SWISS SOCIETY OF NEONATOLOGY

Umbilical venous catheter-associated pleural effusions

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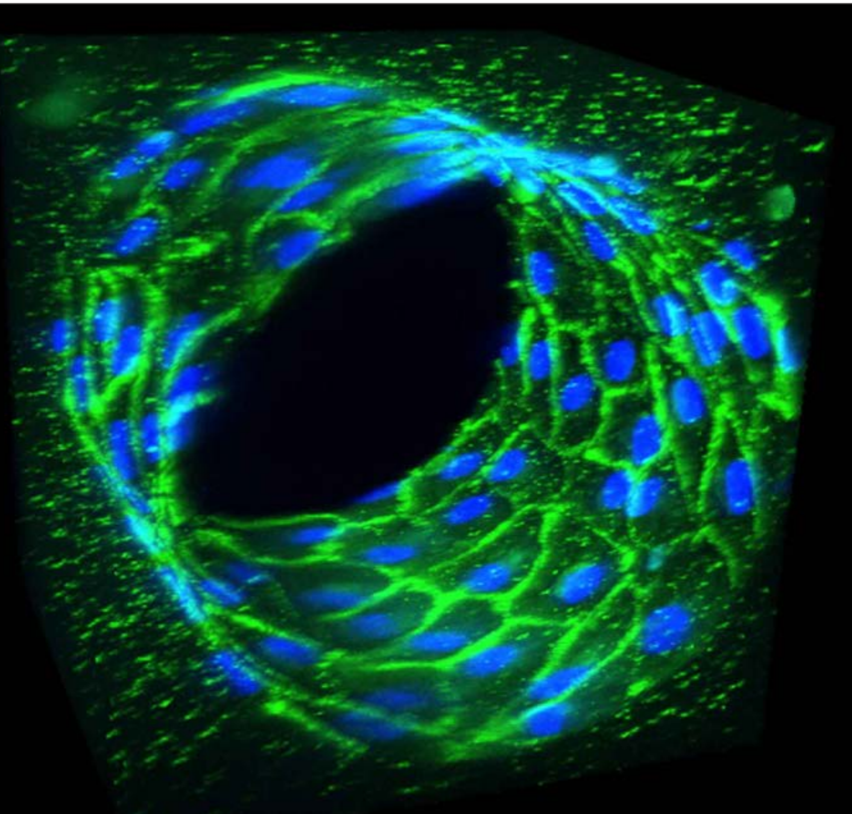

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Title figure:
Human umbilical vein endothelial cells (HUVECs) stained for PECAM-1 (green) and nuclei (blue).
Source: Institute for NanoBioTechnology, Johns Hopkins University (www.inbt.jhu.edu)

INTRODUCTION

The use of umbilical venous catheters (UVC) in neonatology is common practice but not without risks. We report the case of an unusual and potentially lethal complication of a centrally positioned UVC. We will review the literature for this specific complication and discuss risks of UVC placement in general, as well as the best way to verify catheter position to minimize risks.

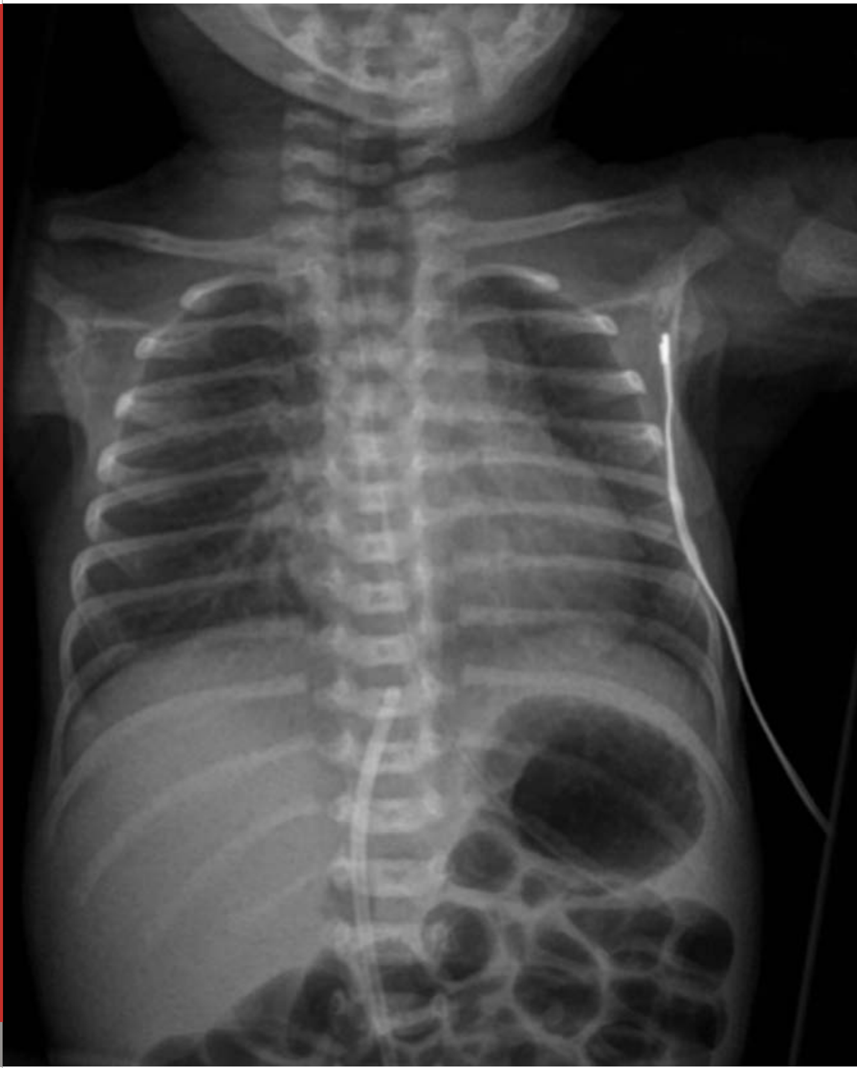


Fig. 1

X-ray obtained in the delivery ward: UVC tip at T9 level.

Fig. 2

Babygram following intubation at 48 hours of life: there are bilateral pleural effusions; the tip of the UVC projects over T10 suggestive of a ductus venosus placement.

This female infant was born at 30 4/7 weeks to a 35-year-old G3/P1 by Cesarean section due to pre-eclampsia, intrauterine growth restriction (IUGR) and abnormal umbilical Doppler waveforms. Pregnancy had been unremarkable up to this point. Umbilical cord pH were 7.26 (arterial) and 7.30 (venous), and Apgar scores 4, 7, and 8 at 1, 5 and 10 minutes, respectively. The infant had a birth weight of 1070 g (P18), a length of 38 cm (P34) and a head circumference of 27 cm (P30).

Due to mild respiratory distress, nasal CPAP was initiated with room air in the delivery ward and a UVC was inserted with good blood return. On X-ray, the catheter tip projected over T9 and was thus considered being in a central position (Fig. 1). The postnatal course was uneventful until 48 hours of life, when the baby's oxygen requirement rapidly increased. This sudden respiratory deterioration required intubation and mechanical ventilation. On chest X-ray, bilateral pleural effusions were noted (Fig. 2) and subsequently drained with chest tubes.

The pleural fluid revealed a glucose concentration of 44 mmol/l, a protein concentration of < 0.2 g/l, a lactate dehydrogenase of 46 U/l, triglycerides of 1.4 mmol/l, a white cell count of 35/mm^3 with macrophage predominance (77 %) and a red blood cell count of 200/mm^3. The bacterial culture remained sterile.

The high sugar content of the pleural fluid was compatible with an infusothorax (an extravasation of parenteral nutrition fluid into the pleural cavity). On a lateral view, the tip of the UVC projected slightly above the diaphragm (Fig. 3). The catheter was therefore suspected to be the cause of the pleural effusions and removed at 72 hours of life. A peripherally inserted central catheter (PICC) was inserted to continue parenteral nutrition.

The girl was extubated shortly thereafter on the 3rd day of life and the pleural drains were removed one day later. There was no recurrence of the pleural effusions or respiratory distress, and CPAP was stopped on the seventh day of life. The rest of the hospital stay was uneventful and patient was discharged at a corrected gestational age of 39 weeks.

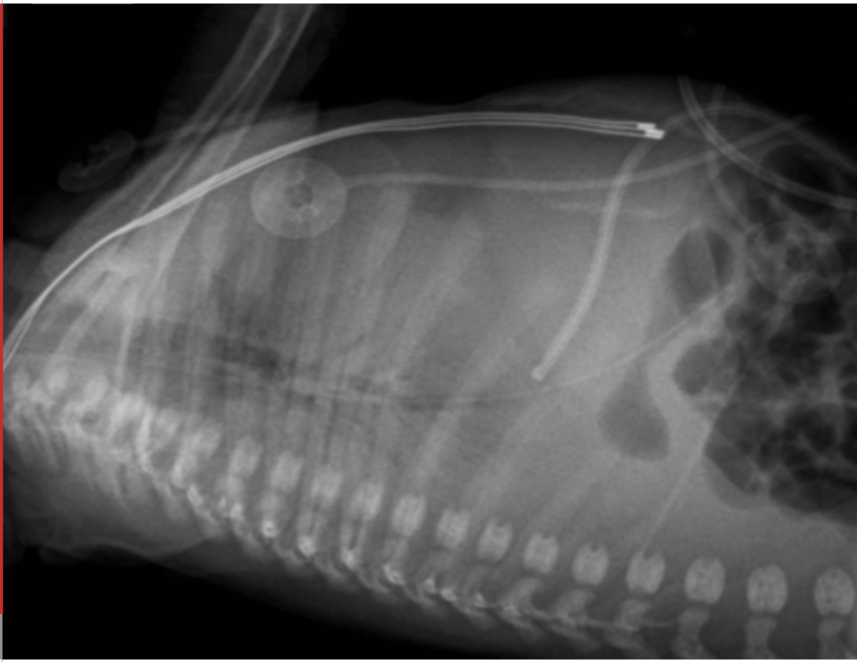


Fig. 3

Chest X-ray lateral view using a horizontal beam technique: the UVC runs almost perpendicular to the abdominal surface from front to back; note that the tip is slightly above the diaphragm where it probably perforated.

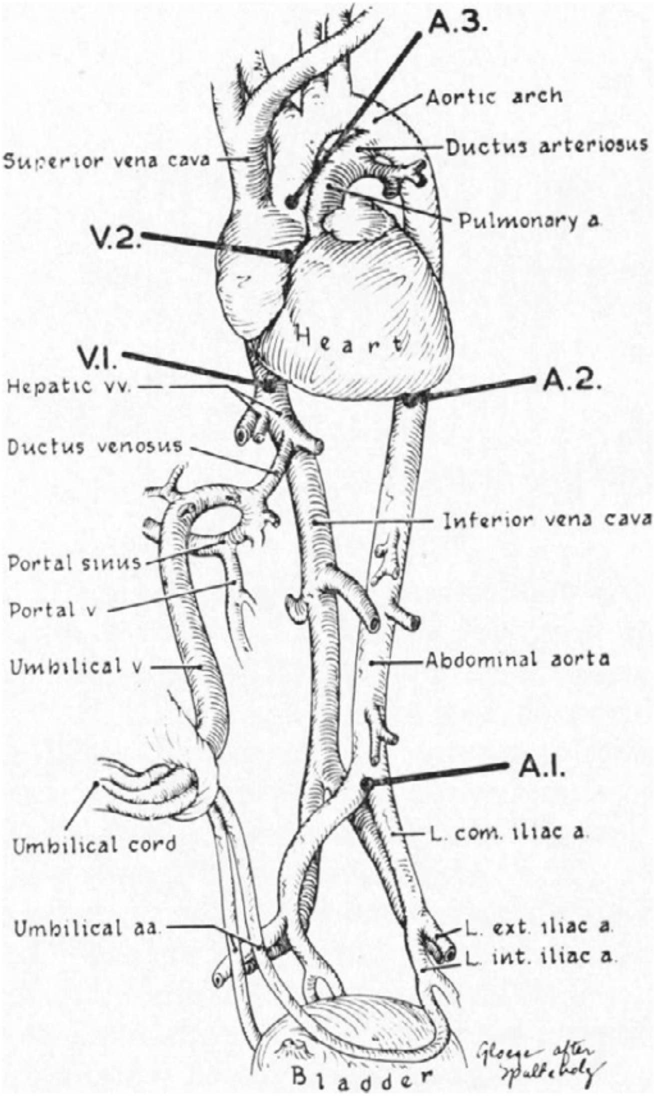


Fig. 4

Overview of the perinatal anatomy of the umbilical confluent (from Dunn PM. Localization of the umbilical catheter by post-mortem measurement. Arch Dis Child 1966;41:69 – 75) (26).

DISCUSSION

The use of UVCs is common in both term and preterm neonates as it provides rapid central venous access during the first days of life, essential for the delivery of various solutions and drugs during stabilization in the delivery room and ongoing care in the intensive care units.

In the presented case, the high glucose concentration and the presence of triglycerides in the aspirated pleural fluid, as well as the fact that there was no recurrence of the pleural effusion after UVC removal, support a causal relationship between the UVC and the pleural effusions. The mechanisms considered were vessel wall or myocardial erosion due to the hyperosmolarity of the parenteral nutrition solution. Direct perforation by the catheter during insertion itself seems unlikely since blood could be aspirated from the UVC on the first day of life. On the other hand, catheters have been described to migrate over time and, interestingly, blood could no longer be aspirated after 24 hours of life.

The umbilical vein has a specific trajectory (Fig. 4, 5), moving very superficially in a cranial direction and slightly to the right, then along the lower surface of the liver to join the left branch of the portal vein. The venous canal of Arantius (or ductus venosus) directly leads to the inferior vena cava, thus (partially) bypassing the hepatic circulation. During fetal life, well-oxygenated blood returning from the placenta is thus directed to the right atrium and, after shunting from right to left through the foramen ovale, to the coronary and cerebral circulation. The umbilical vein collapses after birth, but remains accessible in the first days of life.

UVC complications may arise from faulty use of a correctly placed catheter (e.g., emboli or catheter-related infections) or from a faulty position despite its correct use. Adverse events are more common when UVCs are mal-positioned (1). There are two acceptable UVC positions: 1) sub-hepatic position for short-term use during resuscitation and stabilization, and 2) central position in the inferior vena cava for longer-term use. Table 1 summarizes the main UVC complications observed with different (apparent) catheter tip positions.

Table 1. UVC tip position and associated complications.

Sub-hepatic	Liver laceration (2,3)
	Cavernoma of the portal vein (4,5)
	Ascites / intra-peritoneal extravasation (6 – 8)
	Thrombosis of hepatic vessels / portal vein thrombosis (5,9)
	Hepatic abscess (10)
	Hepatic hematoma (11)
Central	Pleural effusion (12 – 14)
	Pericardial effusion / cardiac tamponade (15 – 17)
	Thrombi (intracardiac, inferior vena cava) (1,18)
	Dysrhythmias (19 – 21)
	Endocarditis (22)
Both	Nosocomial infection (23,24)
	Hemorrhage
	Air embolism

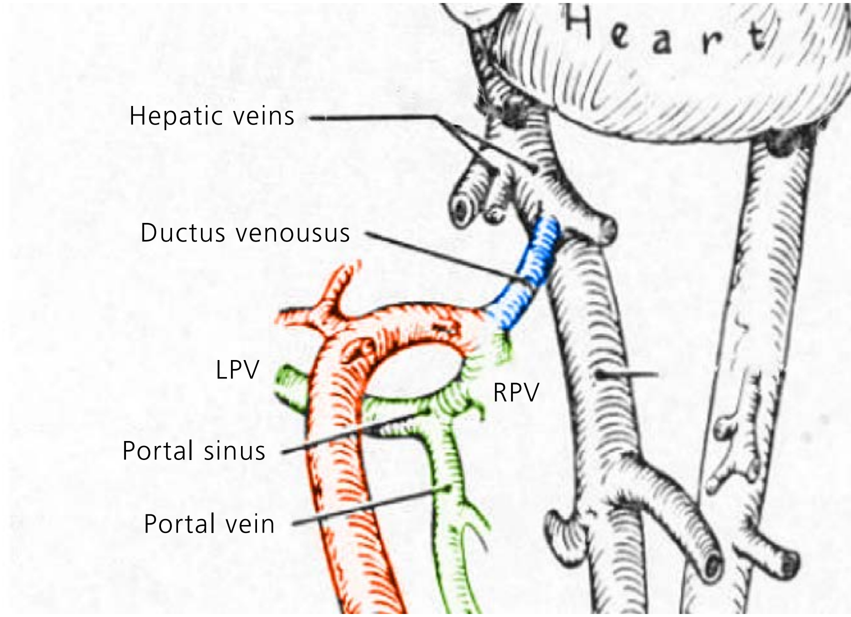
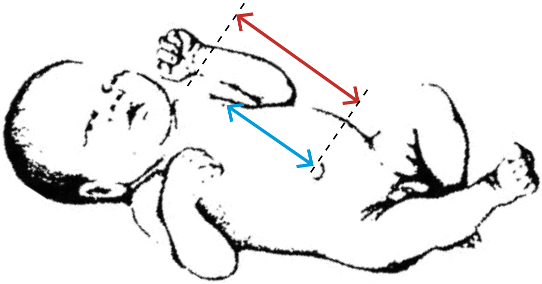


Fig. 5

Detailed view of the perinatal anatomy of the umbilical confluent: red: umbilical vein; green: portal vein system (LPV: left portal vein; RPV: right portal vein); blue: ductus venosus Arantii (from Dunn PM. Localization of the umbilical catheter by post-mortem measurement. Arch Dis Child 1966;41:69 – 75) (26).



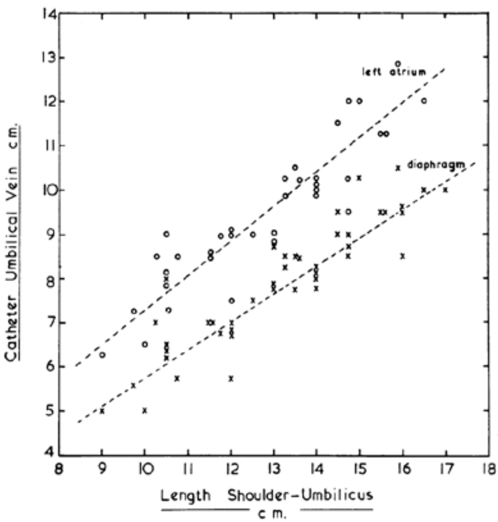
Gupta method (blue arrow) (27)

UVC insertion depth (cm) = umbilicus to nipple distance -1

Shukla method (27)

$$\text{UVC insertion depth (cm)} = \frac{3 \times \text{birth weight (kg)} + 9}{2} + 1$$

Dunn method (red arrow) (26)



Different methods to determine UVC insertion depth.

Fig. 6

UVC positioning is based on anatomical references. Different formulas have been proposed to estimate catheter insertion depth to achieve a particular position. The ideal central position of the UVC tip is either at the level of the inferior vena cava (IVC) and right atrial junction, or in the thoracic IVC (25). Two methods are commonly used to decide on catheter insertion depth. The Dunn method (26) uses a nomogram based on the distance between the umbilicus and the shoulder, and the Shukla method (27) uses a regression equation based on birth weight. More recently, Gupta et al. (28) described a method based on distance between the umbilicus and the nipple leading to correct insertion depths in 94% of UVC placements (Fig. 6).

After catheter placement, blood return should be confirmed clinically and correct position should be verified by X-ray. An AP view of the trunk (known as a babygram) is most frequently used for this purpose. The desired tip location is at the level of the 8th or 9th thoracic vertebral bodies, which usually corresponds to a position at the IVC to right atrial junction. However, sensitivity, specificity and accuracy of this method are relatively low with reported values between 50% and 75% (1, 29, 30). Little or no data is available on the performance of lateral X-ray views.

Some studies have suggested that ultrasound, possibly with saline «contrast» injection to document the distal catheter tip location, should be the gold standard to confirm correct UVC placement (31–33). In one study (33), 27% of all UVCs placed required repositioning when ultrasound examination revealed sub-optimal tip position despite presumably optimal position on chest X-ray. While neonatologists can perform such ultrasound examinations, it does require appropriate training. The reported accuracy with an area under the receiver operating character curve was relatively high with a value of 0.81. However, despite its theoretical advantages (avoidance of radiation, bedside availability), the technique is operator-dependent and thus far has not been widely adopted. In addition, the safety of micro-bubble injections used to generate saline «contrast» remains unclear, and techniques based solely on ultrasound may have a lower accuracy. Finally, it remains unclear to what extent correctly fixed catheters can move simply with routine care or varying degrees of abdominal distension, particularly in low birth weight infants.

CONCLUSION

In summary, UVC position should be verified both clinically and radiologically prior to its clinical use. Progressive or sudden clinical deterioration of a neonate who has a UVC in place should prompt rapid evaluation for possible UVC complications. X-ray or echocardiography can rapidly rule out pleural effusions or cardiac tamponade. While ultrasound examination may be superior to chest radiography for UVC tip position, its practicality and risks have not been evaluated. Future clinical research should therefore assess practicality, sensitivity, specificity and accuracy of various methods for verification of proper catheter tip position in routine clinical settings; it may also include the value of an additional lateral X-ray view.

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