

Usefulness of skills in point of care ultrasound and simulation-based training as essential competencies in acute management of neonatal cardiac tamponade

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SUMMARY

Peripherally inserted central catheter (PICC) insertion is a routine procedure in the neonatal intensive care unit required for prolonged intravenous fluid, nutrition and medication support. Neonatal cardiac tamponade is a serious and rare complication of PICC line insertion. Early detection by point of care ultrasound (POCUS) and management by pericardiocentesis improves the chances of survival. Regular simulation-based training sessions on a mannequin, along with knowledge of POCUS, can assist neonatologists and paediatricians for a quick and appropriate response in this emergency condition.

BACKGROUND

A peripherally inserted central catheter (PICC) line is a long, thin, flexible tube that is inserted through a peripheral vein (saphenous vein, popliteal vein, femoral vein in the leg or basilic, axillary or cephalic vein in the arm) and then threaded through to a larger vein (superior or inferior vena cava) near the heart.¹ It is used to provide long-term access to the bloodstream for the administration of fluids, total parenteral nutrition (TPN), medications and blood products. It can lead to multiple complications, most commonly catheter-related sepsis, thrombosis, haemorrhage, catheter breakage, line migration leading to pleural effusion, pericardial effusion, ascites, embolism, etc.^{2,3} We report a case of PICC-induced pericardial effusion leading to cardiac tamponade and its management. Emphasis is required on the need for simulation-based training sessions on a mannequin along with knowledge of point of care ultrasound (POCUS), based on resources and expertise, in managing such a rare clinical scenario.

CASE PRESENTATION

A male neonate was born at 32 weeks of gestation by vaginal delivery, to a primigravida mother with preterm premature rupture of membranes and preterm labour pain. At birth the neonate had Apgar scores of 7, 8 and 8 at 1, 5 and 10 min, respectively. Delivery room continuous positive airway pressure (CPAP) was administered for respiratory distress and the patient was moved to the neonatal intensive care unit (NICU) on a T-piece resuscitator. On arrival at the NICU, the neonate was started on CPAP support of 6 cm H₂O and 25% fraction of inspired oxygen (FiO₂) support. Oro-gastric (OG) feeding was started in the form of minimal enteral nutrition on day 1 of life. His birth weight was

1902 g, which was just above the 50th centile on a modified Fenton chart. Chest X-ray and POCUS of the lung was suggestive of grade 1 respiratory distress syndrome. Surfactant was not administered, and supportive management was continued in the form of CPAP support. OG feeds were gradually increased, and intravenous fluid was stopped 48 hours after the birth. The patient responded well with CPAP which was tapered over 96 hours.

On day 7 the neonate developed abdominal distension and two episodes of vomiting. Investigations revealed pneumatosis intestinalis on X-ray of the abdomen, the stool was positive for occult blood, and the platelet count was 73 000/mm³. The patient was treated for neonatal necrotising enterocolitis (NNEC) stage IIb. He was kept on nil by mouth, started on intravenous fluids, and the antibiotics cefotaxime, amikacin and metronidazole were added empirically as per the antibiogram of our NICU. Blood culture grew *Klebsiella pneumoniae* which was sensitive to amikacin, which was therefore continued. Cerebrospinal fluid examination was normal. A silicone, peripherally inserted, central catheter (PICC) line (epicutaneo-cava catheter; 24G/2Fr; VYGON India, code 1284.00) was inserted from the left cephalic vein and advanced to the superior vena cava. The PICC line tip position was confirmed by POCUS and a chest X-ray taken with the left arm positioned perpendicular to the chest wall. The patient was started on TPN with amino acids and lipids. In view of new onset respiratory distress and blood gas analysis revealing the presence of respiratory acidosis, CPAP support was restarted.

On day 9 of life, the neonate developed features of shock in the form of tachycardia, prolonged capillary filling time and cold peripheries. A clinical examination with transillumination and X-ray of the chest and abdomen revealed no features of tension pneumothorax or bowel perforation due to NNEC. A clinical diagnosis of cardiogenic shock was made and the differential diagnosis of myocarditis (because of NNEC) was considered; however, in view of the patient's rapid deterioration over 30 min, an urgent point of care echocardiography was performed by the neonatology team. It was suggestive of a large pericardial effusion and the PICC line was visible inside it ([figure 1](#)).

INVESTIGATIONS

Analysis of the aspirated fluid revealed a triglyceride concentration of 296 mg/dL with no



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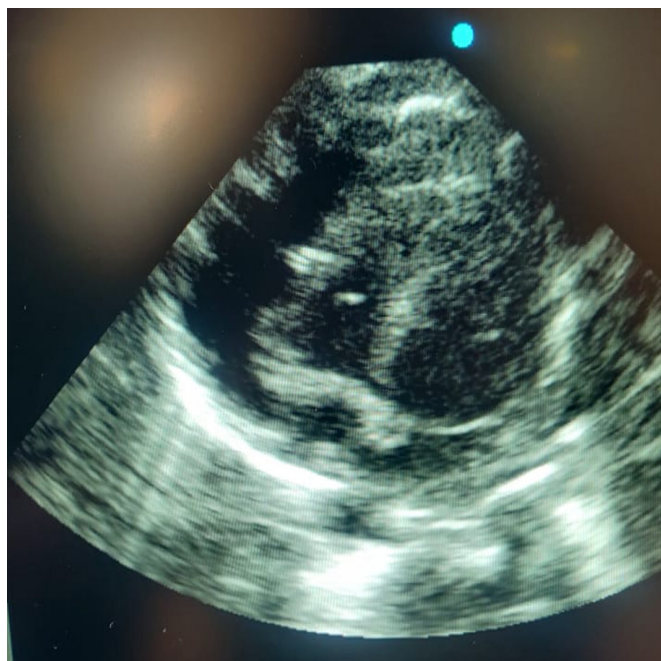


Figure 1 Pericardial effusion with the tip of the peripherally inserted central catheter inside the effusion causing cardiac tamponade.

cells, confirming the diagnosis of TPN leakage as the possible cause of pericardial effusion

DIFFERENTIAL DIAGNOSIS

The differential diagnosis considered for sudden onset collapse were tension pneumothorax, gastric perforation and pericardial effusion/cardiac tamponade.

TREATMENT

The effusion was causing cardiac tamponade and compressing the right ventricle significantly. The neonate was intubated and supported with invasive mechanical ventilation in view of his rapid clinical deterioration. TPN solution was stopped in the PICC line; aspiration of the PICC did not drain any significant volume of fluid, and it was subsequently removed. An urgent ultrasound-guided pericardiocentesis was carried out through the subxiphoid approach. A 22 gauge (22G) cannula was inserted just below the xiphoid process with the tip pointing towards the left shoulder, and only 2 mL of creamy-white fluid was aspirated. Echocardiography revealed persistence of pericardial effusion and a cardiac tamponade effect. It was suspected that the blockage of the 22G cannula was due to the highly viscous nature of the fluid; hence, a larger bore cannula of 20G was inserted and then another 10 mL of fluid was aspirated (figure 2), thereby relieving the tamponade effect.

Clinically, the neonate showed signs of improved perfusion in the form of improved capillary filling time, normalisation of temperature and colour of extremities along with a lower FiO₂ and invasive ventilation pressure requirement. Point of care echocardiography revealed an improvement in cardiac contractility in the form of improved fractional shortening and ejection fraction post-procedure. Another silicone PICC line (epicutaneous catheter; 24G/2Fr; VYGON, code 1284.00) was inserted through the right popliteal vein and TPN was restarted. Over the next 24 hours, mechanical ventilation parameters improved, and the patient was extubated 24 hours post-procedure onto CPAP support which was also withdrawn over the next 36 hours.



Figure 2 Lipid containing solution aspirated by pericardiocentesis.

After 7 days of nil by mouth, feeds were reintroduced in a staggered approach which was tolerated well, and by day 20 of life the patient reached a feeding volume of 150 mL/kg. Intravenous antibiotics were administered for a total of 14 days and were stopped once a repeat blood culture was sterile. Repeat echocardiography on day 20 of life, performed by a cardiologist, revealed no pericardial effusion. The patient tolerated syringe feeds by day 22 and direct breast feeding by day 25. The infant had persistent weight gain on breastfeeds and was discharged on day 30 of life with a discharge weight of 2100 g. Hearing screening, neurosonography and retinopathy of prematurity screening were normal.

OUTCOME AND FOLLOW-UP

The infant was followed up for growth, neurodevelopmental outcome and possible cardiac complications. He showed catch up growth and by 3 months of age achieved a weight of 5.3 kg (between 10th and 50th centile of the modified Fenton chart), head circumference of 38.5 cm (50th centile of the modified Fenton chart) and length of 58 cm, and partial neck control. Ophthalmological evaluation at 44 weeks postmenstrual age (gestational age plus chronological age) revealed bilateral mature retinas with no evidence of retinopathy of prematurity; hearing was normal for age.

DISCUSSION

Pneumothorax, bowel perforation and pericardial effusion/cardiac tamponade are causes of sudden acute deterioration in a newborn undergoing intensive care. Pericardial effusion and cardiac tamponade are rare complications of central line insertion in newborns, with a reported incidence of 0.07–2%.^{2 4 5} Both umbilical catheter and PICC lines are implicated in their causation. Central lines inserted using a guidewire (Seldinger technique) is known to have a greater risk of pericardial effusion in neonates.^{4 5} Use of silicone catheters reduces the risk of catheter-associated pericardial effusion, though this was not the case in our patient.⁴

The two possible causes for pericardial effusion following central line insertion are catheter drift and catheter tip distortion. Catheter drift is more common in insertion from the upper limb rather than the lower limb, as adduction of the shoulder joint along with flexion at the elbow joint can lead to slippage of the PICC into the right atrium.^{5,6} It occurs most commonly within the first 72 hours of insertion.^{7,8} In our case catheter migration occurred within 48 hours of insertion through the upper limb. To decrease the chances of catheter drift, it is recommended to keep the catheter tip 1 cm outside the cardiac silhouette in preterm infants and 2 cm outside the heart outline in term infants.⁹ This position is usually confirmed by chest X-ray and POCUS. The British Association of Perinatal Medicine recommends positioning the upper limb PICC in the superior vena cava, checking with an X-ray that the relevant arm is positioned perpendicular to the chest wall.¹⁰

Catheter tip distortion leads to mechanical friction inside the atrial chamber damaging the myocardium with consequent microperforation in the endocardium and resultant pericardial effusion.⁵ TPN solution is a medium- to high-risk infusion that can also lead to abnormal fluid collection leading to pleural effusion, pericardial effusion and ascites.^{11–14} The signs and symptoms of acute pericardial effusion are dyspnoea, chest pain, bradycardia, distant heart sounds, hypotension, non-palpable peripheral pulses, acidosis and an enlarged heart on X-ray, all of which are non-specific.² It is associated with a high mortality rate of 75% due to delayed diagnosis, inadequate management, poor training in pericardiocentesis and lack of resources. Mortality can be reduced to 8% by early detection and treatment by pericardiocentesis.^{4,5}

Conventional drainage of the pericardiocentesis in emergency situations is part of the curriculum of all neonatology residents. In cases of acute deterioration, pericardiocentesis under ultrasound guidance is preferred. In addition, PICC line aspiration for drainage of the pericardial effusion can also be tried in cases where the tip of the catheter lies inside the effusion.^{5,11} This is associated with relative success, but it was not successful in our case and the PICC was removed. Routine simulation training in mannequins is carried out for all life-saving emergency neonatal procedures at our centre for all neonatology residents. Use of simulators for training residents in emergency management of cardiac tamponade is well known in cardiology and paediatric residents.^{15–17} Very few such dedicated models for training are available for neonatology residents. 'GiriSohi' is a dedicated, low-cost, indigenously developed model developed at our centre for pericardiocentesis training. In addition, all neonatologists are trained in point of care echocardiography. Thus, for a neonate who has a central line in situ and suddenly develops shock-like features and deteriorates rapidly, cardiac tamponade should be kept as the differential diagnosis, and immediate echocardiography by a POCUS-trained neonatologist or a cardiologist and subsequent pericardiocentesis can be lifesaving for a newborn.

Pericardiocentesis was initially attempted with a 22G cannula, but it was not successful. Use of a 20G cannula led to effective drainage of the pericardial effusion. A higher bore needle may occasionally be required in drainage of lipid-containing effusions which are of higher viscosity. Removal of the PICC line after pericardial effusion is not a dictum. The position can be readjusted, and the line can be used under careful monitoring.⁵ In our case we took the decision to remove the PICC and insert another one from the lower limb. POCUS is an option, if there are resources and expertise available, for confirmation of position at the time of insertion and periodic tip monitoring. This can help in the early identification of catheter tip displacement.^{18–20} Early

diagnosis and well-trained neonatologists in emergency POCUS and pericardiocentesis led to a good outcome in our patient.

Learning points

- ▶ Sudden deterioration with features of shock in a newborn with a central line in situ should arouse the suspicion of obstructive shock due to cardiac tamponade.
- ▶ Point of care ultrasound is useful for early diagnosis of cardiac tamponade.
- ▶ Early and effective pericardiocentesis is lifesaving in neonatal cardiac tamponade.
- ▶ Skills training of residents using a pericardiocentesis simulator and point of care ultrasound can improve the management of neonatal cardiac tamponade.
- ▶ Lipid-containing effusion may require a higher bore cannula for drainage due to higher viscosity.

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Case reports provide a valuable learning resource for the scientific community and can indicate areas of interest for future research. They should not be used in isolation to guide treatment choices or public health policy.

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REFERENCES

- 1 Chiang MC. Neonatal percutaneous central venous catheters: equations for the inserted length and locations of the insertion sites. *Pediatr Neonatol* 2019;60:235–6.
- 2 Zarkesh MR, Haghighi M. Neonatal cardiac tamponade, a life-threatening complication secondary to peripherally inserted central catheter: a case report. *J Med Case Rep* 2022;16:305.
- 3 Pizzuti A, Parodi E, Abbondi P, et al. Cardiac tamponade and successful pericardiocentesis in an extremely low birth weight neonate with percutaneously inserted central venous line: a case report. *Cases J* 2010;3:15:1–3.
- 4 Wang J, Wang Q, Liu Y, et al. The incidence and mortality rate of catheter-related neonatal pericardial effusion: a meta-analysis. *Medicine* 2022;101:e32050.
- 5 Hou A, Fu J. Pericardial effusion/cardiac tamponade induced by peripherally inserted central catheters in very low birth weight infants: a case report and literature review. *Front Pediatr* 2020;8:235.
- 6 Wrightson DD. Peripherally inserted central catheter complications in neonates with upper versus lower extremity insertion sites. *Adv Neonatal Care* 2013;13:198–204.
- 7 Acun C, Baker A, Brown LS, et al. Peripherally inserted central catheter migration in neonates: incidence, timing and risk factors. *J Neonatal Perinatal Med* 2021;14:411–7.
- 8 Pet GC, Eickhoff JC, McNeven KE, et al. Risk factors for peripherally inserted central catheter complications in neonates. *J Perinatol* 2020;40:581–8.
- 9 Khoo WV, Choo YM, Zahari N, et al. Cardiac tamponade from peripherally inserted central venous catheters in neonates: three case reports. *Med J Malaysia* 2021;76:566–8.
- 10 British Association of Perinatal Medicine. Use of central venous catheters in neonates: a framework for practice. n.d. Available: <https://www.bapm.org/resources/10-use-of-central-venous-catheters-in-neonates-revised-2018>
- 11 Bashir RA, Callejas AM, Osiovič HC, et al. Percutaneously inserted central catheter-related pleural effusion in a level III neonatal intensive care unit: a 5-year review (2008–2012). *JPEN J Parenter Enteral Nutr* 2017;41:1234–9.
- 12 Alhatem A, Estrella Y, Jones A, et al. Percutaneous route of life: chylothorax or total parenteral nutrition-related bilateral pleural effusion in a neonate. *Fetal Pediatr Pathol* 2021;40:505–10.

- 13 Sertic AJ, Connolly BL, Temple MJ, *et al.* Perforations associated with peripherally inserted central catheters in a neonatal population. *Pediatr Radiol* 2018;48:109–19.
- 14 Anand V, Pournami F, Panackal AV, *et al.* Parenteral nutrition ascites: calamity from an umbilical vein cannula. *Journal of Child Science* 2020;10:e230–2.
- 15 Tsai SL, Seslar SP. Initial experience with a novel pericardiocentesis training simulator incorporating a three-dimensional printed cardiac model. *J Innov Card Rhythm Manag* 2021;12:4551–5.
- 16 Belliveau DJ, Moeller A, Ramer S. High-fidelity model to simulate ultrasound-guided pericardiocentesis for cardiology resident training. *Can J Cardiol* 2019;35:1600–3.
- 17 Augenstein JA, Deen J, Thomas A, *et al.* Pediatric emergency medicine simulation curriculum: cardiac Tamponade. *MedEdPORTAL* 2018;14:10758.
- 18 Singh Y. Use of echocardiography in the neonatal intensive care unit. *Paediatr Child Health* 2022;32:351–6.
- 19 Zaghoul N, Watkins L, Choi-Rosen J, *et al.* The superiority of point of care ultrasound in localizing central venous line tip position over time. *Eur J Pediatr* 2019;178:173–9.
- 20 Oleti T, Jeeva Sankar M, Thukral A, *et al.* Does ultrasound guidance for peripherally inserted central catheter (PICC) insertion reduce the incidence of tip malposition? A randomized trial. *J Perinatol* 2019;39:95–101.

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