

The Hidden Danger of Unseen Intravenous Catheters

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The Case

A 6-week-old infant underwent a craniotomy and excision of abnormal brain tissue for treatment of hemimegalencephaly and epilepsy. The infant had no other congenital abnormalities and was pre-operatively assigned an American Society of Anesthesiologists (ASA) physical status classification level III, indicating a patient with severe systemic disease, due to the underlying brain malformation.¹

General anesthesia was induced with sevoflurane, a halogenated inhalational anesthetic, after which the patient was intubated and mechanically ventilated. A right femoral central venous catheter and an arterial catheter were inserted. A 22-gauge intravenous catheter was inserted into the external jugular vein. Surgical drapes were then placed over this intravenous catheter, making the external jugular vein cannulation site difficult to monitor by both the neurosurgeon and the anesthesiologist. During the surgical procedure, the neurosurgeon adjusted the patient's head, displacing the external jugular intravenous catheter into the subcutaneous tissue. The catheter's dislodgment went unnoticed due to its position underneath the surgical drapes.

The patient experienced significant blood loss during the surgical procedure and became hemodynamically unstable. Blood products and intravenous fluids were infused under pressure into the external jugular intravenous catheter rather than the femoral central venous catheter. Despite these resuscitative efforts, the patient developed severe hypotension and, ultimately, pulseless electrical activity. The surgical drapes were removed to facilitate chest compressions. At this time, marked subcutaneous fluid extravasation was noted at the site of the external jugular intravenous catheter. An emergency thoracotomy was performed but the patient could not be resuscitated and died in the operating room.

The Commentary

By Marissa G. Vadi, MD, MPH, and Mathew R. Malkin, MD

Background

Intravenous catheters provide routes to administer fluids, drugs, and blood products during the anesthetic and perioperative management of surgical patients. Major surgical procedures, including craniotomy, require large-bore venous access in case of rapid and/or massive blood loss.

Intravenous catheter placement in the pediatric population, particularly in the very young or small child, may at times be difficult. Complex surgeries usually require at least two large-bore intravenous catheters, with 22-gauge catheters typically providing appropriate access in infants. Both catheter diameter and length affect fluid flow rates. Shorter catheters provide less resistance to flow than longer ones and thus are preferred when rapid large-volume infusion of fluids is anticipated.² Common sites for large-bore catheters in infants include the saphenous and antecubital veins.

The external jugular vein is an alternative venous cannulation site for children with difficult peripheral venous access, particularly in emergent situations that require the rapid placement of additional intravenous catheters. The vein tends to be superficial and can often be visualized without imaging technology. The external jugular vein may accommodate larger intravenous catheters than other peripheral veins; however, this vein remains a rare site for cannulation in children, particularly infants.³ Movement of the patient's neck after external jugular intravenous catheter placement may result in dislodgment of the catheter into the subcutaneous tissue as happened in this case. Indeed, several case reports document major complications of dislodgment in infants including bilateral pleural effusions and respiratory distress.⁴⁻⁶ As in this case, surgical drape placement for intracranial procedures can limit the anesthesiologist's ability to assess for catheter dislodgment or infiltration and any resultant complications.

A Systematic Approach to Improving Patient Safety

This case illustrates how failure to adhere to patient safety practices, particularly those regarding the detection of intravenous catheter malfunction, may lead to tragic outcomes.

Efforts to mitigate the intraoperative risks associated with intravenous catheters during complex pediatric surgical procedures should incorporate the following considerations:

Appropriate Training of the Anesthesiologist

Graduates of pediatric anesthesiology fellowships accredited by the Accreditation Council for Graduate Medical Education complete 12 months of training specializing in the perioperative and intraoperative care of medically complex children, infants, and neonates. In 2017, the American College of Surgeons launched a verification program for Levels I, II, and III children's surgical centers. The verification program requires a pediatric anesthesiologist to perform or supervise care for any child less than 6-months-old or ASA physical status classification level III or higher.⁷ Pediatric anesthesiologists are uniquely qualified to care for patients such as the infant in the highlighted case, who was less than 6-months-old *and* had an ASA classification level III and should be utilized for medically complex children or children undergoing complex surgical

procedures.

Proper Intravenous Catheter Site Monitoring and Detection of Infiltration

Intravenous infiltration is defined as “the efflux of solutions from a vessel into the surrounding tissue during an infusion” and may cause grave injury.⁸ Common methods used to confirm the intravascular position of a peripheral intravenous catheter include the ability to aspirate blood from the catheter with a syringe, the ability to easily inject a small volume of normal saline, the absence of infiltration or hematoma after small volume fluid injection, and the free flow of intravenous fluids running under gravity. Unfortunately, these methods are not always reliable in the small and fragile veins of neonates and infants. A color-flow injection test, using ultrasound to detect changes in color-flow in proximal veins after injection of saline, may be useful in determining the intravascular position of intravenous catheters in pediatric patients.⁹

Intravenous catheter sites must be monitored frequently throughout the operation, by both palpation and visual inspection through a transparent occlusive dressing. Signs of complications include evidence of dislodgment, redness, swelling, infiltration, induration, and drainage.¹⁰

Unique characteristics of the perioperative setting may result in increased frequency and severity of infiltration events. In the operating room, patients receive greater volumes of fluids at higher administration rates. High-pressure fluid infusion may also increase the risk of intravenous catheter infiltration.^{11,12} The ASA Anesthesia Quality Institute recommends the placement of intravenous catheters in observable areas using clear securement devices as well as frequent intravenous catheter assessments prior to and during large volume infusions.¹¹ In this case, pressurized fluids were administered via an intravenous catheter that could not be assessed under the surgical drapes. Had the anesthesiologist chosen a cannulation site that allowed for easy intraoperative inspection, intravenous catheter infiltration could have been detected much earlier and the patient's unfortunate outcome avoided.

Selection of Intravenous Catheter Insertion Site

Anesthesiologists must consider several factors when selecting a site for intravenous catheter insertion including the size of catheter required, the expected stability of the catheter in the proposed insertion site, and the ability to easily monitor the catheter site intra-operatively. The type of surgical procedure may alter options for safe venous cannulation.

It is prudent to avoid external or internal jugular venous cannulation in children undergoing intracranial procedures. Jugular venous cannulation requires use of the Trendelenburg (head down) position during intravenous catheter insertion, which may elevate intracranial pressure. There is also a risk of accidental carotid artery puncture and hematoma formation, which may decrease cerebral blood flow and intracranial venous drainage. If an internal jugular venous catheter is placed, the venous pressure should be transduced, and the waveform trace should be displayed and monitored continuously.

If adequate peripheral intravenous access cannot be obtained prior to the start of a pediatric intracranial operation, consideration should be given to femoral vein cannulation.¹³ Femoral central venous catheters

are visible and accessible to the anesthesiologist during most neurosurgical procedures, unlike intravenous catheters in the neck that may be hidden by surgical drapes.

It is not clear why the anesthesiologist in this case chose to place an intravenous catheter in the external jugular vein rather than in another large-bore vein such as the saphenous or antecubital vein. The external jugular vein is often cannulated when other veins cannot be accessed,¹⁰ but it is unclear whether cannulation attempts at alternative sites were unsuccessful. The anesthesiologist may have preferentially used the external jugular catheter for administration of blood products given its shorter length than the femoral venous catheter. Flow through an intravenous catheter is inversely proportional to the length of the tubing; therefore, a short large-bore peripheral intravenous catheter yields a higher maximum flow rate than a longer central venous catheter.^{2,14} In this case, the potential advantage of higher maximum flow rate through the external jugular intravenous catheter was outweighed by the risk of catheter dislodgement and inability to monitor the catheter site during pressurized fluid administration.

Team Communication and Universal Surgical Checklist

Checklists promote clear and respectful communication between operating room team members. The World Health Organization (WHO) [Surgical Safety Checklist](#) was published in 2009 with the goal of reducing perioperative complications and mortality through improved teamwork, communication, and consistency of care.¹⁵ Three phases of communication are advised (1) before induction of anesthesia, (2) before skin incision, and (3) before the patient leaves the operating room. During the first phase, team members are asked whether there is a risk of blood loss greater than 500 ml in adults or 7 ml/kg in children. If yes, the checklist prompts further discussion of required intravenous access and suggests two intravenous catheters or central access. In the aforementioned case, adhering to the WHO Surgical Safety Checklist would have identified high anticipated blood loss and triggered a discussion between the anesthesiologist and the surgeon regarding the type and location of intravenous access necessary for the patient's safe care. During the second communication phase, the surgeon is asked to confirm the anticipated blood loss and the anesthesiologist is asked to outline any patient-specific concerns. This would have provided a second opportunity for the surgeon and anesthesiologist to discuss anticipated blood loss as well as the intravenous catheters obtained, the stability of the intravenous catheters, and the ability to properly monitor these catheters intraoperatively. Institutional policies and procedures should mandate the use of surgical safety checklists for all surgical procedures. Operating room team members should ensure that all checklist points are thoroughly discussed, and concerns addressed, before proceeding to the next phase of the patient's care.

Take Home Points

- Pediatric anesthesiologists are uniquely qualified to provide perioperative and intraoperative care for medically complex children, infants, and neonates.
- External jugular venous catheters are prone to dislodgment into the subcutaneous tissue with potentially catastrophic sequelae.

- Intravenous catheters must be frequently monitored intraoperatively, and insertion sites must not be obscured by surgical drapes.
- Femoral central venous catheter insertion is preferable to internal jugular central venous catheter insertion in pediatric patients undergoing intracranial neurosurgical resections.
- Surgical safety checklists are important tools for improving operating room communication and preventing surgical complications.

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