Infusoabdomen with abdominal compartment in extremely low birth weight neonates

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ABSTRACT

Central venous catheters (CVCs) are frequently used in neonatal care. The rate of complications upon CVC use is high and the spectrum ranges from catheter tip dislocation to cardiac tamponade and death. Here we present an explanation model to the phenomenon of paravasate into human anatomical cavities based on two illustrative cases: Extremely low birth weight twins suffering from abdominal compartment syndromes due to different pathologies—one with a trans-peritoneal and one with intra-abdominal effusion. In both siblings the peripherally introduced central catheter (PICC) perforated the vessel without clinical signs of bleeding and contributed to abdominal and thoracal complications. Case I (23 + 5 gestational week; 770 g; female) showed clinical signs of an abdominal compartment syndrome without respective intestinal pathology upon open surgical procedure with ileostomy. Radiographic contrast examination showed retroperitoneal leakage when administered through the catheter. Replacement into the subclavian vein led to cardio-respiratory misbalance due to severe pleural effusion. Re-replacement finally led to clinical restitution after 60 days of intensive care. Case II (23 + 5 gestational week; 690 g; female) showed clinical signs of an abdominal compartment syndrome, too. Radiographic contrast examination showed leakage from the PICC into the abdomen. Replacement of the PICC and invasive care led to improvement after 3 days. The 2 cases reveal that the displacement of a PICC can occur without direct clinical signs of hemodynamic imbalance i.e. bleeding or hematoma. Displacement of the catheter tip from intra-vascular, retro-peritoneal position can cause abdominal compartment syndromes either via trans-peritoneal migration of fluids or after perforation of the peritoneum via intra-abdominal administration of given infusion. Both options caused life threatening complications. Watchfulness and intensive surgical and non-surgical care are indicated to handle these severe complications.

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very low birth weight have poor venous integrity with a decreased stability of the respective vessel wall. Also they might have more flexible peri-vascular tissue without increasing the infusion pressure upon extravasation of the applied fluids [3]. Both explanatory models are leading to unrecognized peri-vascular extravasation of the applied infusions with severe complication toward the respective regions.

Whereas the explanation of a perforation-associated pleural infusion in neonates is evident, the mechanism leading to an abdominal compartment syndrome remains elusive. Here we present 2 cases of female neonate twins with birth weight of 770 and 690 g suffering from abdominal distension and respiratory distress due to different pathologies during neonatal intensive care: a transperitoneal effusion and an intra-abdominal effusion. Further, we intend to provide for the first time in literature an explanatory model for an intra-abdominal effusion due to perforation of retroperitoneal positioned catheters in order to better understand the underlying mechanism.

1. Case presentation

1.1. Case 1

A 23 + 5 gestational week 770 g female twin, delivered by urgent caesarian section, got a rifampicin-coated 1 French catheter (Vygon, Aachen, Germany) at the first day of life (DOL). Insertion into the left greater saphenous vein (GSV) was guided by ultrasound. X-ray control showed the tip of the catheter positioned in the left common iliac vein and thus using it as a CVC. Parenteral global nutrition was given at a maximum speed of 5.4 ml/h. At 9th day of life (850 g) abdominal distension and increasing infectious parameters (wbc 21390/μl, IL6 1.281 pg/ml, CRP 1.4 mg/dl) were noticed. Presuming a necrotizing enterocolitis with an additional central line-associated bloodstream infection, antimicrobial therapy with Vancomycin 3 × 13 mg per day (solved to 2.6 ml with Aqua + Glucose 5%), Gentamycin 1 × 5 mg per day (solved to 1.25 ml with NaCl 0.9%) and Tazobactam 3 × 75 mg (solved to 2 ml with NaCl 0.9%) was started. Due to increasing circulatory and pulmonary insufficiency, additional volume was given via the PICC with a maximum speed of 17.7 ml/h. Maximal infusion rate recommended by the manufacturer was 36.0 ml/h.

High-flow nose ventilation was assumed to cause progressive abdominal volume. With an aggravated abdominal situation endotracheal intubation was performed. Neither nasogastric nor rectal tube yielded abdominal improvement. Radiographic examination failed to show intra-abdominal free air but showed signs of dilated bowels. Ultrasound examination showed intra-abdominal free fluid in the sub-hepatic area and in the lower left abdomen.

15 h after the onset of the acute abdominal symptoms, cardiopulmonary parameters became worse again and x-ray examination revealed right-sided pleural effusion (Fig. 3). Pleural drainage was inserted and analysis of the intra-thoracic effusion confirmed an infuso-thorax. The CVC was removed and a new CVC (Vygon, Aachen Germany) was introduced into the left subclavian vein guided by ultrasound. The tip was positioned in the superior vena cava also controlled by x-ray. Since removing of the PICC no further fluids were discharged by the peritoneal drainage.

At 11th DOL cardiopulmonary parameters became worse again and x-ray examination revealed right-sided pleural effusion (Fig. 3). Pleural drainage was inserted and analysis of the intra-thoracic fluid confirmed an infuso-thorax. The CVC was changed by a new CVC into IVC via the right GSV and the baby and all clinical parameters recovered in between 6 h. The pleural drainage could be removed at DOL 13. At 71st DOL and with a bodyweight of 2100 g, closure of the ileostomy was performed without complications.

1.2. Case 2

The second twin (23 + 5 gestational week), revealed a bodyweight of 690 g at first DOL. A 1 French Rifampicin coated PremiStar Catheter (Vygon, Aachen Germany), was immediately and inserted into the left GSV guided by ultrasound. Due to occlusion of the system the catheter was changed into the right GSV after 20 days. X-ray control showed the correct placing of the tip towards the inferior vena cava and the catheter was thus used as a central line. Parenteral nutrition was continued with a maximum infusion rate of 5.3 ml/h.

At 26th DOL and 1030 g bodyweight, an increase of the abdominal circumference was visible. The abdomen was still soft by palpation and the skin showed no signs of inflammation. Cardiopulmonary parameters increased significantly and the cardiopulmonary situation worsened. Inflammatory parameters were wbc 39 500/μl, IL6 1295 pg/ml, CRP 17.7 mg/dl. An abdominal ultrasound scan confirmed free peritoneal fluid. A contrast solution was given via
PICC and radiography revealed an intra-abdominal effusion at the tip of the PICC with diffusion between the bowels (Fig. 4). Removal of the PICC and replacement into the superior vena cava was performed. Additionally endotracheal intubation, volume substitution (with maximal flow 20.2 ml/h) and antibiotic therapy (Vancomycin 3 × 16 mg per day soluted to 3.2 ml with aqua + glucose 5%) and Metronidazol 2 × 31 mg per day (6.2 ml solution ready to use) led to clinical stabilization with decreasing inflammation parameters. Abdominal distension went down to a normal circumference and without ionotropic substances cardio-respiratory status improved. Extubation was performed 3 days later and we were able to start with minimal enteral nutrition.

2. Discussion

Here we presented 2 illustrative cases of abdominal compartment syndromes with different pathogenesis in female twins with extremely low weight at birth due to venous catheter associated complications. In both siblings the catheter was peripherally introduced (greater saphenous vein) and due to the central position (inferior vena cava) of the tip the catheters were used in both cases as central lines. Albeit the insertion of the PICC’s were guided by real-time ultrasound as a standard procedure [15,16] perforation of the vein and dislocation of the catheter tip occurred 6 and 9 days after primary insertion. Maximum speed of the infusion was 5.3 and 5.4 ml/h before onset of complications, 15% of the maximum flow rate recommended by the manufacturer of the PICC.

Interestingly in both cases the perforation of the vein caused no clinically apparent hemorrhagic episodes, albeit intensive monitoring was performed. Also no increased pressure values were
recorded during administration of the infusions. In case 1 the catheter tip was detected extra-abdominal in a retro-peritoneal position and in case 2 in an intra-peritoneal position. Several explanatory models exist at present for the dislocation of the catheter tip:

1. Infants have elastic and thus less resistant perivascular tissue which easily distends with fluid application without markedly increasing the infusions pressure. This makes an identification of displacement tough.

2. Neonates and septic infants have a reduced venous integrity and are thus more vulnerable to mechanical stimuli. Increased motion f.i. during hygiene procedures is capable to force the catheter tip toward the vessel wall and by thus increasing the risk for perforation.

3. Hyperosmolarity of the administered infusion might be also capable to produce a chemical lesion in the venous vessel wall and thus to facilitate the migration of the catheter tip toward the extra-vascular space.

However, in our presented case 1 no perforation of the peritoneum occurred and the catheter tip was detected extra-vascular but in retro-peritoneal position (Fig. 2). During ongoing infusion extravasation occurred and the catheter tip was detected extra-vascular but in case 2 a dislocation toward an intra-peritoneal position.

Explanatory models exist at present for the dislocation of the catheter tip which also can lead to a higher permeability and conquer the pore filter mechanism. Osmolarity of parenteral nutrition at the moment of the extravasation [26]. According to the model of Rippe and colleagues the peritoneum contains pores of several sizes from 0.3 to 3.0 nm width [20,21]. The pores allow proteins or large molecular solutes to pass depending on size, structure and charge. Parenteral nutrition for neonates consists on water, glucose, electrolytes, vitamins, amino acids and fatty acids which are in general incapable to penetrate the peritoneum due to their molecular size. The mean globule size of infusions ranges from 160 nm to 316 nm for 10% and from 42.8 nm to 68.0 nm for 20%. The passage of fluids is facilitated by microvascular permeability which also can lead to a higher permeability and conquer the pore filter mechanism. Osmolarity of parenteral nutrition at the moment of the extravasation [26].

Elevated retroperitoneal pressure, local inflammation together with the immaturity of the peritoneal membrane may be causative for an increased peritoneal permeability [3,21]. Likewise may hyperosmolar fluids induce an inflammatory reaction of the (retro-)peritoneal wall which also can lead to a higher permeability and conquer the pore filter mechanism. Osmolarity of parenteral nutrition at the moment of the extravasation [26].

Several previous reports in literature reveal an increasing number of abdominal compartment syndromes during hip arthroscopy in adults [23–25] showing evidence that extra-abdominal fluids are capable to enter the intra-abdominal cavity. The passage of fluid in these orthopedic cases was facilitated by microvascular permeability which also can lead to a higher permeability and conquer the pore filter mechanism. Osmolarity of parenteral nutrition at the moment of the extravasation [26].

These and the above mentioned mechanisms might be the driving factors why in our presented case 1 intra-abdominal fluids were seen during laparotomy and later on in the drainage while the tip of the catheter was detected in retro-peritoneal position. After replacing the catheter, the intra-abdominal fluid production stopped immediately, which could be interpreted as the leading reference that the fluids were related to the position of the catheter.

3. Conclusion

Paravasate due to dislocated PICC’s of the inferior vein system can penetrate into both abdomen and retroperitoneum – with similar clinical appearance. Once symptoms like abdominal distension, respiratory distress or increased inflammatory parameters in ELBW occur we should take extravasation of a central venous catheter into consideration. If any failure is suspected tightly observation of central lines by using ultrasound, two-plane x-ray and contrast examination may lead to early diagnosis of paravasate. Hence life-threatening deterioration would be evitable.

Conflict of interest

None of the authors have a conflict of interest or financial ties related to this study.

References