A Term Neonate with a Malpositioned Umbilical Artery Catheter Tip

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THE CASE

A term neonate with respiratory distress receiving endotracheal mechanical ventilation undergoes placement of umbilical venous and arterial catheters.

Prenatal and Birth Histories

- Full-term female neonate
- Born to a 27-year-old gravida 6, para 5, white woman
- Prenatal maternal laboratory screening unremarkable
- Emergent cesarean delivery for fetal tachycardia with recurrent late decelerations at the local community hospital
- Meconium-stained amniotic fluid noted at delivery
- Infant had poor tone and no spontaneous respiratory effort at delivery
- Infant was dried, positioned, and suctioned
- Positive pressure ventilation was administered in the delivery room followed by continuous positive airway pressure due to respiratory distress
- Apgar scores: 4 and 8 at 1 and 5 minutes, respectively

Presentation

The infant was admitted to the community hospital NICU. Endotracheal intubation was performed at 2 hours of age for increasing oxygen requirements and respiratory failure. Conventional mechanical ventilation was initiated with a fraction of inspired oxygen of 1.0. Chest radiography suggested meconium aspiration syndrome. Exogenous surfactant was administered and umbilical vein catheter (UVC) was placed. On radiography, the UVC tip was visualized in the liver and the catheter readjusted to a low-lying position and secured at 5 cm. The umbilical artery catheter (UAC) placement was unsuccessful. Blood culture specimen was obtained and treatment with ampicillin and gentamicin initiated. Persistent pulmonary hypertension of the newborn was suspected based on a 10% difference in pre- and postductal oxygen saturation; at 3 hours of age, inhaled nitric oxide (iNO) of 20 parts per million (ppm) was initiated for an oxygen index of 18 determined on a radial arterial blood gas.

The infant was transferred to a level IV NICU for further evaluation and consideration of extracorporeal membrane oxygenation. Upon arrival at the level IV NICU, the neonate was placed on high-frequency oscillatory ventilation and iNO was continued at 20 ppm. Echocardiography showed pulmonary hypertension based on right ventricular systolic pressures estimated at near-systemic level. The low-lying UVC was replaced with a new UVC. At the same time, a UAC was placed. Both catheters passed easily on first attempt with good blood return.

AUTHOR DISCLOSURE Drs Haggerty and Kurepa have disclosed no financial relationships relevant to this article. This commentary does not contain a discussion of an unapproved/investigative use of a commercial product/device.

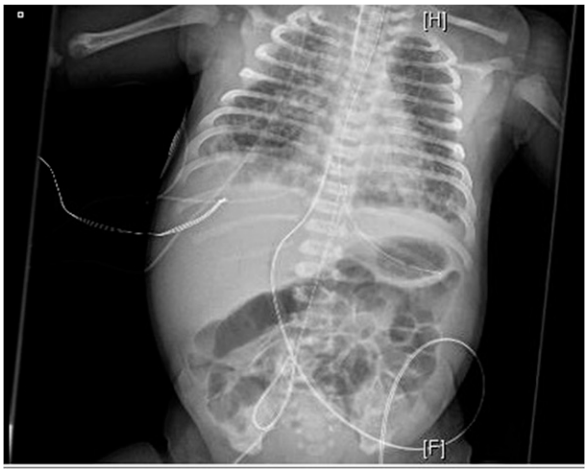

Figure 1. Radiography of the chest and abdomen.

Radiography of the chest and abdomen showed UVC tip in the right atrium and malpositioned UAC tip (Fig 1).

Physical Examination

- Normal status for gestational age

DIFFERENTIAL DIAGNOSIS OF MALPOSITIONED UMBILICAL ARTERY CATHETHER

- Placement in (1):
  - Femoral artery
  - Gluteal artery
  - Renal artery
  - Celiac plexus
- Perforation through umbilical artery (2)
- Catheter folding or coiling

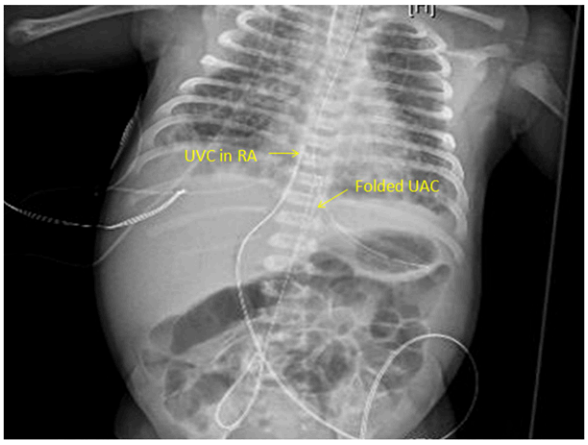

Figure 2. Radiography of the chest and abdomen showing UVC tip in the right atrium and distal UAC coiled in aorta.

ACTUAL DIAGNOSIS

Thoracoabdominal radiography showed that the UVC tip was located in the right atrium and that the distal UAC was coiled in the aorta (Fig 2). Point-of-care ultrasonography (POC-US) of the heart and abdomen confirmed that the UVC tip was in the right atrium and UAC was folded in the descending aorta (Fig 3).

CASE PROGRESSION

Under sterile conditions and real-time ultrasound guidance, the UAC was carefully retracted until it uncoiled, then advanced to above the celiac artery. The UVC tip was retracted to the cavoatrial junction also by using POC-US. Initial placement of UAC and UVC and postprocedure radiography took 40 minutes. Correction with POC-US took less than 10 minutes.

The infant tolerated weaning of respiratory support and underwent extubation at 6 days of age and weaned to room air at 10 days. The infant was discharged from the hospital at 23 days of age in room air and full oral feedings. Echocardiography before discharge showed resolution of the pulmonary hypertension.

WHAT THE EXPERTS SAY

Umbilical catheterization is an integral part of the care of sick newborns in the first week after birth.

Umbilical venous catheters are indicated mainly for the administration of fluids, parenteral nutrition, and medications. They are also used for exchange transfusions, central venous pressure monitoring, and diagnosis of total anomalous pulmonary venous return below the diaphragm. (3) Complications of malpositioned UVCs include infection,

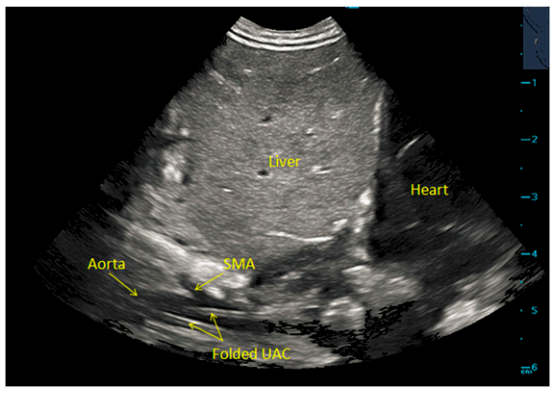

Figure 3. Ultrasound with sagittal view of the aorta showing folded distal tip of the UAC.

abscess, hepatic necrosis, laceration, cysts, colonic perforation, ascites, pleural effusion, hydrothorax, arrhythmias, myocardial perforation, pericardial effusion and tamponade, pneumopericardium, thrombosis, or embolization. (3)(4)(5)

Umbilical arterial catheters are used for arterial blood pressure monitoring, frequent or continuous measurement of arterial blood oxygen tension, frequent blood sampling, exchange transfusion, and angiography. (6) They can also be used for emergency administration of fluids and medications in situations in which venous access is unavailable. Complications of umbilical arterial catheterization are rare but potentially serious, and include infection, hemorrhage, hypoglycemia, bladder rupture, bowel perforation, necrotizing enterocolitis, paraplegia, loss of limb, hypertension, umbilical artery rupture, aortic dissection, aneurysm and/or rupture, thrombosis, and embolization. (6)(7) As expected, the risk of central line complications is increased with malpositioned catheters.

For UAC placement, the high position is recommended. This high distal tip position is in the descending aorta above the diaphragm. (6)(8) A meta-analysis by Barrington found that high positioning leads to fewer ischemic complications compared with low positioning. (8) Low positioning at the level of lumbar vertebrae L3 to L4 should be used only in rare cases when there is a critical need for arterial access and high positioning is unsuccessful. (6)

At the authors' institution, the neonatal fellows and neonatal nurse practitioners perform umbilical catheterization. When the catheter is inserted, it is blindly advanced to a predetermined length calculated by the weight-based regression equation described by Shukla and Ferrara. (9) Catheter position is then confirmed with postprocedure radiography. For UAC placement, optimal placement is in the high position, corresponding to thoracic vertebral levels T6 to T9, and for UVC placement, it is at the level of the inferior vena cava–right atrial junction. If adjustments are necessary, catheter position is confirmed again on radiography. Recently, our institution has begun to perform adjunct real-time POC-US–guided central catheter placement for specific cases. At present, the authors' use of POC-US is reserved for more challenging cases in which catheter position on radiography may be ambiguous, for very unstable patients with time constraints, or for patients who may be adversely affected by repeated manipulation.

The use of ultrasonography to determine umbilical catheter position was reported as early as 1983 by Garg et al, but it is still not the standard of care. (10) As availability of POC-US has increased, several recent studies have examined its accuracy and timeliness. In 2011, a randomized controlled trial by Fleming and Kim compared the use of ultrasound-guided UVC placement versus the standard procedure of advancement to a precalculated distance followed by postprocedure radiography. Ultrasound guidance reduced procedure time by an average of 64 minutes, as well as decreased the number of catheter manipulations. In addition, ultrasound guidance can identify incorrectly positioned catheters in real-time so that they can be immediately removed or adjusted, thus potentially reducing severe complications. (11) Simanovsky et al prospectively compared UVC catheter tip placement using both ultrasonography and radiography in 75 neonates, and concluded that ultrasonography is reliable for detecting catheter malposition. (12) In 2012, Michel et al compared ultrasonography to radiography for the detection of UVC tip position and found that it was more sensitive and specific (93.3% and 95.6% vs 66.7% and 63.0%, respectively). (13)

In 2016, Nguyen performed a literature review of 12 studies describing ultrasound-guided central venous catheter insertion as well as postinsertion ultrasonographic confirmation of the catheter tip position. He concluded that ultrasonography can be a complementary technique for central venous catheter placement but the evidence is inadequate for ultrasonography to replace radiography for catheter tip position confirmation. (14) Nevertheless, in 2017 a prospective observational study performed on 65 very-low-birthweight infants suggested, yet again, that radiography may be imprecise in determining umbilical venous catheter position. Only 44% of UVCs that were in the appropriate position on radiography were found to be in optimal position using ultrasonography. This study also examined rates of UVC migration during the first week of age. They found that 50% of infants experienced UVC migration. This was attributed to drying of the Wharton jelly and shrinking of the umbilical cord and/or changes in abdominal girth. Using POC-US for serial assessments of catheter tip position can obviate the need for repeated radiography. (15)

This case supports the use of real-time POC-US as a valuable adjunct technique for both UAC and UVC placement.

American Board of Pediatrics Neonatal-Perinatal Content Specifications

- Recognize the causes and clinical manifestations of catheter complications of parenteral nutrition.
- Know the pathogenesis and complications of umbilical arterial catheter–related thrombi.

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