Section: Paediatric Anaesthesia

Case Series

OPTIMIZING CENTRAL VENOUS CATHETER PLACEMENT IN PAEDIATRICS: ESSENTIAL INSIGHTS FROM A CASE SERIES

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ABSTRACT

Central venous catheterization (CVC) is crucial in paediatric care but presents unique challenges, including malpositioning. This series discusses four cases highlighting complications and management strategies. An infant with congenital cardiac anomalies required repositioning of a PICC line due to jugular malposition. A preterm neonate's CVC was found extravascular, necessitating removal under surgical supervision. Additional cases involved misplacement in the subclavian vein and overlying the right ventricle, both successfully corrected. These instances underscore the importance of proper technique, monitoring, and the use of diagnostic tools to enhance patient safety and minimize complications associated with CVC insertion in children.

INTRODUCTION

Central venous catheterization (CVC) is vital for assessing blood volume, cardiac status, and vasomotor tone by placing a catheter in a central vein. CVCs enable administration of vasoactive drugs, chemotherapy, parenteral nutrition, and access for patients with poor peripheral veins. They can be mono- or multi-lumened, tunneled or non-tunneled, including dialysis catheters or peripherally inserted central catheters (PICCs). In young children, CVC insertion presents challenges, with malposition occurring in 3-4% of cases,[1] often leading to complications.[2] The POCA registry (1998-2004) identified CVC-related lung and vascular injuries as primary causes of equipment-related cardiac arrests in paediatric patients.[3] This case series highlights four cases to investigate methods for prevention, identification, and correction. With approval from the Institutional Ethics Committee (IEC Code 2023-11-IM-60 dated 1/12/2023) and informed parental consent, we are sharing these cases.

Case 1

An infant, with congenital cardiac anomalies, required a PICC line, in the Cardiac ICU. A 4 Fr, GroshongR single lumen PICC line was inserted in left basilic vein under ultrasound guidance, and fixed at 22 cm, after confirming backflow. A post-procedure chest X-ray showed the catheter tip in the ipsilateral jugular vein. The PICC line was then withdrawn and repositioned to 20 cm using fluoroscopic guidance. [Figure 1]

Case 2:

A preterm neonate weighing 1.5 kg in the cardiac critical care unit required a central venous catheter (CVC). A 22 G, 4 cm single lumen CVC (Vygon, Leaderflex) was inserted into the right internal jugular vein under ultrasound guidance using the Seldinger technique on the second attempt and fixed at 4 cm at the skin. Aspiration and backflow of blood were successful; however, a post-procedure chest X-ray showed extravascular placement over the right lung. [Figure 2]

No fluids were transfused through the CVC, which was removed under paediatric surgery supervision. A repeat chest X-ray one hour later revealed no collection or effusion. The patient was monitored

for 48 hours for respiratory distress and cardiovascular compromise, showing no clinical deterioration. A repeat X-ray 12 hours later also confirmed no collection or effusion.

Case 3:

A two-month-old child, needed a CVC for a PDA procedure, perioperatively. A 22 G, 4 cm, single lumen CVC (Vygon, Leaderflex) was inserted into the right internal Jugular Vein (IJV) under ultrasound (USG) guidance, using the Seldinger technique, under anaesthesia. A chest X-ray revealed the CVC misplaced in the subclavian vein. [Figure 3] The catheter was then pulled out 2 cm and repositioned using the guide wire and fluoroscopic guidance.

Case 4:

A 5-year-old child weighing 15 kg needed a CVC, perioperatively. A 5.5 F double lumen CVC (Vygon, Leaderflex, 8 cm) was placed, under USG guidance, through the Right IJV, using the Seldinger technique, and fixed at 8 cm. A postoperative chest X-ray revealed it to be too far in, overlying the right ventricle. The catheter was adjusted to 6 cm at skin, and a follow-up CXR confirmed correct placement.

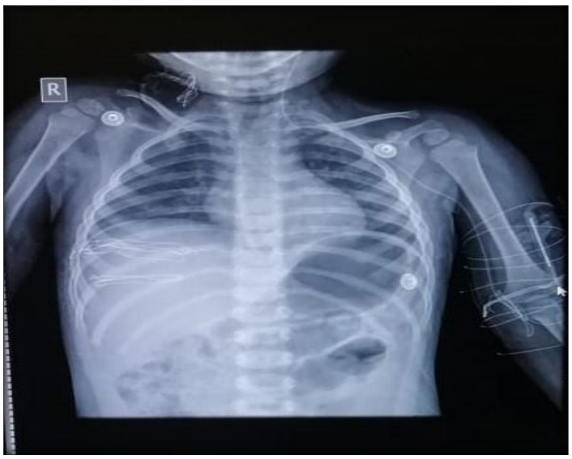

Figure 1: Left sided PICC catheter tip malpositioned in Left jugular vein

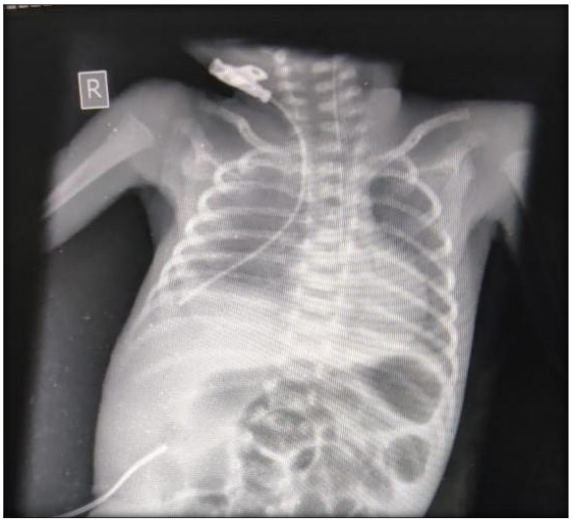

Figure 2: Chest X-ray showing CVC from Right IJV malpositioned extravascularly over the Right lung.

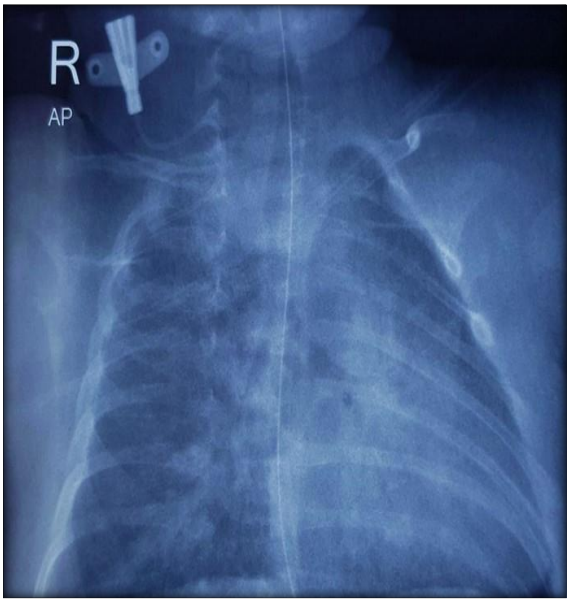

Figure 3: Chest X-ray showing CVC from Right IJV malpositioned into Right subclavian vein.

DISCUSSION

Effective CVC placement necessitates technical skill and awareness of potential complications. The right internal jugular vein (IJV) is preferred for its direct course, reducing risks like stenosis and thrombosis,[4] and allowing for manual compression if arterial puncture occurs. The optimal CVC tip position is now accepted to be within a large central vein (superior or inferior vena cava), outside the pericardial sac, parallel to the long axis, and not abutting the vein or heart wall.[5]

If the CVC tip is positioned too low in the right atrium or in the right ventricle, there are risks of catheter dysfunction, arrhythmia, atrial mural thrombus, and, rarely, cardiac perforation.[5,6]

Misplacement can occur within the venous system, which is more common and less dangerous, or in areas like the pleura, pericardium, or peritoneal space, which are rarer and riskier. Factors influencing misplacement include insertion site, needle bevel direction, vein anatomy,[7] technique, body position, and patient factors.

Types of Complications

Complications of CVC placement can be classified as early or late. Early complications, often related to procedural factors, include malpositioning (intravenous, intra-arterial, or extravascular) and air embolism. Late complications may involve infection, catheter fracture, dysfunction or occlusion, and vessel thrombosis, stenosis, or occlusion.[8]

a. I.V. misplacement

Incorrect catheter positioning, common during placement of catheters without X-ray screening, occurs commonly with subclavian or left-sided placements. Malpositioned IV catheters may need repositioning or replacement. While minor vein wall tears are typically harmless, major bleeding can

occur if connected to low-pressure cavities. Misplaced IV catheters are unsuitable for chemotherapy or high-flow procedures. In our series, Cases 1, 3, and 4 involved malpositioned intravenous CVCs. Early detection in each case was followed by prompt and appropriate repositioning, successfully avoiding complications.

b. Intra-arterial misplacement

Intra-arterial misplacement occurs in 1-11% of procedures.[9] Recognized cases are managed by removing the needle and applying pressure, while unrecognized cases may involve guide wire or catheter insertion. Detection relies on blood colour, pulsation, and tools like pressure transducers. Complications include hematomas, bleeding, dissection, and embolism. Removal of large-bore catheters misplaced in arteries may require surgical intervention or endovascular treatment.

c. Extravascular placement

Malpositioned needles, guide wire, dilator, and catheters can damage nearby structures, leading to perforation of great veins or arteries and bleeding into low-pressure spaces, evident only after catheter removal. Complications include cardiac perforation, tamponade, and pneumothorax.

In Case 2 of our series, the CVC was found to be malpositioned extravascularly. Rather than removing it hastily, a paediatric surgical opinion was sought, and the catheter was removed under supervision. The patient was closely monitored for respiratory and cardiovascular compromise for the next 48 hours.

Techniques for Confirming Central Venous Catheter Placement

a. Ultrasound Guidance: Useful for identifying target veins and anatomical variations, but limited in preventing distal misplacement. Transesophageal ultrasound is 100% accurate but restricted by availability and expertise.
b. Pressure Transducers: Attaching these to the needle helps confirm placement in the venous or arterial system prior to guide wire insertion.
c. Blood Gas Analysis: Can confirm placement before guide wire insertion, but results can be delayed, making it impractical in urgent situations.
d. ECG Guidance: Verifies placement at the caval-atrial junction, with characteristic P wave changes indicating incorrect placement. It achieves 95-100% accuracy when confirmed by transesophageal echocardiography.[7]
e. Chest X-ray: Confirms catheter position and detects complications like pneumothorax or effusions. While less accurate due to parallax error, it is a cost-effective and widely used bedside tool.[9,10]
f. CT and MRI: Provide detailed cross-sectional images but costly and impractical for routine use; valuable for managing complications.
g. Electromagnetic Navigation: Utilizes a coil on the guide wire to verify proximity to the SVC but does not confirm the exact vein location.[11]

Ultrasound-guided venous puncture and fluoroscopy guided tip placement have showed 98% success,[12] but may not be available in all hospitals.

In all our cases, CVC placement was performed using ultrasound guidance, which did not prevent distal misplacement. Other modalities, such as pressure transducers, blood gas analysis, or ECG guidance, were however, not utilized for placement. Postoperative chest X-rays in all cases successfully detected the malpositioning of the CVCs. Further, In Cases 1 and 3, the misplaced IV catheters were repositioned using ultrasound with fluoroscopy.

Management of misplaced CVCs

Management of misplaced catheters depends on location, indication, and patient condition. Consider these checks:

a. Aspirate Blood: Check for blood return through all lumens. Inability to aspirate may indicate blockage or malposition.
b. Blood Characteristics: Aspirated blood, if venous, should be dark, non-pulsatile, and low-pressure. Bright, pulsatile blood suggests arterial placement.
c. Transducer Waveform: Confirm placement in the SVC or right atrium. Ensure the catheter is not kinked and follows the correct trajectory.
d. CXR Check: Confirm the catheter's placement in the SVC or right atrium, ensuring it's not kinked and follows the correct trajectory.

If any check indicates a problem or if there is doubt about placement, further evaluation is necessary, typically involving additional imaging like contrast injection (linogram/venogram) or CT.

In all our cases, we successfully aspirated blood from all lumens, which appeared venous—dark, low-pressure, and non-pulsatile. We did not confirm placement using a transducer due to lack of suspicion of misplacement. However, postoperative chest X-rays confirmed catheter malpositions.

CONCLUSION

In conclusion, minimizing central venous catheter (CVC) malposition in children requires a multifaceted approach including effective training in catheter insertion techniques, combined with the use of available diagnostic tools such as ultrasound, ECG guidance, chest X-ray, TEE etc. Recognizing malposition patterns and seeking further imaging when needed enhances patient safety, improving CVC procedure success rates and safeguarding the well-being of children during catheterization.

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REFERENCES

1. Naaz S, Asghar A, Shadab M, et al. Malposition of central venous catheter in a pediatric patient. The Indian

Anaesthetists Forum 2019;20(2): 110-112. doi: 10.4103/The IA Forum. The IA Forum_23_19.
2. Janik JE, Cothren CC, Janik JS, et al. Is a routine chest x-ray necessary for children after fluoroscopically assisted central venous access?. J Pediatr Surg. 2003;38(8):1199-1202. doi:10.1016/s0022-3468(03)00267-7
3. Bhananker SM, Ramamoorthy C, Geiduschek JM, et al. Anesthesia-related cardiac arrest in children: update from the Pediatric Perioperative Cardiac Arrest Registry. Anesth Analg. 2007;105(2):344-350. doi:10.1213/01.ane.0000268712.00756.dd
4. Ruesch S, Walder B, Tramèr MR. Complications of central venous catheters: internal jugular versus subclavian access--a systematic review. Crit Care Med. 2002;30(2):454-460. doi:10.1097/00003246-200202000-00031
5. Vesely TM. Central venous catheter tip position: a continuing controversy. J Vasc Interv Radiol. 2003;14(5):527-534. doi:10.1097/01.rvi.0000071097.76348.72
6. Jahnke C, Hoxha E, Söffker G, Seiffert M. Cardiac perforation due to delayed migration of a chronic dialysis catheter: a case report. Eur Heart J Case Rep. 2021;5(9):ytab332. Published 2021 Sep 3. doi:10.1093/ehjcr/ytab332
7. Amerasekera SS, Jones CM, Patel R, Cleasby MJ. Imaging of the complications of peripherally inserted central venous catheters. Clin Radiol. 2009;64(8):832-840. doi:10.1016/j.crad.2009.02.021
8. DC. McGee, MK. Gould. Preventing Complications of Central Venous Catheterization. N Engl J Med 2003;348: 1123-1133.
9. Jobes DR, Schwartz AJ, Greenhow DE, Stephenson LW, Ellison N. Safer jugular vein cannulation: recognition of arterial puncture and preferential use of the external jugular route. Anesthesiology. 1983;59(4):353-355.
10. Tan PL, Gibson M. Central venous catheters: the role of radiology. Clin Radiol. 2006;61(1):13-22. doi:10.1016/j.crad.2005.07.010
11. Starkhammar H, Bengtsson M, Kay DA, Shapiro AR. Central venous catheter placement using electromagnetic position sensing: a clinical evaluation. Biomed Instrum Technol. 1996;30(2):164-170.
12. McGee DC, Gould MK. Preventing complications of central venous catheterization. N Engl J Med. 2003;348(12):1123-1133. doi:10.1056/NEJMra011883.