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Abstract

A rare complication of umbilical venous catheter (UVC) insertion is the extravasation of the infusate into the peritoneal cavity. We report three cases of abdominal extravasation of parenteral nutrition (PN) fluid via UVCs. Two of these cases presented as 'acute abdomen' which were assumed to be necrotising enterocolitis (NEC) clinically, however, during post-mortem PN ascites and liver necrosis were found. A further case is described in an infant with congenital diaphragmatic hernia. Whilst we were unable to ascertain direct vessel perforation by the catheter in any of these cases, based on pathological and histological examination the proposed mechanism of PN fluid extravasation is leakage through microinjuries of liver vessel walls and necrotic parenchyma. PN extravasation should be considered as a differential diagnosis of acute abdomen when PN is infused via an UVC presumably as PN may have a direct irritant effect on the peritoneum.

Introduction

Umbilical venous catheters (UVCs) are commonly used in neonatal practice to establish central venous access. Parenteral nutrition (PN) as well as medication such as inotropes are frequently administered via the UVC. A rare complication of UVC insertion is the extravasation of the infusate into the peritoneal cavity.[1-4] We report three cases of abdominal extravasation of PN fluid via UVCs. Two of these cases presented as 'acute abdomen' which were assumed to be necrotising enterocolitis (NEC) clinically, however, during post-mortem PN ascites and liver necrosis were found. A further case is described in an infant with congenital diaphragmatic hernia. Whilst we were unable to ascertain direct vessel perforation by the catheter in any of these cases, based on pathological and histological examination the proposed mechanism of PN fluid extravasation is leakage through microinjuries of liver vessel walls and necrotic parenchyma.

Case reports

Case 1

Clinical background: A double-lumen UVC was inserted as part of the care of a neonate of 24 weeks gestation. Abdominal radiographs demonstrated that the UVC position was initially aberrant with the tip seen in the liver, presumably positioned in one of the hepatic vessels. Therefore, the catheter was pulled back to T11-12 position, and the tip was confirmed to be on the right side of the T12 vertebra on a repeat radiograph. On day 4 of life, the abdomen became distended with increasing ventilatory requirements, anaemia and a profound metabolic acidosis. There was a reduced intestinal gas pattern and a progressively featureless abdomen on subsequent abdominal radiographs. The baby was screened for infection, minimal enteral feeds were stopped, and treated with antibiotics for presumed NEC. The baby continued to deteriorate, in spite of full intensive care, and died 24 hours later (Table 1).

Post-mortem and histology: At post-mortem, the abdomen was grossly distended. There was 44 ml of milky, yellow fluid in the peritoneal cavity, strongly suggestive of PN ascites. There was no evidence of NEC. The UVC was found within the portal vein, prior to entering the liver and before the anastomosis with the ductus venosus. Injection study (mixture of Agar gel and tissue dye) of the umbilical vein was performed to follow the flow of PN fluid and to identify the site of extravasation, which primarily affected the left lobe of the liver. Dye coloured the superior mesenteric vein, peritoneal branches, splenic vein and left and right gastroepiploic veins and appeared to spread through the injured liver parenchyma (Fig. 1). Liver histology demonstrated micro injury and thrombosis of portal vein branches associated with focal liver necrosis (Fig. 2).

Biochemistry: the lipaemic peritoneal fluid consisted of cholesterol < 0.5 mmol/L; triglyceride 17.2 mmol/L; glucose 47.2 mmol/L and had a high phosphate content which are consistent with PN.

Case 2

Clinical background: A double-lumen UVC was inserted as part of the care of a 28 week gestation twin with a history of twin to twin transfusion, this twin being the donor. The position of UVC was confirmed with abdominal radiograph and its tip was found to be on the right side of the T12 vertebra. On day 4 of life, the baby's condition deteriorated with increasing ventilatory requirements, and a distended and tender abdomen, which was attributed to NEC. The baby was screened for infection, treated with antibiotics and minimal enteral feeds were stopped, for presumed NEC. The baby continued to deteriorate, and died 24 hours later (Table 1).

Post-mortem and histology: At post-mortem examination, there was 43 ml of homogenous, yellowish, milky fluid in the peritoneal cavity, strongly suggestive of PN ascites. There was no evidence of NEC. There was non-occluding portal vein thrombosis possibly secondary to the UVC, and no evidence of direct vessel perforation. On histology, there were foci of subcapsular liver necrosis.

Biochemistry: Analysis of the fluids demonstrated high phosphate, glucose, calcium and magnesium concentrations consistent with PN.

Case 3

Clinical background: A double-lumen UVC was sited in a term neonate with an antenatal diagnosis of left sided congenital diaphragmatic hernia (CDH). The tip of the UVC was confirmed to be on the left side of the T12 vertebra with abdominal radiographs. However, the catheter was also noted to take an aberrant bend positioned in the left side of the abdomen. On day 10, the baby became acutely unwell with sudden oxygen desaturation and asymmetry of chest wall movement. Following chest radiograph, which demonstrated pleural effusion, needle thoracocentesis was performed. Five ml of milky fluid was aspirated. A chest drain was inserted and drained a further 100 ml of milky

fluid. Ultrasound demonstrated residual left sided pleural effusion and ascites. Care was re-orientated due to worsening of pulmonary hypertension (Table 1).

Post-mortem and histology: At post-mortem, pleural cavities and peritoneal cavity were found to be connected via a left sided diaphragmatic defect. The cavities contained 180 ml of yellowish, milky fluid. Following injection of dye into the umbilical and portal vein system, there was no evidence of direct vessel perforation. There was discolouration and parenchymal abnormalities of an area at least of 1.5 cm diameter within the left lobe of liver. Histology confirmed liver necrosis. In addition there was thrombosis of the left branches of portal vein with injury of the vessel wall. Subcapsular liver necrosis was associated with the portal vein thrombosis. Injection study demonstrated extravasation of the tissue dye around the injured portal vein wall. These findings suggested that there was extravasation of PN fluid, through the injured vessel wall and hence through the wall of hepatic sinusoids and injured liver capsule.

Biochemistry: The fluid glucose level was 79.3 mmol/L consistent with PN.

Discussion

The post-mortem findings from the above three cases demonstrated no evidence of direct perforation of the vessels by the tip of the umbilical catheter. Liver necrosis and portal vein thrombosis were demonstrated in all cases. Such complications have previously been described in the literature.[5,6]

Based on histological findings, we suggest that the UVC tip in the three cases may have been wedged within the ductus venosus and abut the portal vein causing microinjury of the vessel wall. This complication may be more common in case of a low UVC position with the catheter tip at the level of T12 rather than at the level of the diaphragm, around T7. In Case 1, the catheter needed repositioning to a low position due to an initially aberrant position on the radiograph. The

mechanical risk may have increased with readjustment of the catheter. Mechanical microinjury and infusion of hyperosmolar PN fluid and inotropes could have led to portal phlebothrombosis and consequent liver necrosis. Leakage of PN fluid appeared to occur via necrotic foci, injured sinusoids and small subcapsular veins.

Previous case reports have proposed that one of the risk factors for hepatic necrosis relates to hypertonicity of the infusate.[7] PN extravasation in Case 3 could have been the result of a malpositioned UVC. The risk of an UVC cannulating the intrahepatic vessels is higher with co-existing congenital malformation which distorts the anatomy.[8] In this case the left lobe of the liver had herniated into the thoracic cavity resulting in aberrant positioning of the umbilical veins, ductus venosus and hepatic vasculature. This limited radiographic interpretation of UVC position.

A further adverse effect of PN ascites is the reduction of the intrapleural space by elevating the diaphragm, and therefore compromising the expansion of the lungs and effective ventilation.[9] This could have contributed to the onset of clinical deterioration in the reported cases. In the presence of abdominal distension and progressively featureless abdominal radiographs, an abdominal ultrasound scan may be helpful to demonstrate the presence of ascetic fluid. Should this be present in a considerable amount, surgical drainage or laparoscopy may help to reverse clinical symptoms.

In summary, we describe three cases of PN ascites whereby extravasation occurred via the vessel wall of the portal branches and the hepatic capsule. In two of the cases, the clinical presentation was consistent with NEC, which is the most common cause of an acutely deteriorating preterm baby with a distended abdomen, so-called acute abdomen. We hypothesize that PN and certain types of medication, such as inotropes given via an UVC may have a direct irritant effect on the vessel wall and peritoneum. Extravasation of inotropes in particular may cause ischemia and tissue necrosis. Therefore, fluid extravasation should be considered as a differential diagnosis of acute abdomen, in addition to NEC, when PN or medication is infused via an UVC.

Declaration of Conflicting Interests

The Authors declare that there is no conflict of interest.

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References

1. Coley BD, Seguin J, Cordero L, Hogan MJ, Rosenberg E, Reber K. Neonatal total parenteral nutrition ascites from liver erosion by umbilical vein catheters. Pediatr Radiol. 1998; 28: 923-7.

2. Oztan MO, Ilhan O, Abay E, Koyluoglu G. An umbilical venous catheter complication presented as acute abdomen: case report. Arch Argent Pediatr. 2016; 114: e429.

3. Adesanya O, Naqvi M. Term neonate with liver laceration, obstructive uropathy, and ascites secondary to extravasation of total parenteral nutrition: a complication of malpositioned umbilical venous catheter. Glob Pediatr Health. 2016; 3: 2333794X16670494.

4. Pegu S, Murthy P. Ascites with hepatic extravasation of total parenteral nutrition (TPN) secondary to umbilical venous catheter (UVC) malposition in an extremely preterm baby. BMJ Case Rep. 2018; 2018. pii: bcr-2018-226377.

5. Schmidt B, Zipursky A. Thrombotic disease in newborn infants. Clin Perinatol 1984; 11: 461-88.

6. Kim JH, Lee YS, Kim SH, Lee SK, Lim MK, Kim HS. Does umbilical vein catheterization lead to portal venous thrombosis? Prospective US evaluation in 100 neonates. Radiology 2001; 219: 645-50.

7. Williams S, Chan AK. Neonatal portal vein thrombosis: diagnosis and management. Semin Fetal Neonatal Med 2011; 16: 329-39.

8. Raisanen P, Cassel I, Martin G, Graziano K. Umbilical venous catheter complication in an infant with left-sided congenital diaphragmatic hernia: extravasation owing to hepatic vein catheterization. J Pediatr Surg 2010; 45: e33-5.

9. Shareena I, Khu YS, Cheah FC. Intraperitoneal extravasation of total parental nutrition infusate from an umbilical venous catheter. Singapore Med J 2008; 49: e35-6.

Figure legends

Figure 1. Tissue dye administered into the umbilical vein distributed in the damaged liver tissue and penetrated through the liver capsule (Case 1).

Figure 2. Injection study of the portal vein demonstrates spreading of the tissue dye around the small portal vein branch (Case 1).

Table 1. Clinical information of the presented cases. PN – parenteral utrition, UVC – umbilical venous catheter

	Case 1	**Case 2**	**Case 3**
Gestational age (weeks)	24	28	40
Infusate via UVC	PN and inotropes from birth	PN and inotropes from birth	Clear fluids and inotropes from birth, PN from day 5 of life
UVC tip position	T12	T12	T12
Age at deterioration (days)	4	4	10
Age at death (days)	5	5	11