

Umbilical Arterial and Venous Catheter Insertion

Joint Neonatology Education Program
Neonatal Intensive Care Units

Hospital for Sick Children
Sunnybrook Health Sciences Center
Mount Sinai Hospital

Department of Paediatrics
University of Toronto



Content of Training Package

1. Indications and contraindications for umbilical line insertion
2. Anatomy of umbilical and associated vasculature
3. Complications of umbilical line insertion
4. Procedure for umbilical line insertion

Indications for Umbilical Catheter Insertion

Umbilical venous catheter (UVC)

- Emergency vascular access
- Central venous monitoring
- Exchange transfusion
- Central venous access for IV fluids and medications (e.g. hyperosmolar solutions such as dextrose concentrations greater than D12.5W)

Umbilical arterial catheter (UAC)

- Frequent measurement of arterial blood gases and/or blood sampling
- Continuous arterial blood pressure monitoring

Contraindications for Umbilical Catheter Insertion (UVC or UAC)

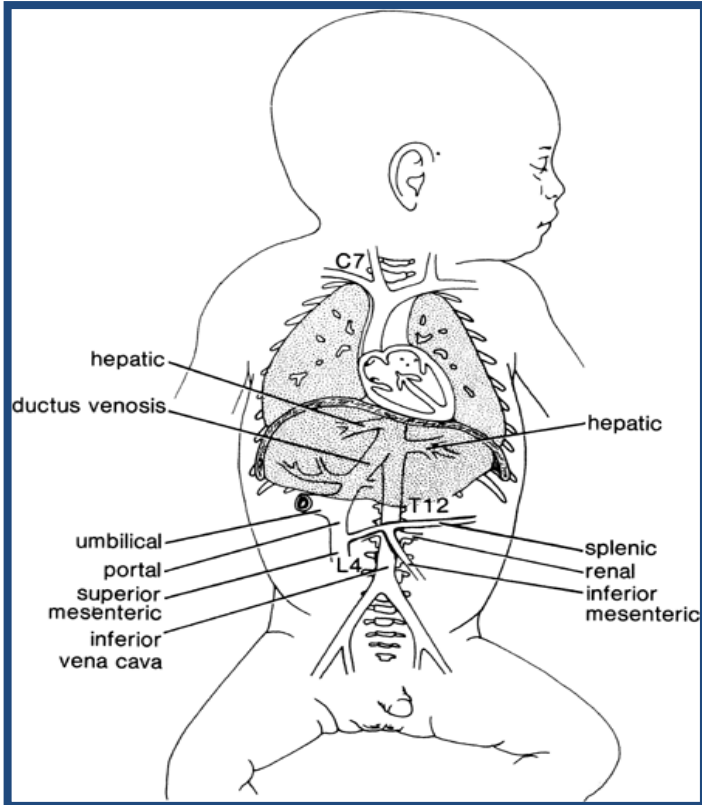
- Necrotizing enterocolitis
- Omphalitis
- Omphalocele
- Gastroschisis
- Peritonitis

UAC specific contraindication: Evidence of vascular compromise in lower limbs or buttocks

Duration of Catheterization

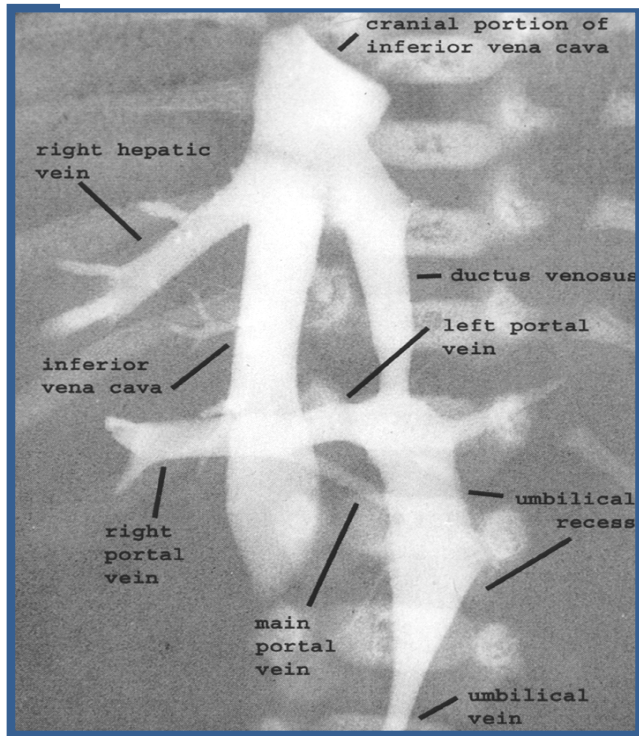
- Decisions regarding duration of UVC placement should be individualized for each patient
- Review patient's need for catheter daily
- Catheters should be removed as soon as they are no longer required
- Remove umbilical arterial catheters immediately if there are any signs of vascular insufficiency to the lower extremities or buttocks
- Ideally, umbilical arterial catheters should be removed after 5 days¹
- If treated aseptically, umbilical venous catheters can remain in place up to 14 days¹
- **Low UVCs** can be used for non-vesicant solutions for **1-2 days** until more suitable access is obtained

Anatomy: Umbilical Vein

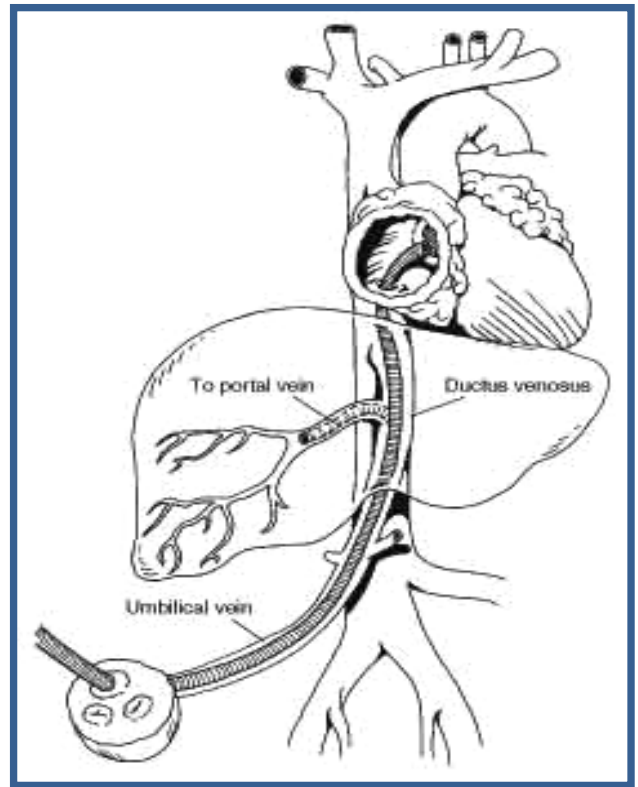


Atlas of procedures in neonatology. 4th ed. 2007

- Only one umbilical vein
- Umbilical vein larger and less round than the two umbilical arteries
- Umbilical vein is a thin-walled vessel located close to periphery of the umbilical stump
- In a full-term infant, umbilical vein is about 2 to 3 cm in length and 4 to 5 mm in diameter
- From the umbilicus, it passes cephalad and a little to the right, where it joins the left branch of the portal vein after giving off several large intra-hepatic branches that are distributed directly to the liver tissue

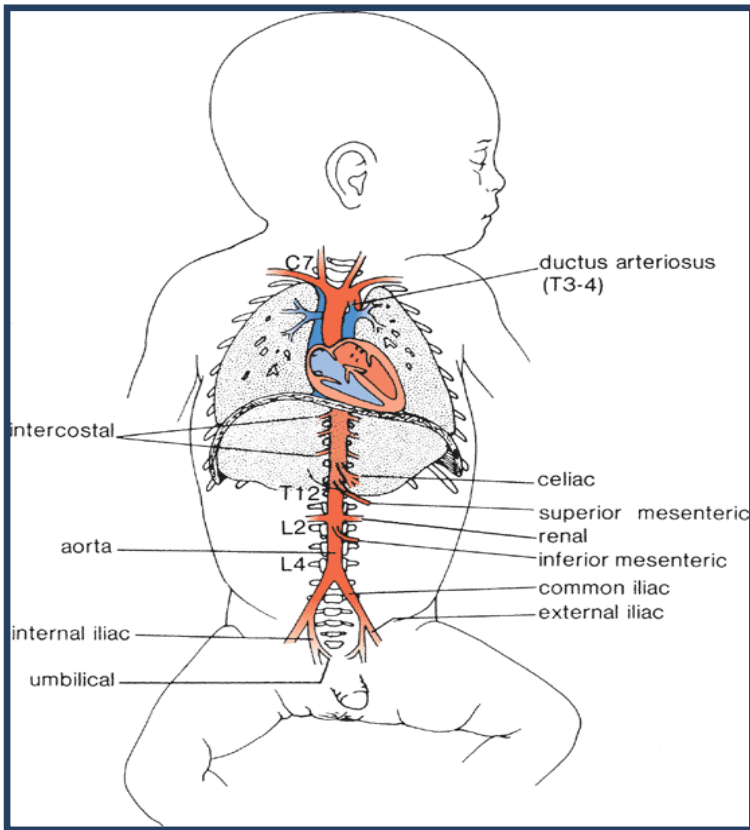


AJR 2003; 180:1147-1153

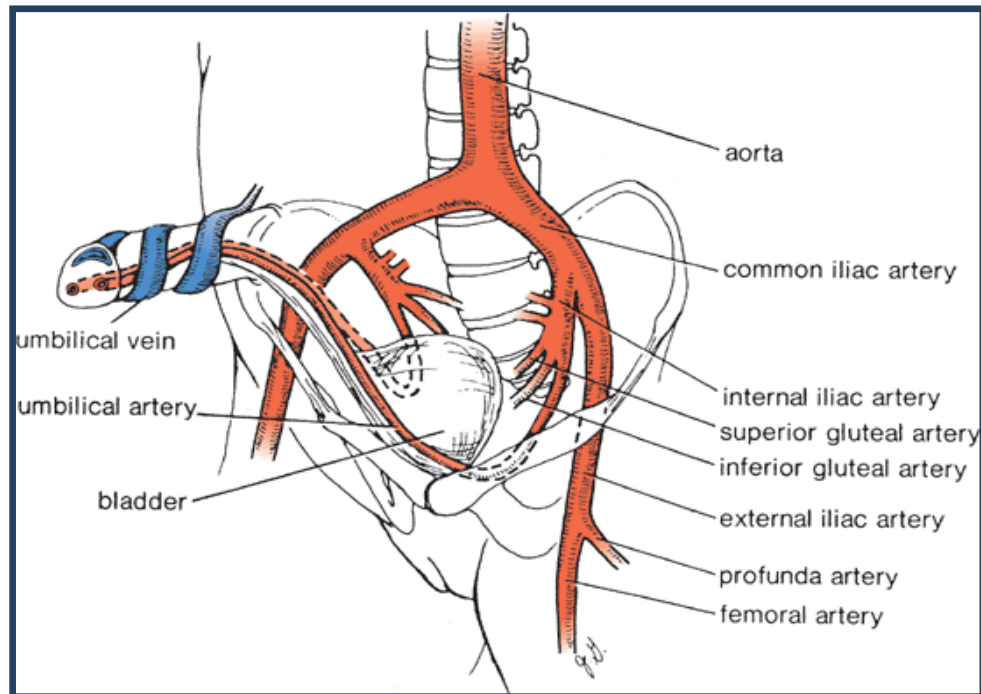


Principles of Pediatric Surgery 2003

Anatomy: Umbilical Artery



- Normally, there are two arteries which are a continuation of the internal iliac arteries
- Arteries are smaller with thicker muscular walls than the umbilical vein
- In a full-term infant, the arteries are about 7 cm in length and 2 to 3 mm in diameter
- A catheter introduced into the umbilical artery will usually pass into the ascending aorta from the internal iliac artery. Occasionally, it may pass into the femoral artery via the external iliac artery, which becomes an unsuitable site for blood sampling, pressure monitoring or infusion and should be removed.



Atlas of procedures in neonatology. 4th ed. 2007

Positioning of Umbilical Catheters

Umbilical arterial catheter (UAC)

High position: catheter tip at the level of thoracic vertebrae 6 to 9 (tip above celiac axis)

Low position: catheter tip at the level of lumbar vertebrae 3 to 4 (tip below major aortic branches such as the renal or mesenteric arteries)

High versus low positioning

- High position is preferred
- Low placement acceptable but associated with increased vascular complications^{2,3}
- If high positioning cannot be established, low positioning may be used

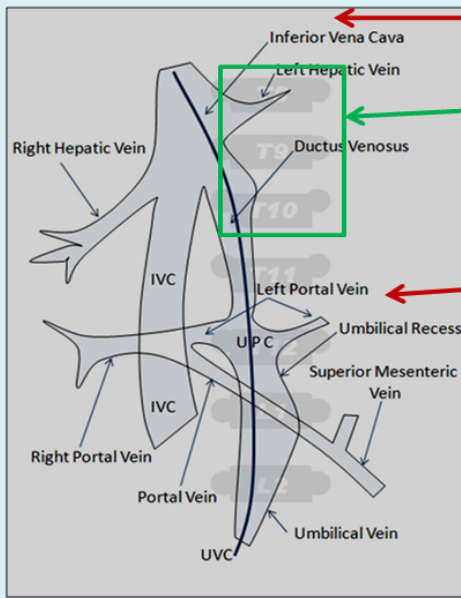
Umbilical venous catheter (UVC)

- Position catheter tip in inferior vena cava just outside the right atrium (T9 to T10, just above the right diaphragm)
- Do not leave the UVC in the right atrium; if in the heart, a repeat xray is required to document that the tip is outside the heart
- Positioning in ductus venosus is acceptable except for the measurement of central venous pressure

UVCs near the liver

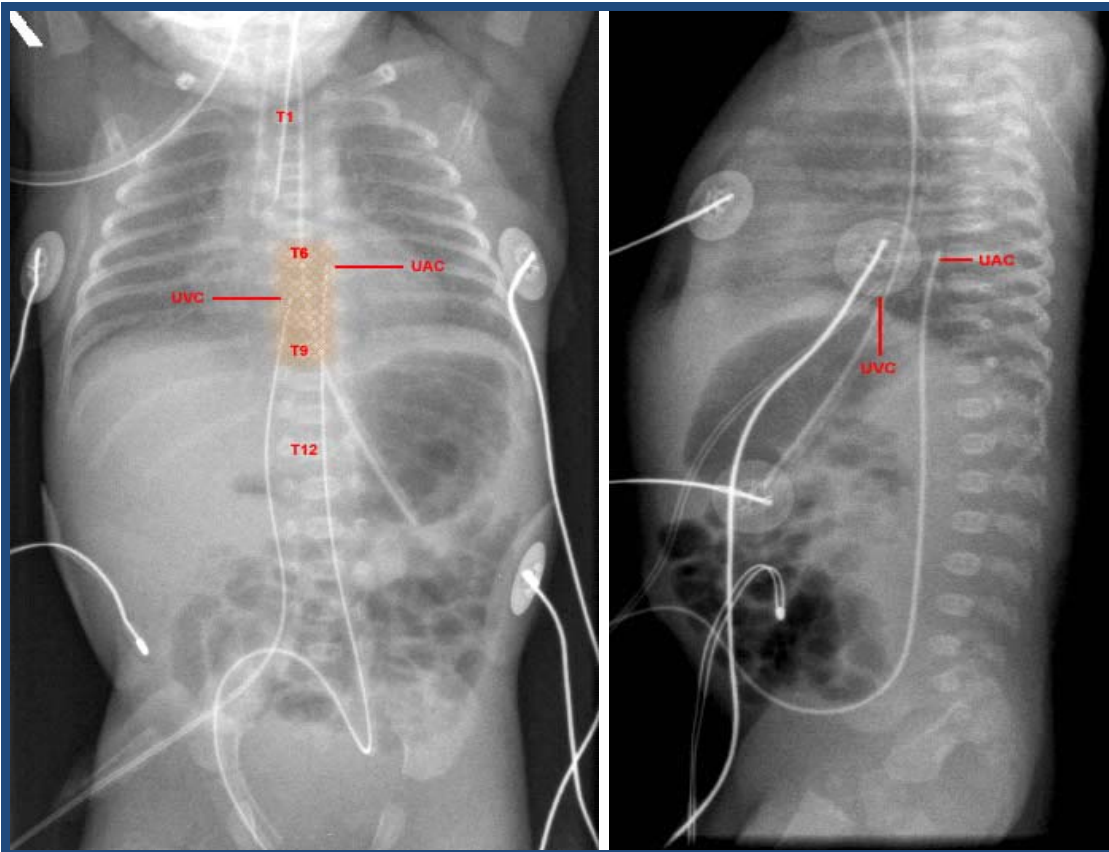
- Never leave a UVC in the portal vein or adjacent to the portal vein
- It should be replaced with an properly positioned UVC or pulled to a low position below the portal vein, in the umbilical vein
- Low UVCs can be used for non-vesicant solutions for 1-2 days until more suitable access is obtained

Vertebral Levels



Right atrium T7
 RA – IVC junction T8-9
 UVC target level T8-10
 Portal vein near T11

Artwork by MJ Fuller: <http://www.wikiradiography.com/page/Neonatal+Lines,+Tubes+and+Catheters>
 Bradshaw & Furdon. Advances in Neonatal Care June 2006; 6(3):127
 Meerstadt (2000). Manual of Neonatal Emergency X-Ray Interpretation



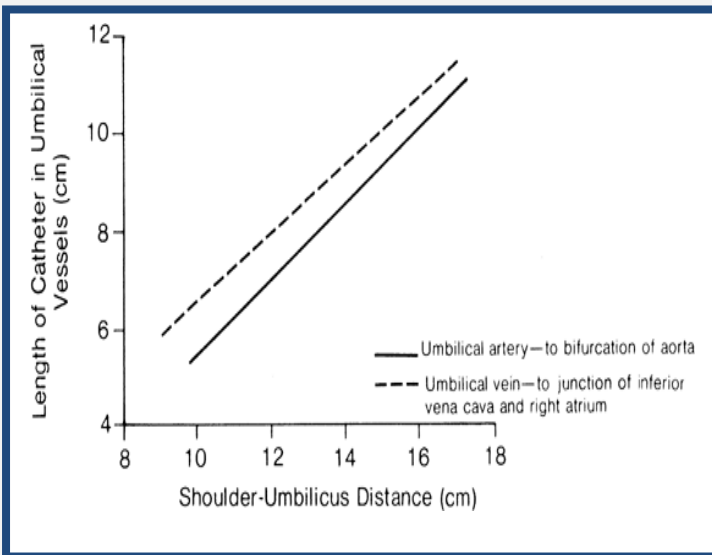
Determining Length of Catheter Insertion

An ideal measurement results in accurate placement of catheter upon initial insertion. Mal-positioning on initial insertion results in increased infant handling, radiation exposure and infection risk (due to line manipulation)

Measurement Methods: Several measures are available to determine depth of umbilical catheter insertion but the most commonly used methods are the nomogram by Dunn and the formula method by Shukla and Ferrara.

Method #1-Nomogram Method (Dunn)⁴

- Study:** In 1966 Peter Dunn completed a study of the localization of umbilical catheters in fifty post-mortem infants ranging between 600-4027 grams and 26-44 weeks gestation.
- Method:** Umbilical venous and arterial catheters were positioned to various anatomical points (e.g. IVC immediately above diaphragm) and the internal catheter length and external body measurements (e.g. shoulder-umbilicus, total body length) were completed.
- Findings:** Relationship identified between internal catheter length and shoulder-umbilical and crown-rump length. Nomogram developed which has been widely used.



Graph for determination of length of catheter to be inserted for appropriate aortic and venous placement. Length of catheter is measured from umbilical ring. Length of umbilical stump must be added. (Adapted from Dunn P. Localization of the umbilical catheter by postmortem measurement. Arch Dis Child 1966; 41:69)

Measuring Shoulder-Umbilicus Distance



Shoulder-umbilicus distance = top of the shoulder over the lateral end of the clavicle and a point vertically beneath it that is level with the centre of the umbilicus

Method # 2: Formula Method (Shukla & Ferrara)⁵

Study:	In 1996 Shukla and Ferrara used various measurements, including birth weight, to determine which measurement best predicts insertional umbilical catheter lengths.
Findings:	Birthweight showed better correlation than shoulder-umbilicus and total body length. A modified linear regression equation was then developed.
Benefits:	Reliable; no need to measure; can be easily calculated in emergency situations
Formulas:	Umbilical arterial catheter length = $3 \cdot \text{birthweight} + 9$ Umbilical venous catheter length = $\frac{1}{2}$ UA line calculation + 1

REMEMBER: to add length of umbilical stump to distance inserted

What Method Is To Be Used for Determining Depth of Umbilical Catheter Insertion? The Formula Method by Shukla & Ferrara⁵

Although use of the nomogram method by Dunn is acceptable for determining depth of umbilical catheter insertion, the Shukla & Ferrara formula method is more accurate and easier to use, particularly in emergent situations. Therefore, to promote consistency and decrease practice variability, the Shukla & Ferrara formula method is to be used for determining the depth of umbilical catheter insertions.

Formula for Determining Umbilical Catheter Depth Insertion

UAC: (weight in kg x 3 + 9) + length of umbilical stump (in cm)

Example: 2 kg infant; umbilical stump 1 cm:
(2 kg x 3 + 9) + 1 = 16 cm

Note: In low birth weight infants the formula may overestimate insertion length⁵. As with all umbilical catheters, x-ray confirmation of catheter tip placement and completion of necessary adjustments are essential.

UVC: [(weight in kg x 3 + 9) ÷ 2] + 1 + length of umbilical stump

Example: 3 kg infant; umbilical stump 2 cm: [(3 kg X 3 + 9) ÷ 2] + 1 + 2
= (18 ÷ 2) + 1 + 2 = 12 cm

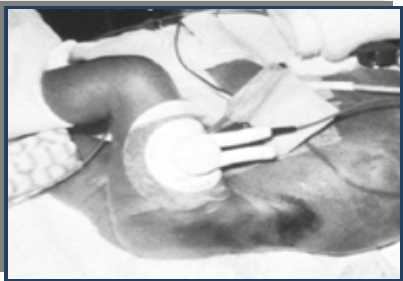
Selection of Umbilical Catheter Size & Type

- **Single hole catheters** are to be used as this reduces the surfaces for potential thrombus formation
- **Single lumen catheters** should be used for umbilical arterial catheterization
- **Multiple lumen catheters** may be used for umbilical vein catheterization
- Minimize the number of lumens used; more lumens may increase infection risk
- **Feeding tubes are *not* recommended** except in emergency situations when umbilical catheters are unavailable as they are associated with a higher incidence of thrombosis⁷

Catheter Size for UA & UV: <1.5 kg: 3.5-French
≥1.5 kg: 5-French

Complications of Umbilical Catheterization (not an inclusive list)

⚠️ALERT: If there is sudden distress in an infant with a UVC, emergent assessment for possible pericardial effusion/cardiac tamponade should be performed and infusions through the line should be held.

Complication	Effect												
Infection	Local and/or systemic infection (catheter-related blood stream infection)												
Catheter malpositioned in the heart and great vessels	Pericardial effusion or cardiac tamponade Cardiac arrhythmias Thrombotic endocarditis Hemorrhagic pulmonary infarction Hydrothorax (UVC lodged in or perforation of pulmonary vein)												
Catheter malpositioned in portal system	Necrotising enterocolitis Perforation of colon Hepatic necrosis												
Malpositioned catheter	Vessel perforation Refractory hypoglycaemia (if catheter tip opposite coeliac axis) Peritoneal perforation False aneurysm												
Vascular accident	<table border="0"> <tr> <td>Thrombosis</td> <td>Embolism/Infarction</td> </tr> <tr> <td>Air embolus</td> <td>Wharton-jelly embolus</td> </tr> <tr> <td>Cotton-fibre embolus</td> <td>Vasospasm</td> </tr> <tr> <td>Heart failure (from aortic thrombosis)</td> <td>Paraplegia</td> </tr> <tr> <td>Loss of extremity</td> <td>Hypertension</td> </tr> <tr> <td>NEC</td> <td></td> </tr> </table>  <p>Vascular compromise in left buttock owing to umbilical artery catheter displaced into internal iliac artery. From Atlas of procedures in neonatology. 4th ed. 2007</p>	Thrombosis	Embolism/Infarction	Air embolus	Wharton-jelly embolus	Cotton-fibre embolus	Vasospasm	Heart failure (from aortic thrombosis)	Paraplegia	Loss of extremity	Hypertension	NEC	
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NEC													
Equipment related	Broken catheter Transection of catheter Plasticizer in tissues												
Other	Perforation of peritoneum Obstruction of pulmonary venous return (in infants with TAPVD) Intestinal necrosis or perforation Hemorrhage Transection of omphalocele Plasticizer in tissues Herniation of appendix through umbilical ring Portal Hypertension												

Procedure

Umbilical Catheter Insertion is a Two-Person Procedure

- Umbilical catheter insertion is a 2-person procedure with one person being designated as scrubbed and the other unscrubbed.
- The **scrubbed** person inserts the catheter and must use maximal barrier precautions and maintain aseptic throughout the procedure. Maximal barrier precautions are the wearing of a surgical hat, a mask and sterile gown and gloves.
- The **unscrubbed** person is in the patient zone to continuously monitor the patient's condition. The unscrubbed person is to wear a mask, surgical hat and non-sterile gown. If the unscrubbed person directly assists with the procedure, they are required to comply with the recommendations outlined as for the scrubbed person.

Prepare Patient

- Maintain infant in a neutral thermal environment. Assess whether an additional heat source with an overbed heater or heated mattress is required. Infant temperature should be monitored throughout procedure with a properly positioned skin probe.
- Monitor clinical condition of the patient throughout procedure with continuous cardiorespiratory and oxygen saturation monitoring.
- To prevent limbs from entering and contaminating the sterile field, secure limbs in a developmentally appropriate position.

Gather Equipment

Personal protective equipment:

Sterile gown and gloves

Non-sterile hat, mask

Face shield or eye protection recommended (refer to institutional recommendations)

Neonatal tray

Straight iris scissors

2 smooth curved iris forceps

3 mosquito hemostats

1 toothed mosquito hemostat

Needle driver

Dilator

Sterile 4-by-4 gauze

Drape with hole in center

Sterile drape/towels

Add additional equipment

Umbilical tie

11-blade scalpel

Umbilical catheter

4.0 silk curved suture

5 or 10 ml sterile syringes as needed

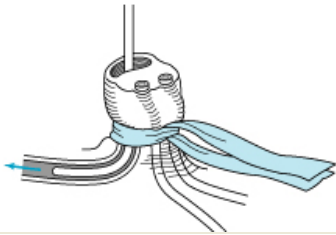
Sterile normal saline or normal saline with heparinized flushing solution

Skin antiseptics solution

For UAC, three-way stopcock with Luer-lock

Steps	Key Points
1. Gather necessary equipment and check cart contents	
2. Determine catheter size and length of catheter to be inserted using the formulas	
3. Put on mask and hat. Use face shield or eye protection if desired or as per institution recommendations.	<p>Mask: contain and filter droplets of microorganisms Cap: minimize shedding onto surgical attire or surgical site Face shield: protection from potential exposure to patient fluids</p>
4. Perform handwash as per protocol	
5. Put on sterile gloves and gown	
6. Unscrubbed individual opens tray and while maintaining sterility and transfers additional equipment to tray	
<p>7. For UAC: attach stopcock to hub of catheter and fill each port of the stopcock with flush solution and then turn stopcock “off” to catheter For UVC: attach luer-lock syringe to hub of catheter and fill system with flush solution</p>	<p>☀ALERT: AIR EMBOLUS RISK To ensure an air-free catheter and prevention of introduction of air into the patient, fill the lumen with infusion solution and close the stopcock until the catheter is in the vein.</p> <p>Ensure that the catheter does not touch non-sterile surfaces during preparation of the flush solution</p>
<div data-bbox="142 989 972 1373" data-label="Image"> <p>Portal venous gas introduced from air in UVC</p> </div>	
8. Place sterile gauze around umbilical stump and elevate out of sterile field or have ungloved assistant grasp cord with cord clamp or forceps and pull cord vertically out of sterile field	<p>☀ALERT: Do not allow the antiseptic solution to pool under the infant as it may burn the skin particularly in the very low birthweight infant</p>
9. Cleanse umbilical cord and skin as per institution specific guidelines	
10. Drape area surrounding cord using sterile towels and/or sterile drape so that a minimal amount of skin around the stump is exposed	

11. Place umbilical tie securely around the skin at the base of the umbilical stump and loosely tie with a single knot



From Gomella, Neonatology: management, procedures, on-call problems, disease and drugs-6th Ed. (2009)

⚠ALERT: Place the umbilical tie around the skin and not on the umbilical cord.

12. Using 11-blade scalpel, cut cord below existing cord clamp approximately 1 to 1.5 cm from skin. If oozing of blood occurs, tighten umbilical tie and blot surface of cord stump with gauze swab.

Give the cord clamp to assistant while maintaining sterility.

□ PEARL: Cut cord horizontal to abdomen to ensure vessels are cut in full cross section

Avoid sawing back and forth when cutting cord. Aim to make a single cut as this provides a straighter site for catheter insertion.

The umbilical vein may bleed more than artery because the vein is not a contractile vessel.

Rubbing damages tissue and obscures anatomy.

13. Identify desired cord vessel



N Engl J Med 2008;359:e18

□ PEARL: When identifying vessels, remember that the vein is usually located in the 12-o'clock position and the arteries at 5-o'clock and 7-o'clock position

14. With mosquito clamp, grasp cord stump away from vessel and apply traction to stabilize cord stump

Alternate method: Open sterile 4 X 4 cm gauze and twist it to make a long "cord" Wrap this cord around the base of the umbilical stump to stabilize and elevate stump

UMBILICAL VENOUS CATHETER

a) Gently insert closed tips of the curved toothless iris forceps into the lumen of the vein and remove any clots. Probe towards the head as vein goes cephalad.

b) Grasp umbilical catheter 1 cm from tip, between free thumb and fore-finger or with curved iris forceps and insert fluid-filled catheter attached to syringe into lumen of vessel.

c) Advance catheter 4 cm and then draw back on syringe to verify intraluminal position. If there is smooth blood flow, flush catheter with ~0.5 mL flush solution and then continue to insert catheter to measured distance.

If blood return is not easy a clot may be present. Withdraw catheter while maintaining gentle suction on the syringe. Once catheter is out of vessel, flush catheter to clear blood and attempt insertion again.

Suspicion that UVC has entered the portal system

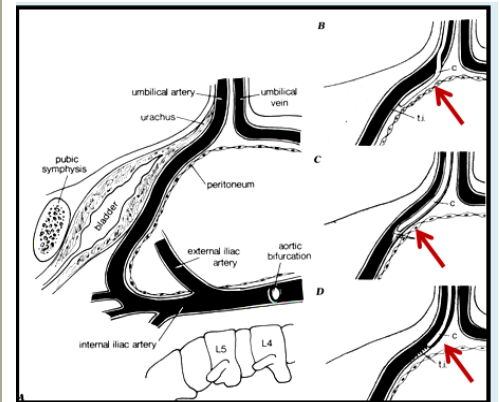
If the UVC meets obstruction prior to reaching the measured distance, it may have entered the portal system

- Withdraw catheter to 3 cm then advance the catheter while rotating catheter clockwise
- Flush catheter gently while advancing slowly
- Try postero-lateral mobilization of liver to realign the vessels
Ensure sterility is maintained
- Attempting to insert another catheter into vessel while the misdirected catheter is in place is NOT recommended as this may cause vessel damage and/or thrombus formation

☀ALERT: Ensure all visible clots are removed prior to catheter insertion

□PEARL: If catheter fails to advance in the umbilical vein at 1-2 cm, apply gentle traction to the cord stump caudally. It may be necessary to loosen umbilical tie when inserting the catheter.

☀ALERT: Do not force a catheter if meeting resistance. Excessive force can increase the risk of perforation.



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☀ALERT: Never leave the catheter open to atmospheric pressure. The abdominal venous system is under negative pressure; with a deep inspiration, air can enter the catheter with resultant air embolism.

Emergency Situations

In an emergency, the catheter is best advanced to 3-5 cm in full term infants, which is 1-2 cm beyond the point at which good blood return is obtained to avoid injecting hyperosmolar fluids into the portal vessels and causing liver necrosis.

UMBILICAL ARTERIAL CATHETER

- a) Gently insert closed tips of the curved toothless iris forceps into the lumen of the artery to a depth of approximately 0.5 cm and allow points to open and maintain forceps in this position for 15 to 30 second to dilate vessel.

Alternate method: use dilator instead of iris forceps and follow above steps

- b) Grasp umbilical catheter 1 cm from tip, between free thumb and fore-finger or with curved iris forceps and insert fluid-filled catheter attached to syringe into lumen of vessel between the prongs of the iris forceps
- c) With a firm, steady motion insert umbilical catheter approximately 2 cm into lumen of vessel and then remove iris forceps
- d) Grasp cord again with mosquito clamp and pull gently toward head of infant
- e) Advance catheter to 5 cm and then draw back on syringe to assess for blood return and verify intraluminal position
- f) If there is smooth blood flow, flush catheter with ~0.5 mL flush solution and then continue to insert catheter to measured distance

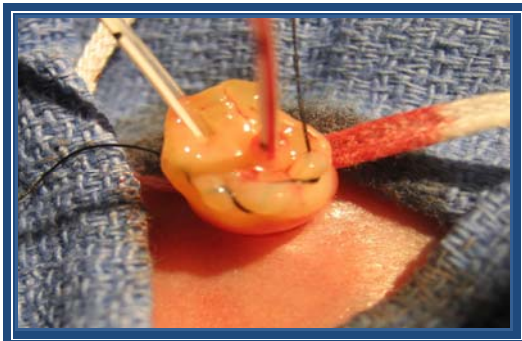
□ **PEARL:** Taking the time and care to dilate the artery decreases the risk of false tracking and increases the likelihood of success.

If catheter does not advance at 2-3 cm, it may be necessary to loosen umbilical tie.

☀ **ALERT: Do not force a catheter if meeting resistance. Excessive force can increase the risk of perforation.**

If there is no blood return the catheter is likely outside the vessel in a false channel.

15. With needle facing away from catheter, place purse-string suture around the base of the cord, using 2-3 'bites' into the stump and make a knot.



N Engl J Med 2008;359:e18

Secure the catheter to the stump by wrapping the tails of the suture snugly around the catheter and then tying securely.

☀ALERT: Do not place sutures on skin

□**PEARL:** If inserting both UAC and UVC, insert UAC first, then UVC, in case the cord needs to be cut further for the more difficult UAC insertion

Once both catheters are in, suture UVC first, since it is more likely to dislodge, then UAC

Suture UAC and UV separately

16. Note cm mark at the surface of the cord

☀ALERT: For ongoing surveillance for timely recognition of catheter displacement

17. Obtain lateral and anteroposterior radiograph to confirm position

18. Once the sterile field is down, do not advance catheter

Prevents introduction of a contaminated portion of catheter into vessel

19. If necessary, adjust position of catheter after x-ray. If repositioning required, may attempt repositioning without cutting the sutures. If cutting of sutures is required, re-suture after repositioning. Once correct positioning of catheter is determined, secure catheter with a tape bridge and attach to heparin infusion as per unit protocol

Heparin decreases thrombotic complications and prolongs catheter life^{8,9}



21. Document procedure in chart including:
▪ type of procedure ▪ number of attempts ▪ size and length of catheter ▪ position on x-ray ▪ number of cm pulled back if repositioned ▪ complications ▪ patient status during & after procedure

☀ALERT: Accurate and thorough documentation is essential for ongoing surveillance for timely recognition of catheter displacement

CATHETER REMOVAL

UAC

1. Leave umbilical tie loose around cord stump as precaution against excessive bleeding
2. Withdraw catheter slowly and evenly, until approximately 5 cm remains in vessel, tightening purse-string suture or umbilical tie
3. Discontinue infusion
4. Pull remainder of catheter out of the vessel at rate of 1 cm/min (to allow vasospasm). If there is bleeding, apply lateral pressure to the cord by compressing between thumb and first finger.

UVC

1. Leave umbilical tie loose around cord stump as precaution against excessive bleeding
2. Withdraw catheter slowly and evenly, until approximately 2-3 cm remains in vessel, tightening purse-string suture or umbilical tie
3. Discontinue infusion
4. Pull remainder of catheter out of the vessel at rate of 1 cm/min. If there is bleeding, apply pressure to the cephalad side of abdominal wall

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