

Umbilical venous catheter malposition and errors in interpretation in newborns with Bochdalek hernia

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Abstract

Background Neonates with congenital diaphragmatic hernia (CDH) often require placement of lines and tubes for supportive therapy. The resulting altered anatomy can result in diagnostic errors when interpreting the location of support lines and tubes such as UVCs (umbilical venous catheters).

Objective The purpose of this study was to evaluate the effect of CDH on UVC position and to evaluate the accuracy at which radiologists describe the position on chest radiographs.

Materials and methods During a 5-year period, 406 chest radiographs performed within 7 days of birth in infants with congenital diaphragmatic hernia were identified and reviewed for the following data: presence of UVC, location of catheter tip (cavoatrial junction, intracardiac, intrahepatic or umbilical vein), and location of CDH (right or left). The radiologic report of the UVC tip location for each case was then reviewed individually to determine the adequacy of interpretation. Inadequate reports were classified as incorrect (the wrong location of the catheter tip was reported), no mention (the location of the catheter tip was in a suboptimal location but not mentioned), and not specified (the precise location of the catheter tip was not clearly stated in the report when the tip was in a suboptimal location).

Results A total of 60 infants were identified as having CDH (56 on the left, 4 on the right). The most common location for an incorrectly placed UVC was the contralateral chest, accounting for 26.7% (16/60) of the infants, followed by an abdominal intrahepatic location (16.7%) and the umbilical vein (8.3%). Thirty percent (120/406) of the chest radiograph reports were found to be inadequate regarding the interpretation of the location of the catheter tip. The majority of the

inadequate reports (48/406, 11.8%) did not specify when the catheter tip was in a suboptimal location. In 37 reports (9.1%), the location of the catheter tip was reported incorrectly, and no mention of the catheter location was made in 35 reports (8.6%).

Conclusion The location of an UVC in an infant with Bochdalek hernia can pose a diagnostic challenge because of the altered anatomy and change in the expected course of the catheter. Familiarity with the altered anatomy and vigilance of the various abnormal locations in which UVCs can be placed can help optimize management for the child and reduce morbidity and mortality.

Keywords Interpretation errors · Umbilical vein catheters · Congenital diaphragmatic hernia · Radiography · Neonate · Infant

Introduction

Congenital diaphragmatic hernia (CDH) is a rare structural defect associated with physiological abnormalities such as pulmonary hypoplasia and pulmonary hypertension, which often require antenatal supportive therapy in the neonatal intensive care unit (NICU). In Bochdalek hernias, normal anatomical relationships are altered by herniation of abdominal organs, such as liver and bowel into the chest as well as contralateral shift of mediastinal structures. These anatomical changes can alter the expected course of support lines and tubes, which can in turn lead to errors in interpretation of vascular support lines.

We evaluated the effect of CDH on umbilical catheter position and evaluated the accuracy at which radiologists describe the position on chest radiographs.

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Materials and methods

Hospital institutional review board approval was granted for this study. We conducted a retrospective review of all chest radiographs performed in the first 7 days after birth in infants with congenital diaphragmatic hernia born at our large urban tertiary care pediatric hospital during a 5-year period from Jan. 1, 2009, to Dec. 31, 2013.

Using a department database, we electronically identified and reviewed 406 chest radiographs for the following data: presence of umbilical venous catheter (UVC), location of catheter tip (cavoatrial junction, intracardiac, intrahepatic or umbilical vein) and location of CDH (right or left).

Each case was then reviewed individually and the report interpretation of the UVC tip location was characterized as adequate or inadequate. For interpretations deemed inadequate, further characterization into the following categories was made: incorrect (the wrong location of the UVC tip was reported), no mention (the location of the catheter tip was in a suboptimal location but not mentioned), and not specified (the precise location of the catheter tip was not clearly stated in the report when the catheter tip was in a suboptimal location). The criteria used to assess the position of the UVC was based solely on a radiographic approach in which a UVC seen below the diaphragm and heading away from the heart was deemed to be in the liver and an UVC overlying the left chest was deemed to be in the contralateral chest.

Results

Of the 76 infants with CDH, the hernia was on the left side in 69 (90.8%) and right side in 7 (9.2%). No UVC was placed in 16 of the 76 infants. A total of 406 chest radiographs and reports obtained on the remaining 60 infants with CDH (56 on the left, 4 on the right) were reviewed by a board certified pediatric radiologist with 29 years of experience.

The UVC tip was determined to be in a suboptimal anatomical location in 58.4% of the chest radiographs (237/406) and 51.7% of the infants (31/60) (Table 1).

Table 1 Suboptimal anatomical location and frequency of umbilical venous catheter (UVC) placement

UVC location	n (infants)	% (total n=60)
Umbilical vein	5	8.3
Intrahepatic	10	16.7
Contralateral chest	16	26.7

A total of 31/60 infants had suboptimal placement

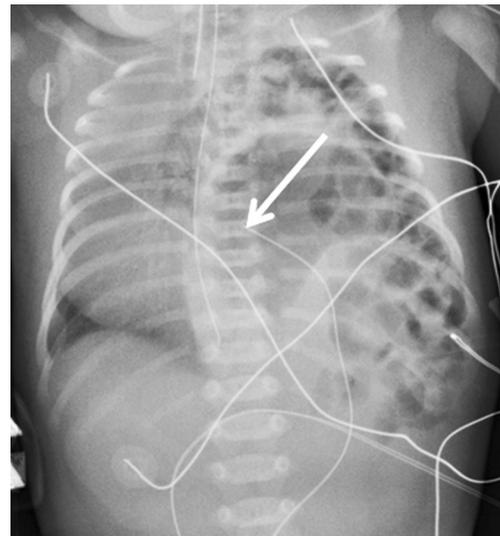


Fig. 1 Anteroposterior radiograph of the chest and abdomen in a newborn girl shows placement of a UVC (umbilical venous catheter) in the contralateral chest (arrow)

The contralateral chest was the most common location for an atypically positioned UVC (Fig. 1), accounting for 26.7% of the infants with CDH, followed by an abdominal intrahepatic location of the catheter tip in 16.7% of patients (Fig. 2).

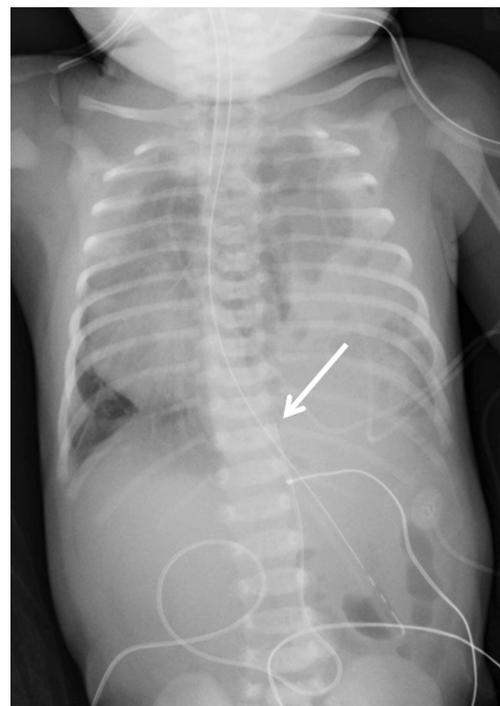


Fig. 2 Anteroposterior radiograph of the chest and abdomen in a newborn girl shows intrahepatic placement of the UVC (umbilical venous catheter) (arrow)

Table 2 Characterization of report interpretation of umbilical venous catheter location and frequency of diagnostic error

Interpretation	<i>n</i> (chest radiographs)	% (total <i>n</i> =406)
Correct	286	70.4
Incorrect	37	9.1
No mention	35	8.6
Not specified	48	11.8

Thirty percent (120/406) were found to be inadequate

Interpretations

When the report interpretations of the location of the UVC tip were reviewed, 30% (120/406) were found to be inadequate (Table 2). Forty-eight reports (48/406, 11.8%) did not specify when the catheter tip was in a suboptimal location (Figs. 3 and 4). In 37 cases (9.1%),

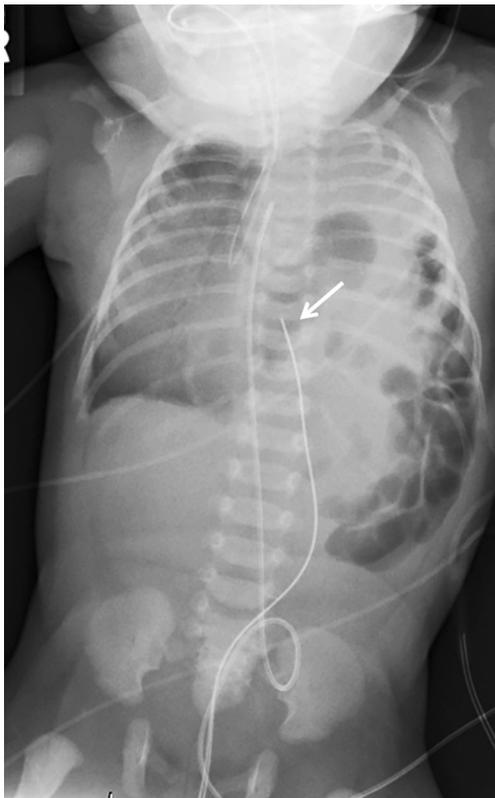


Fig. 3 Anteroposterior radiograph of the chest and abdomen in a newborn girl. The radiology report excerpt was as follows: “A UVC catheter with tip projecting over the right heart border, and UAC catheter with tip projecting over T9 vertebral body are unchanged. An umbilical arterial catheter terminates at the level of T6.” The report did not specify the precise location of the UVC (umbilical venous catheter), which is suboptimal in the contralateral chest (*arrow*). In addition, the report excerpt is confusing, with mention of two umbilical arterial catheters (UACs), when in fact only one is present, terminating at the level of T5

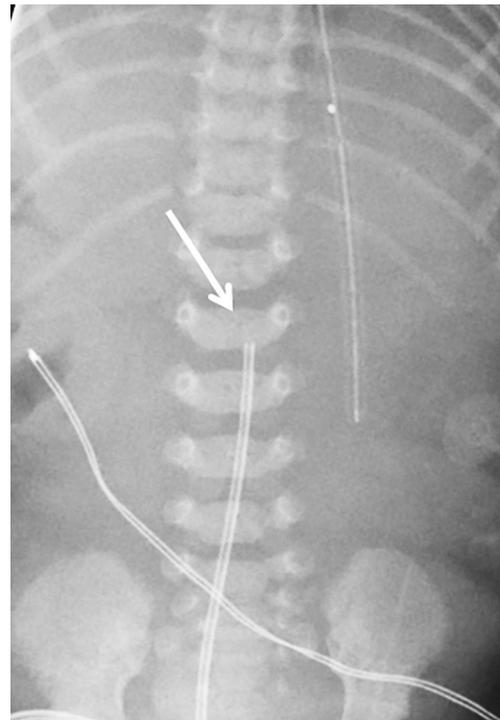


Fig. 4 Anteroposterior radiograph of the chest and abdomen in a newborn boy. The radiology report excerpt was as follows: “Nasogastric tube, UVC and left thoracostomy tube are unchanged and in satisfactory position.” The report did not specify the location of the UVC, which is suboptimal and likely in the umbilical vein (*arrow*)

the location of the UVC tip was incorrectly identified (Figs. 5, 6, 7, and 8), and 35 reports (8.6%) made no mention of the suboptimal location of the catheter tip (Fig. 9). None of the inadequate reports resulted in harm to the infants.

Discussion

Infants with Bochdalek hernias often present with respiratory distress requiring supportive care in the NICU and require the placement of umbilical catheters to facilitate treatment. When the liver herniates with congenital diaphragmatic hernia, the portal veins shift cranially during embryological development to increase blood flow to the left lateral lobe of the herniated liver [1–4]. As a result, there is an increased risk of malpositioning of a UVC during placement with cannulation of the shifted intrahepatic vessels. Intrahepatic UVC placement can be associated with significant morbidity and mortality from hepatic laceration, extravasation and abscess [2, 5–7]. Other complications that have

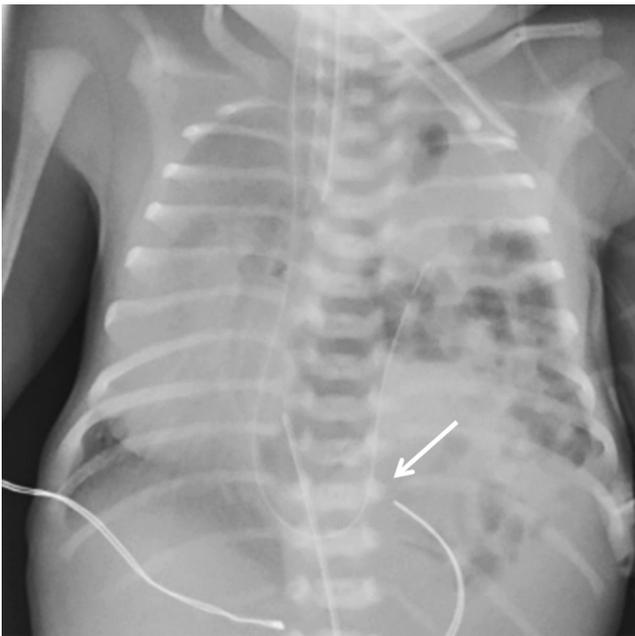


Fig. 5 Anteroposterior radiograph of the chest in a newborn boy. The radiology report excerpt was as follows: “An UVC is seen with tip terminating within the IVC. Two new catheters project over the right and left upper quadrants.” The report incorrectly identified the suboptimal intrahepatic location of the UVC (umbilical venous catheter) as in the IVC (inferior vena cava) (*arrow*)

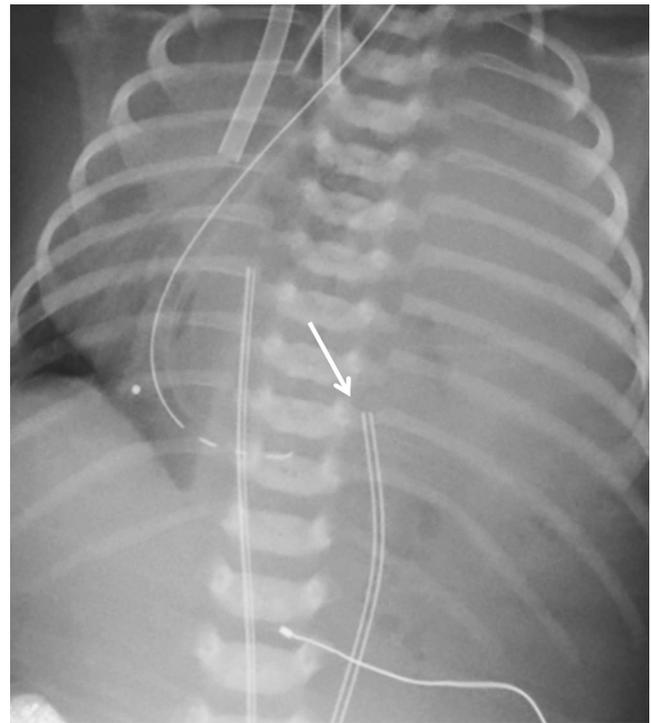


Fig. 7 Anteroposterior radiograph of the chest in a newborn boy. The radiology report excerpt was as follows: “The presumed UVC terminates in the right atrium.” The UVC (umbilical venous catheter) (*arrow*) is incorrectly identified as the umbilical arterial catheter. The UVC is actually to the left of the umbilical arterial catheter and is suboptimal in location, overlying the contralateral chest

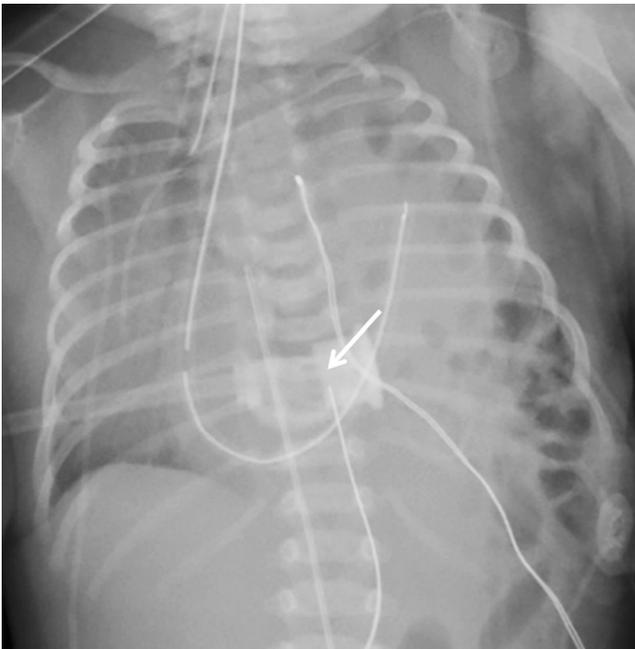


Fig. 6 Anteroposterior radiograph of the chest in a newborn girl. The radiology report excerpt was as follows: “The endotracheal tube terminates about 1–2 cm above the carina. Left-sided PICC line terminates in the distal superior vena cava. UA catheter now terminates at T6-T7. UV catheter terminates in the right atrium.” The UVC (umbilical venous catheter) (*arrow*) terminating at the level of T10 was misinterpreted as being in the right atrium rather than in a suboptimal intrahepatic location. *PICC* peripherally inserted central catheter, *UA* umbilical arterial, *UV* umbilical venous

been reported with malpositioned UVCs include cardiac tamponade, right atrial perforation, pericardial effusion, hemothorax, extravasation of total parenteral nutrition fluid resulting in large pleural and peritoneal effusions from vessel perforation [8–10], and portal vein thrombosis [11]. Prompt and accurate radiographic diagnosis of catheter malposition is imperative for appropriate patient management. We have identified one catheter-related complication caused by UVC malposition in this series. The infant had a left-side CDH containing herniated liver and presented with abdominal distension after umbilical venous and umbilical arterial catheter placement. On sonography the UVC was seen positioned within the umbilical vein with extravasation of administered fluids into the surrounding liver parenchyma (Fig. 10).

Knowledge of the anatomical variation that occurs with Bochdalek hernias can greatly aid in the interpretation of UVC placement. As the left hepatic vein shifts cranially through the herniation, the ductus venosus courses laterally to join the umbilical vein that has been displaced by mediastinal shift to the right. In this

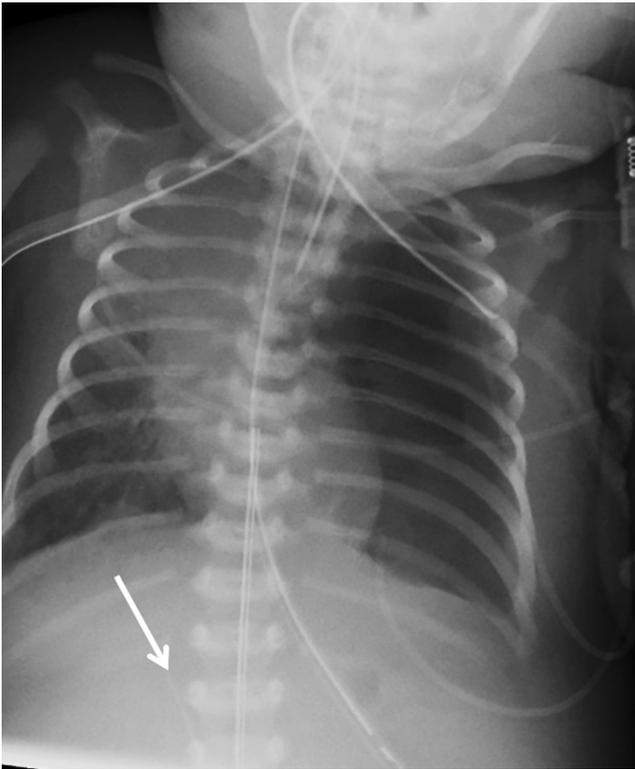


Fig. 8 Anteroposterior radiograph of the chest in a 5-day-old girl. The radiology report excerpt was as follows: “An umbilical arterial catheter terminates at T8. An UVC seen within the intrahepatic IVC.” The lower-extremity PICC (*arrow*) was incorrectly identified as the UVC (umbilical venous catheter). *IVC* inferior vena cava, *PICC* peripherally inserted central catheter

situation, the path of least resistance for the UVC is to enter the left portal vein rather than the ductus venosus (Fig. 11). The ideal location of a UVC is at the inferior cavoatrial junction, which would not be in its expected location in a child with left-side CDH but rather shifted to the right (Fig. 12). A UVC overlying the left chest or midline should raise suspicion of intrahepatic malposition.

Sakurai et al. [4] described typical patterns of nasogastric, endotracheal and endovascular catheter displacements in patients with CDH. Although the umbilical artery catheter might also be displaced in infants with CDH, the displacement is relatively small because of its posterior position. This study is unique in directly analyzing the interpretations of malpositioned UVCs and classifying the diagnostic error.

Altered patient anatomy, poor or limited image quality, inconspicuous lines and incomplete review of prior studies are high-risk situations during which catheter and tube-related diagnostic errors are thought to be more likely [12]. Infants with CDH share several of

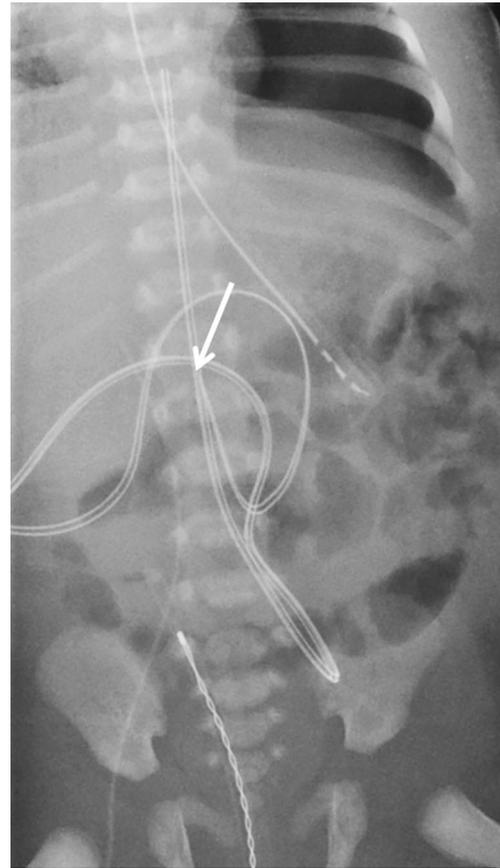


Fig. 9 Anteroposterior radiograph of the abdomen in a 4-day-old girl. The radiology report excerpt was as follows: “There is a right femoral line with the tip in the IVC at the level of L1. The patient has an umbilical artery line with the tip at the level of T8. Feeding tube is in the stomach. Bowel gas and is normal (*sic*). There is a left pneumothorax, not completely imaged.” There was no mention of the suboptimal location of the UVC (umbilical venous catheter) in the radiology report, although it is seen overlying the umbilical vein (*arrow*). *IVC* inferior vena cava

these features, including altered anatomical relationships, imaging with portable radiographs of limited quality, often performed portably under urgent situations, and umbilical catheters that may be difficult to visualize in their entirety on well-coned radiographs.

Conclusion

The location of a UVC in an infant with Bochdalek hernia can pose a diagnostic challenge because of the altered anatomy and change in the expected course of the catheter. Familiarity with the altered anatomy and patterns of catheter malposition can be useful in decreasing diagnostic errors in these high-risk children.

Fig. 10 Anteroposterior radiograph of the chest and abdomen in a newborn girl with a left-side congenital diaphragmatic hernia containing liver. The girl presented with abdominal distension after umbilical venous and umbilical arterial catheter placement. **a** The UVC (umbilical venous catheter) is malpositioned, projecting over the left upper quadrant of the abdomen and likely intrahepatic in location (*arrow*). **b** Sagittal color Doppler image of the liver shows the UVC tip at the level of the umbilical vein (*arrow*) just proximal to the confluence with the left portal vein (*LPV*). **c** Sagittal gray-scale image at the level of the ductus venosus shows abnormal fluid surrounding the catheter tip (*arrows*) and (**d**) extending into the gallbladder (*Gb*) fossa (*arrows*). Findings resulted from an extravasation of administered fluids from the malpositioned UVC

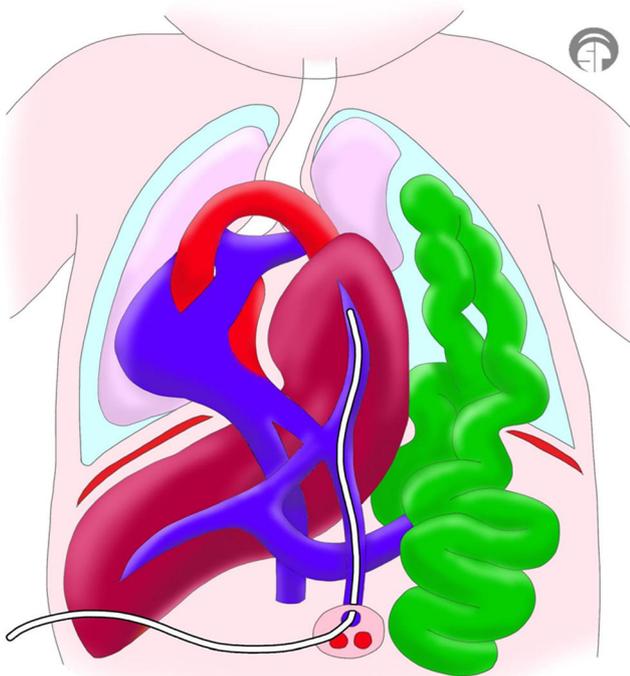
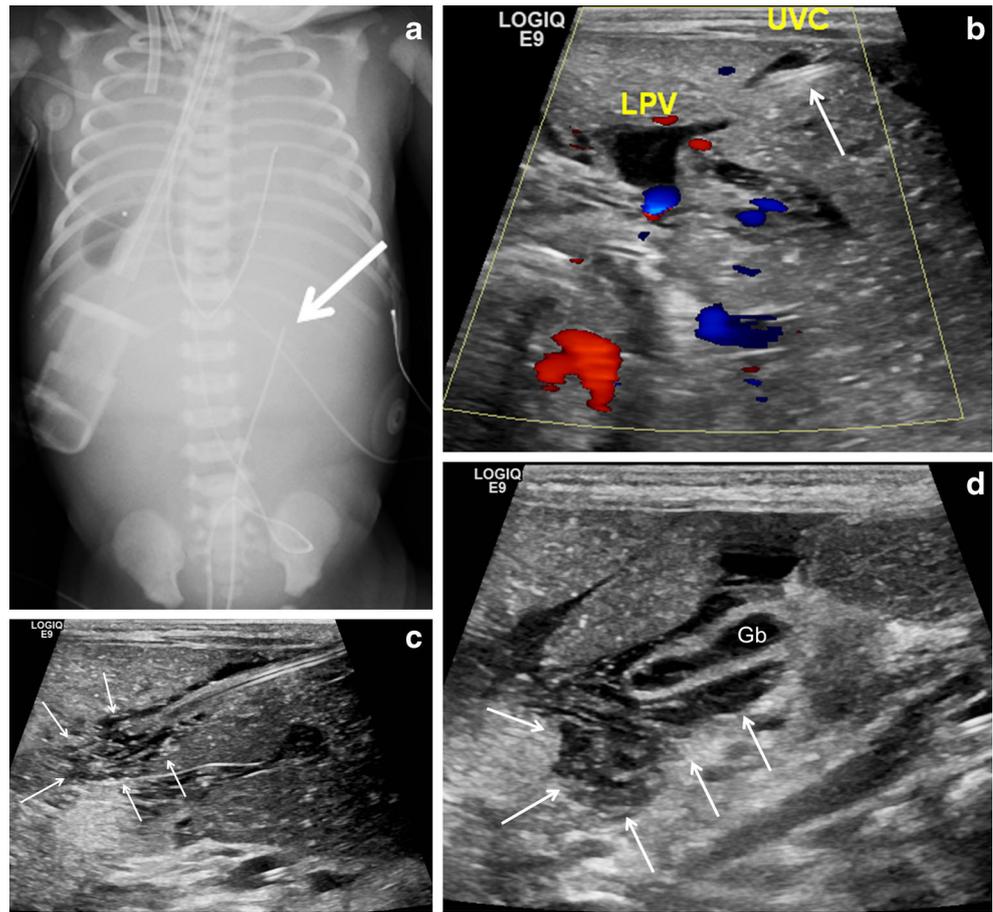


Fig. 11 Illustration shows the altered anatomy that can occur in a left-side congenital diaphragmatic hernia. The shift of hepatic vasculature cranially through the left-side defect can promote inadvertent catheterization of the left portal vein, as shown

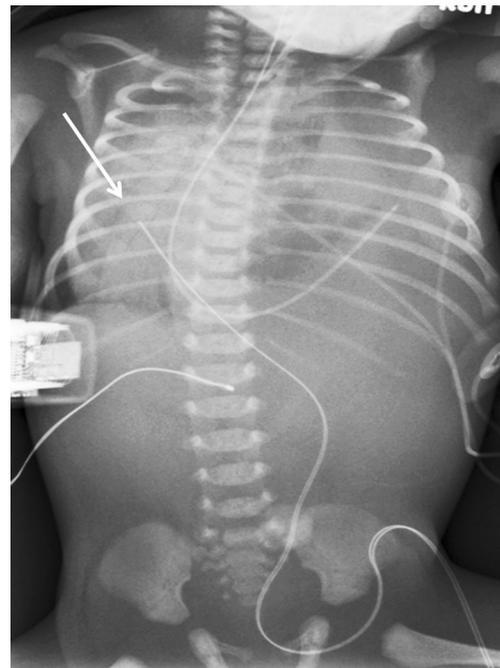


Fig. 12 Anteroposterior radiograph of the chest and abdomen in a newborn boy shows the correct placement of a UVC (umbilical venous catheter) (*arrow*), which courses toward the right in this boy with left congenital diaphragmatic hernia and is overlying the expected region of the rightward deviated inferior cavoatrial junction

Conflicts of interest None

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