Procedures in Family Practice

Umbilical Vessel Catheterization

Stephen C. Prinz, MD, and M. Douglas Cunningham, MD
Lexington, Kentucky

Umbilical vessel catheterization has become a commonly performed procedure in intensive care nurseries across the country. Catheterizing umbilical vessels can be a lifesaving step when newborn infant resuscitation is required. Moreover, considerable diagnostic and therapeutic advantages can be achieved for certain sick infants in observation or special care nurseries. The procedure requires careful patient selection and proper technical performance.

Since Stahlman first made use of umbilical vessel catheterization in the treatment of the sick neonate in 1961,[1] it has become a frequently used and valuable procedure. It is now used in transfusions, blood pressure monitoring, fluid administration, and blood sampling in neonatal intensive care units.

Indications

Umbilical artery catheterization is indicated for any newborn in whom cardiopulmonary insufficiency is severe and mechanically assisted ventilation is required. Preterm infants with respiratory distress frequently need ambient oxygen at above 40 percent. An umbilical artery catheter enables the physician to monitor blood oxygen levels to avoid hyperoxygenation and the associated risk of retrolental fibroplasia. It can also be used to establish a route for exchange transfusion. If used in combination with an umbilical vein catheter, an isovolumetric exchange transfusion can be achieved, thus preventing fluctuations of blood pressure in very small neonates. Continuous monitoring of intra-arterial blood pressure in critically ill neonates is also possible by way of the umbilical arteries.

From the Division of Neonatology, Department of Pediatrics, College of Medicine, University of Kentucky, Lexington, Kentucky. Requests for reprints should be addressed to Dr. M. Douglas Cunningham, Division of Neonatology, Department of Pediatrics, College of Medicine, University of Kentucky, 800 Rose Street—MS 472, Lexington, KY 40536.

Umbilical vein catheterization alone is indicated for infants needing immediate administration of dextrose, calcium, alkali, anticonvulsants, or other emergency intravenous medications. Central venous pressure monitoring is possible through an umbilical venous line placed above the diaphragm. Umbilical vein catheters are more difficult to maintain and are not regularly used for blood sampling.

Contraindications

The insertion of an umbilical vessel catheter merely for the routine administration of parenteral fluids or for routine blood sampling purposes is not appropriate. An umbilical vessel catheter should never be inserted in the presence of omphalitis, or impetiginous skin lesions. The placement of an umbilical catheter is generally contraindicated when abdominal distention suggests embarrassed intestinal circulation or the possibility of necrotizing enterocolitis.

Techniques

Catheterization of umbilical arteries begins by selecting the proper catheter and determining the point to which it will be placed. A 3.5-French, end-hole catheter is most often used for infants less than 1,500 gm, and a 5-French catheter is used for infants weighing more than 1,500 gm. Currently two locations are accepted for umbilical artery

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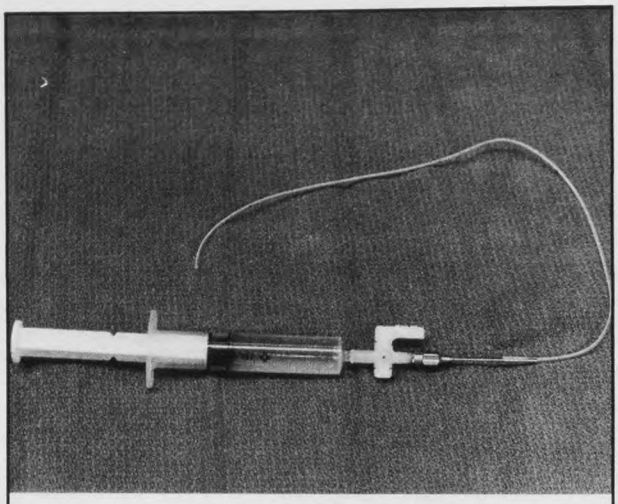

Figure 1. Assembly of materials for insertion of umbilical artery catheter. Note blunt tip needle in catheter to avoid clot formation in widened end of catheter

Figure 2. The freshly cut umbilical cord. Note the pinpoint lumens of the arteries at the base and the more open vein orifice at the top of the cord

catheter tips: the first is above the aortic bifurcation at the third or fourth lumbar vertebrae (L-3 or L-4), and the second is in the thoracic aorta at the seventh or eighth thoracic vertebrae (T-7 or T-8). A recent survey of several neonatal intensive care centers in the United States revealed a 48 percent preference for the former position and 52 percent for the latter.[2] The authors prefer the L-3 to L-4 position because of fewer complications involving bowel or kidneys in their experience. Although there is an increased incidence of vasospasm in the lower extremities with catheters positioned in the L-3 to L-4 region, it can be readily seen and quickly treated.

The entire operation should be carried out in an incubator or beneath a radiant warmer, and the operator should wear a clean gown, mask, and sterile gloves.[3]

The catheter is prepared by first cutting off 2 or 3 cm from the wide end of the catheter and placing a blunt 18-gauge needle into the tapered end (Figure 1). A three-way stopcock is connected to the hub of the needle and the entire assembly filled with heparinized saline solution (one unit of heparin/ml saline).

The umbilical stump and periumbilical area must be prepared with an antiseptic solution, taking care to wipe away any excess with alcohol. The area of the umbilical stump is draped with sterile towels or a sterile circumcision sheet. An umbilical tape is looped around the base of the umbilical cord and a half-knot is tied lightly. The cord is grasped full thickness with a forceps approximately 1.5 cm from the base of the stump and cut across cleanly at the top edge of the forceps with a number 11 blade (Figure 2). The umbilical tape ligature can be pulled tight should any bleeding occur. The remaining cord stump is grasped between the thumb and forefinger with a 2 × 2 gauze pad. The edges of the stump are caught by two small curved hemostats applied to each side of the cord stump, thus everting the cut end of the cord and exposing the umbilical vessels. Lightly blotting with a sterile gauze pad brings the large, thin-walled, and flaccid umbilical vein into view. It is easily distinguished from the two smaller, thick-walled, round arteries. An iris forceps can be gently inserted into an artery to relieve vasospasm and to dilate the lumen.

The catheter is picked up approximately 1 cm from the tip by the thumb and forefinger, or with a small forceps. With the stump held upright, the catheter tip is inserted into the lumen of the vessel. Resistance on insertion into the umbilical artery is usually felt at one of two points. The first is probably due to the existence of subendothelial cushions at the level of the anterior abdominal wall and the second is approximately at the level of the bladder. Resistance to the passage of the catheter may also be due to the dissection of the catheter into the subendothelial tissue of the vessel wall. If the resistance encountered is secondary to vasospasm, it can be relieved often by gentle, steady

pressure for 30 to 60 seconds. If this fails, sometimes it can be relieved by removing the catheter, filling the tip with 0.1 to 0.2 cc of 2% lidocaine (without epinephrine), reinserting the catheter, and gently flushing the lidocaine into the vessel at the point of resistance. Approximately one to two minutes later, one should again gently attempt to advance the catheter. If the catheter will not pass after this maneuver, catheterization of the other artery should be attempted. Throughout the procedure, the lower extremities must be observed repeatedly for vasospasm.

To determine the length of catheter to insert to give the desired aortic position, one can measure the vertical distance from the top of the shoulder over the lateral end of the clavicle to a point vertically beneath it and level with the center of the umbilicus. If the measurement obtained is less than 13 cm, insert the catheter that distance plus 1 cm. If the distance obtained is greater than 13 cm, insert that distance plus 2 cm. This should give the catheter a position in the thoracic aorta just above the diaphragm (Figure 3). If the lower umbilical artery catheter position is desired, the catheter should be advanced in the umbilical artery until blood is first obtained; it is then advanced an additional 1 cm. This usually positions the catheter tip in the region of L-3 or L-4 (Figures 4a and 4b). The catheter position should always be verified after insertion by anteroposterior and lateral thoracic or abdominal roentgenograms.[4] Catheters can always be pulled back after insertion, but they should never be advanced to a higher position because of the increased risk of introducing infection. Most catheters have three black markers 5 cm apart.

Securing the catheter in the final location can be achieved in one of two ways. First, a purse string suture can be placed around the base of the umbilical cord (4-0 or 5-0 silk) prior to the insertion of the umbilical artery catheter. After the position of the catheter tip is finalized, the suture is knotted and a 2 cm loop formed. The loop is tied snugly to the catheter forming a tether, taking care not to occlude the catheter. A second method employs a tape wedge secured around the catheter with the tape extending to either side of the catheter approximately 1 cm. A suture is passed through the skin at the base of the umbilical cord, knotted, and passed through the tape on either side of the catheter and tied into position (Figure 5).

Removal of the catheter should be carried out as soon as indications for placement no longer exist. Although arterial catheters have been left in place for as long as two weeks without apparent complication, every effort should be made to remove catheters within five to seven days of insertion. Considerable data exist demonstrating an increased incidence of infection, thrombus formation, and embolism following prolonged catheterization of more than seven days.[2,5]

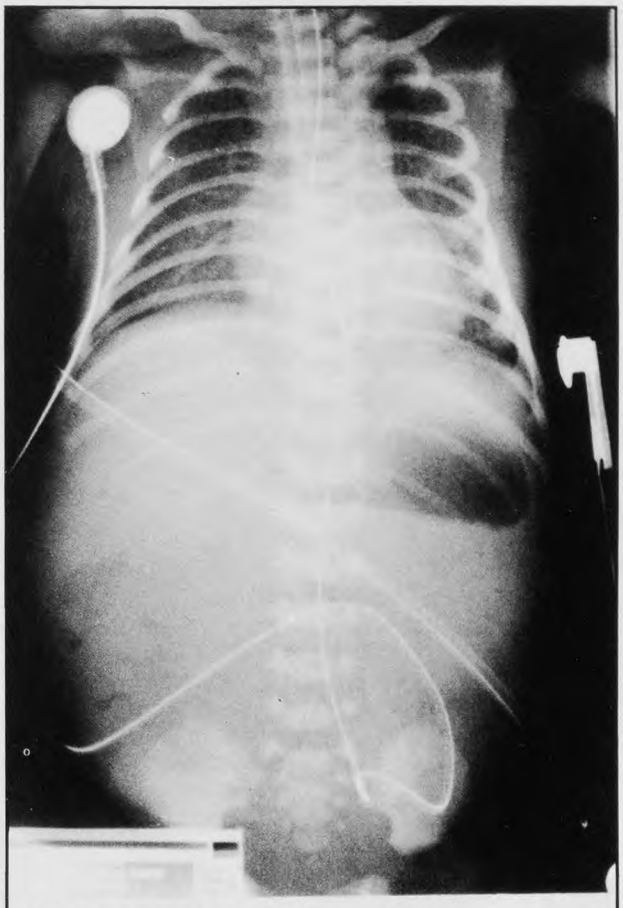

Figure 3. Umbilical artery catheter rests between thoracic vertebrae 7 and 8 well above the diaphragm

To remove the catheter, the stopcock is first turned off, a new loop of umbilical tape is placed around the umbilical stump, and gradually, over three to five minutes, the catheter is withdrawn. If the cord begins to bleed, the umbilical tape ligature is tightened. If hemorrhage persists, the vessel can be grasped with a curved hemostat, or cross-clamped with a DeBakey forceps. Pressure should not be applied vertically to the stump with arterial hemorrhage, as in many instances this will increase rather than decrease the bleeding. Apply-

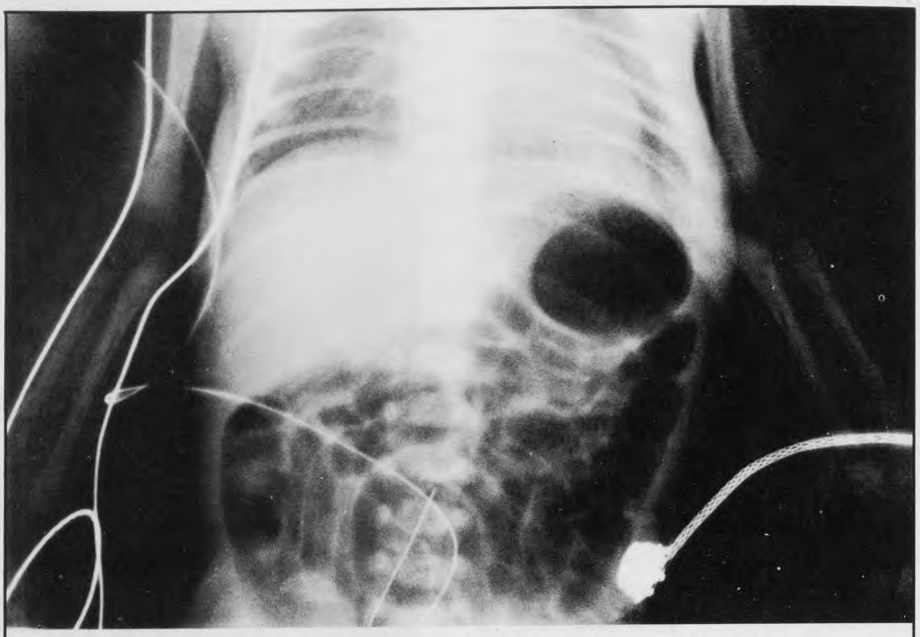

Figure 4a. Anteroposterior roentgenogram showing lower aortic umbilical catheter between lumbar vertebrae 3 and 4

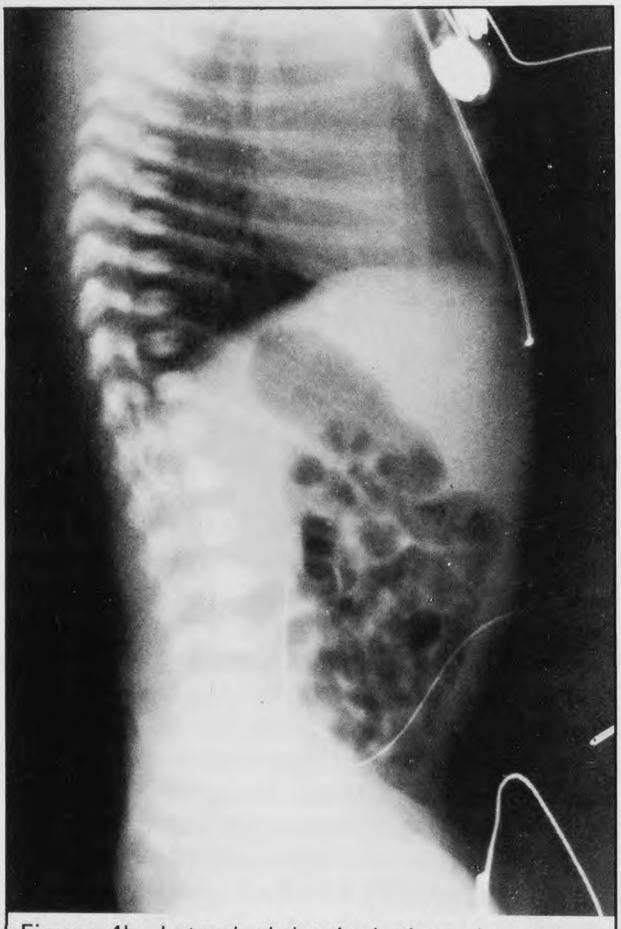

Figure 4b. Lateral abdominal view showing catheter to be satisfactorily placed, but slightly lower and adjacent to body of L-4

ing fingertip pressure just below and around the cord is all that is usually required.

An umbilical venous catheter is placed in essentially the same manner as an umbilical artery catheter. If an umbilical vein is to be used for an exchange transfusion, a catheter with side holes as well as an end hole should be used to avoid pulling negative pressure on the wall of the inferior vena cava or the thin walled right atrium.[6]

The measured vertical distance from a point over the lateral tip of the clavicle to the middle of the umbilicus, multiplied by 0.6, gives the length of catheter to be inserted. This should place the tip just above the diaphragm at the junction of the inferior vena cava and the right atrium (Figures 6a and 6b).

Umbilical vein catheters should be removed in 24 to 72 hours because of the increased risk for retrograde portal vein thromboses. The techniques for removal are essentially the same as for arterial catheters. If the umbilical vein bleeds upon removal of the catheter, fingertip pressure should be applied just above the cord rather than below it.

Complications

A non-functioning, and presumably clotted, umbilical vessel catheter should be immediately removed in all cases. One should never attempt to flush a clotted catheter, as the clot will certainly be discharged into the infant's circulation.

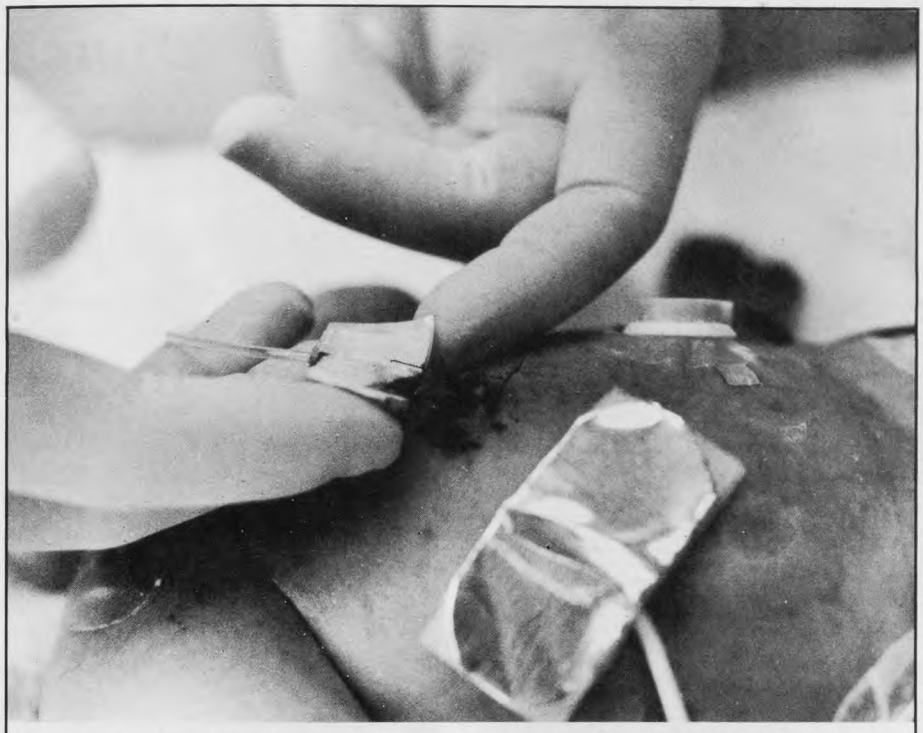

Figure 5. Catheter tape sutured to skin at base of cord. Catheter insertion in full view and tape does not preclude daily cord antiseptic care

Catheter induced vasospasm can sometimes be successfully treated with warm compresses to the contralateral extremity (reflex vasodilation), pulling the catheter back slightly, or elevating the extremity. Occasional success in treating vasospasm has been experienced by the authors by immersion of the extremities in a warm water bath. Vasospasm of the lower extremities which cannot be easily relieved is an indication for prompt removal of an umbilical artery catheter. If vasospasm persists following catheter removal, improvement has been achieved by injecting 1 mg of papaverine into the contralateral extremity, or by infusing 1 mg of tolazoline slowly through a temporarily replaced arterial catheter.[4]

Massive hemorrhage has been observed with accidental dislodgement of a catheter or disconnection of a stopcock, especially if the catheter involved is an umbilical artery catheter. Because of the potential for accidental hemorrhage, it is safest to always have fresh whole blood or packed red blood cells on standby for any child with a catheter in place. Anemia, hypovolemia, and hypoproteinemia have occurred when close attention has not been paid to the amount of blood withdrawn for sampling purposes.

Air embolism is a potential complication if an umbilical venous catheter is accidentally disconnected, or if a three-way stopcock is left opened.

Thrombosis is a fairly frequent complication of umbilical artery catheterization. Approximately 50 to 60 percent of all neonates coming to autopsy with umbilical artery catheters in place have arterial thrombosis.[5] Portal venous thrombosis occurs primarily when hypertonic glucose solutions, calcium, or sodium bicarbonate have been infused through an umbilical venous catheter that has not been advanced past the liver into the region of the inferior vena cava. Vascular damage to the portal venous system has been reported when undiluted alkali solutions have been given through the catheter. Thrombus formation has also been reported occasionally when hypertonic solutions have been given through umbilical artery catheters. Overly aggressive attempts to cannulate the umbilical artery have also been associated with vascular perforation and fatal retroperitoneal hemorrhage.[7]

Infection and sepsis are not uncommon compli-

Figure 6a. Lateral abdominal view showing vein catheter entering umbilicus, following the anterior abdominal wall, traversing the liver via the ductus venosus, and resting in the inferior vena cava just above the diaphragm

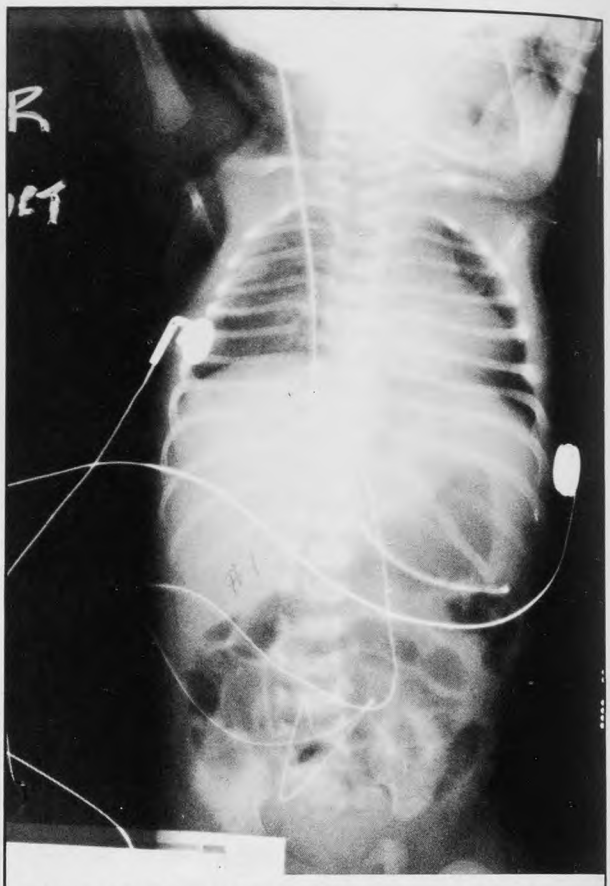

Figure 6b. Anteroposterior view showing venous catheter between T-5 and T-6. Note accompanying umbilical artery catheter at L-4

cations of umbilical vessel catheters. Reported incidents of bacteremia following catheter insertion have ranged from 8 to 56 percent.[8] Staphylococcal organisms are the most frequently identified pathogens.

Conclusions

Umbilical vessel catheterization is a procedure that should not be undertaken without careful consideration of the indications in each particular situation and the concurrent risks. However, in the critically ill neonate it is a procedure that can be lifesaving. Forethought and planning pave the way for technical success. Continuous observation and rapid intervention will reduce complications.

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