point of insertion along venous pathway to suprasternal notch to right 3rd intercostal space	Line must have crossed first rib and passed medially with tip lying between T3 and T6 vertebrae. The line tip must be well outside cardiac chambers (1 cm in preterm and 2 cm in term)
Lower limb - Measure distance from the point of insertion to umbilicus and then to xiphisternum	In the inferior vena cava (IVC) just below the diaphragm (T9-T10) and above L4-L5 vertebrae level

Confirmation of PICC position

1. **X ray**: Always confirm the position of the catheter by performing X-ray; preferably both anteroposterior and lateral views in case of lower limb PICC for better visualization. Use of radio-opaque contrast (0.3 mL-0.5 mL of omnipaque) helps in assessing location of catheter tip in case of small sized catheters.
2. **Real time ultrasound** can also be used for localization of catheter tip, but requires expertise.

Types of PICC materials

The different types of available PICC materials, with their characteristics, are summarized below in table 40.1.

Table 40.1: Types of PICC materials⁷

Type of catheter	Advantages	Disadvantages
Silicon	Soft and pliable, less risk of vein perforation	Poor tensile strength
Polyurethane	Easier to insert, good tensile strength more radioopaque	Increase risk of vein perforation
Polyethylene	Easier to insert, good tensile strength	Risk of vein perforation due to increased stiffness
Polyvinyl chloride (PVC)	Easy to insert	Increased risk of thrombosis

Recommended catheter size

Infant's birthweight 1.0 kg	28 G
Infant's birthweight ≥ 1.0 kg	24 G

Practical tips

If the catheter cannot be advanced to its desired position in SVC/IVC, but yields a good blood return, pull it back to a proximal portion of extremity either at midhumerus/midfemur level and use as peripheral venous access ensuring avoidance of hypertonic solutions.

Maintenance

1. Use transparent occlusive dressings to allow easy visualization of catheter site.
2. Assess the catheter site and review the need for central catheter daily. Always "*scrub the hub*" for at least 15 seconds before using it for initiating any infusion to prevent contamination of central line.
3. Avoid using 1 mL syringes for flushing as it may lead to catheter rupture; preferably use 5 or 10 mL syringes.
4. Avoid transfusing blood products;
Tubing change: every 24 hours for lipid containing lines
5. Dressing change: Change PICC line dressing only when visibly soiled, damp or loosened. For optimizing sterile technique, two persons should perform dressing change.
6. Remove the catheter at the earliest when it is no longer needed.

7. Make use of quality improvement tools and quality indicators such as infection rates, catheter dwell times, patient outcomes, rates of central line associated blood stream infections (CLABSI) for surveillance and reduction of infection. The bundled approach for prevention of CLABSI is described in panel 1.

Panel 1: Bundled approach for prevention of CLABSI⁸

- Key components of bundled approach in CLABSI prevention include
 1. Promotion of proper hand washing: Hand hygiene is the single most important intervention that helps in nosocomial infection prevention.
 2. Incorporating best central venous catheter (CVC) practices which includes optimal insertion practices using an insertion checklist, appropriate daily maintenance of central venous lines and ensuring timely removal of central lines.
 3. Real time surveillance and reporting of infection

Complications

1. Catheter related sepsis: Most common health care associated NICU infection. Bundled care approach helps in reducing rates CLABSIs (Panel 1). Coagulase negative staphylococci is the most common pathogen.
2. Hemorrhage
3. Line migration – Cardiac arrhythmia, pericardial effusion, pericardial tamponade, tissue extravasation, pleural effusion. Ascending lumbar vein (ALV) migration is one of common complications associated with lower limb PICCs.
4. Thrombosis (more with lower extremity placed lines): Include deep venous thrombus, renal vein thrombus, intracardiac thrombus etc
5. Catheter breakage/ dysfunction
6. Phlebitis
7. Extravascular fluid collection (pleural/pericardial effusion, hemothorax, chylothorax)
8. Air embolism

Panel 2: Definitions

CLABSI (Central line associated blood stream infection)

All criteria to be present

1. Occurrence of laboratory-confirmed bloodstream infection (LCBI)
2. Duration of central line (CL) or umbilical catheter (UC) for 2 or more calendar days on the occurrence of CLABSI with day of catheter insertion being the first day
3. The line must be in place either on the day of CLABSI or the day before.
 - Terminology catheter related blood stream infection (CRBSI) is used when the same organism is recovered from percutaneous blood culture and from culture of catheter tip with a 3 fold colony count in the latter.

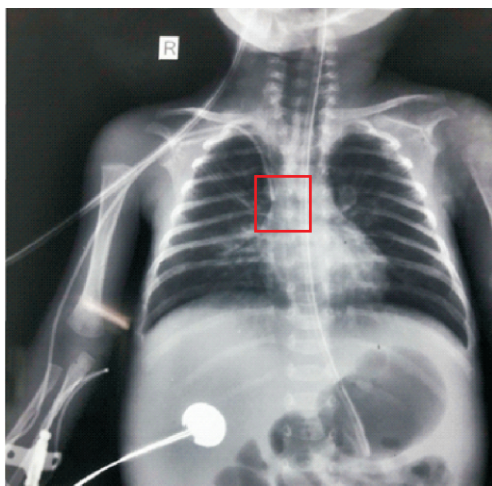


Figure 40.4: Anteroposterior radiograph of chest showing satisfactory position of PICC line (red box) inserted in the right upper limb.

Percutaneous arterial catheterization

Indications

1. Continuous monitoring of arterial blood pressures in critically sick ventilated babies
2. Regular monitoring of arterial blood gases in ventilated babies requiring frequent ABG.

3. Inability to insert a UAC/ removal of UAC due to complications
4. As an access for withdrawal of blood in exchange transfusion

Preferred site

- Radial artery or posterior tibial artery due to good collateral circulation
- Axillary artery, femoral artery, dorsalis pedis artery and temporal artery should preferably be avoided.

Practical tips

- Perform modified Allen's test (Panel 3) prior to cannulation of radial artery in order to establish patency of ulnar artery circulation.
- Use transillumination with a cold light for better visualization of artery
- Always fix the cannula allowing good visibility of fingers and toes
- Maintain patency of catheter using low dose heparin infusion (0.5U/mL)

Complications

1. Vascular-vasospasm/thrombosis/embolism: Most common; can lead to blanching of extremity, skin necrosis, gangrene and loss of digits. Catheter should be removed immediately once evidence of ischemia is seen.
2. Hemorrhage/hematoma at puncture site
3. Infection
4. Air embolism

Panel 3: Modified Allen Test.⁹

- Apply pressure on the palm and fingers of the infant to blanch
- Apply pressure using your fingers to both radial and ulnar arteries of the infant to obstruct blood flow
- Release the occlusive pressure only on ulnar artery
 - o Positive test - If hand flushes within 5 to 15 seconds (good flow in ulnar artery)

- Negative test - If hand does not flush within 5 to 15 seconds poor flow in ulnar artery). Do not puncture **radial artery in such cases.**

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