Angiographic evidence of an inadvertent cannulation of the marginal sinus following central line migration: illustrative case

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BACKGROUND Central venous catheters (CVCs) play an indispensable role in clinical practice. Catheter malposition and tip migration can lead to severe complications. The authors present a case illustrating the endovascular management of inadvertent marginal sinus cannulation after an internal jugular vein (IJV) catheter tip migration.

OBSERVATIONS A triple-lumen CVC was inserted without complications into the right IJV of a patient undergoing a repeat sternotomy for aortic valve replacement. Two weeks postinsertion, it was discovered that the tip had migrated superiorly, terminating below the torcular in the posterior fossa. In the interventional suite, a three-dimensional venogram confirmed the inadvertent marginal sinus cannulation. The catheter was carefully retracted to the sigmoid sinus to preserve the option of catheter exchange if embolization became necessary. After a subsequent venogram, which displayed an absence of contrast extravasation, the entire catheter was safely removed. The patient tolerated the procedure well.

LESSONS Clinicians must be vigilant of catheter tip migration and malposition risks. Relying solely on postinsertion radiographs is insufficient. Once identified, prompt management of the malpositioned catheter is paramount in reducing morbidity and mortality and improving patient outcomes.

Removing a malpositioned catheter constitutes a critical step, best performed by a specialized team under angiographic visualization.

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Central venous catheters (CVCs), defined as a catheter inserted into a large central vein, typically with their tip positioned within the superior vena cava (SVC) or inferior vena cava, play an indispensable role in the clinical management of many patients across various clinical contexts. In the United States, more than 5 million CVCs are inserted annually for a broad spectrum of clinical indications such as drug administration, hemodynamic monitoring, parenteral nutrition, and optimizing the management of patients in the intensive care unit (ICU).1

Common anatomical sites for CVC placement include the femoral, subclavian, and internal jugular vein (IJV), with the latter emerging as the favored approach because of its higher success rate and relatively lower incidence of complications.2,3 In clinical practice, the right IJV is often preferred over the left counterpart because of its larger diameter, more direct route to the SVC, the absence of the thoracic duct, and reduced complications.4–6 The successful placement of a CVC requires not only technical proficiency but also a keen understanding of the potential complications. Although placement of CVCs is generally regarded as a safe procedure, a range of complications has been reported during both the insertion and maintenance phases of the catheter. These include mechanical complications, such as arterial puncture, pneumothorax, and cardiac tamponade, occurring in approximately one-fifth of patients, infections in roughly one-fourth of patients, and the potential for thrombotic events in one of every four cases.7,8

Catheter malposition, a relatively common adverse event occurring in approximately 3% to 14% of cases,9 can lead to severe complications, including potentially fatal outcomes if not promptly addressed.10,11 Catheter malposition may manifest either during initial insertion or later as a result of catheter tip migration. Catheter
Illustrative Case

A 65-year-old male patient presented to our university hospital with a complex medical history significant for rheumatoid arthritis, interstitial lung disease, a prior left middle cerebral artery stroke, aortic stenosis that had necessitated aortic valve replacement (AVR), followed by a total aortic valve replacement (TAVR) 7 years later. The patient presented with recurrent hemoptysis, shortness of breath, and a deteriorating general condition and had been admitted for hypoxic respiratory failure. Subsequent evaluation identified severe intrathoracic regurgitation of the TAVR and moderate mitral regurgitation as the underlying causes of the hemoptysis. Consequently, the patient underwent a repeat sternotomy for AVR, mitral valve replacement, and coronary artery bypass grafting.

In summary, the patient was taken to the operating room. After anesthesia induction and intubation, and under ultrasound guidance, an 8-Fr triple-lumen CVC was inserted via the Seldinger technique into the right IJV using the central approach. The cannulation proceeded without difficulty, and the procedure concluded without apparent complications. However, 2 weeks postinsertion, as the patient’s hemodynamic status improved and his pulmonary artery catheter was removed, it was discovered that the central line, which had been obscured by the pulmonary artery catheter on chest radiographs, had migrated superiorly (Fig. 1). Further evaluation via head computed tomography (CT) demonstrated that the distal end of the CVC was terminating below the torcula in the posterior fossa (Fig. 2). Venous pressure measurements taken from this line registered in the range of 15 to 20 mm Hg, raising concerns regarding intracranial venous pressure. Consequently, the ICU team inserted a new central line in the left IJV and halted all medication infusions through the right line. Our neurosurgery department was consulted to manage and remove the malpositioned catheter. Unfortunately, because of the patient’s incompatible pacing wires, brain magnetic resonance imaging (MRI) could not be performed to distinguish between cerebellar parenchymal and distal venous positioning.

The patient was taken to the interventional suite for angiographic evaluation and removal of the malpositioned catheter under direct visualization using biplanar fluoroscopy. Initially, a gentle contrast injection was attempted via the triple-lumen catheter, but the catheter was found to be occluded. The right-sided femoral artery catheter was catheterized with a 5-Fr sheath. A 0.038 Terumo guidewire and a 5-Fr Berenstein catheter were introduced into the aorta, navigated into the arch, and selectively catheterized the right vertebral artery. A three-dimensional (3D) venogram was then obtained to precisely determine the catheter’s position in relation to the torcula. This revealed that the catheter was coursing superiority into a posterior fossa vein near the transverse sigmoid junction and likely had cannulated the marginal sinus (Figs. 3 and 4). The securing 5–0 Prolene suture around the catheter was cut, and the catheter was gently retracted until its tip reached the distal sigmoid sinus. This precautionary step was taken to preserve the option of exchanging the catheter for a 6-Fr sheath over an exchange wire if embolization became necessary. Subsequently, another venogram was obtained, revealing no contrast extravasation (Fig. 5). The entire central line catheter was carefully removed, and an occlusive dressing was applied. A final venogram, obtained 5 minutes postremoval, showed no evidence of contrast extravasation.

The patient tolerated the procedure well and was transferred to the surgical ICU in stable condition. A postoperative head CT scan was negative for intracranial hemorrhage or any other acute pathology.

Patient Informed Consent

The necessary patient informed consent was obtained in this study.

Discussion

CVC placement is one of the most indispensable procedures for managing critically ill patients. Despite its widespread utilization and apparent procedural simplicity, complications can still arise, some of which can be severe. Traditionally, CVC placements relied on anatomical landmarks for guidance. However, incorporating ultrasound guidance has notably increased the success rate of catheter placements and substantially reduced the relative risk of complications by up to 73%. In a systematic review encompassing 35 trials with 5,108 participants and evaluating the efficacy of
ultrasound-guided IJV CVCs, Brass et al.\textsuperscript{13} reported that compared to the landmark-based approach, ultrasound guidance increased the rate of successful catheter placement from 91.7\% to 97.6\% and reduced the overall incidence of complications from 13.5\% to 3.4\%.

Despite the widespread adoption of ultrasound-guided techniques, it is important to remember that complications remain an inherent aspect of any invasive procedure. Catheter malposition, characterized by the inadvertent placement of the catheter tip within an inappropriate vessel, has been reported in 14\% of CVCs, even when inserted by experienced clinicians and guided by ultrasound.\textsuperscript{9} Although the optimal IJV CVC tip position is still under debate,\textsuperscript{19,20} it is generally recommended that the tip reside at the level of mid-lower SVC to cavoatrial junction, proximal to the pericardial sac to prevent the severe complication of cardiac tamponade. However, if the tip is placed too proximally within the subclavian vein, there can be an increased risk of thrombosis and vessel occlusion.\textsuperscript{15}

**Observations**

CVC malposition can occur during insertion or due to the migration of a catheter tip initially placed in an ideal position. Although the mechanisms behind CVC migration remain incompletely understood, they appear to be multifactorial. Postinsertion movement of the catheter tip can be influenced by respiratory movements, catheter type, insertion site, patient body habitus (particularly obesity), gender (female), and venous anatomy.\textsuperscript{12} In their analysis of 177 patients with IJV CVCs (127 right-sided and 50 left-sided), Smith et al.\textsuperscript{4} reported that left-sided CVCs had a mean cranial tip migration of 3.2 cm (standard deviation [SD] 2.9 cm) versus 0.8 cm (SD 1.9 cm) for right-sided CVCs (p < 0.05) and that catheters that migrated cranially by more than 2 cm had over seven times the dysfunction risk.

Smith et al.\textsuperscript{4} attributed this tip migration to the length discrepancy of left and right CVCs (left CVCs are typically 4 to 6 cm longer), as well as the CVC's polymer (thermoplastic polyurethanes), which tends to soften at body temperature, potentially increasing catheter laxity and promoting migration in longer catheters. Tip migration has also been associated with respiratory movements, with an average displacement of 9 mm during expiration.\textsuperscript{21} The cumulative effect of positional variations becomes more pronounced, particularly when the catheter tip is originally placed too far distally or in patients with atypical...
vascular anatomy. It is worth emphasizing that the venous anatomy in the head and neck region can exhibit substantial variability in terms of major tributaries and minor collaterals.22 Large-scale studies, including prospective investigations, are warranted to elucidate the factors contributing to catheter tip migration.

Catheter malposition within the IJV is usually inconsequential; however, rare instances have been associated with severe complications.3,10,11,15,23 Trimble and Ivanick3 reported a case in which a wire had been inadvertently advanced beyond the torcula, extending into the contralateral transverse venous sinus during subclavian central line placement. Other cases involving cannulation of the sigmoid sinus, followed by uncomplicated catheter withdrawal and repositioning, have been reported.24 Additionally, Seung et al.16 reported the case of an infected, malpositioned IJV CVC, resulting in jugular vein–sigmoid sinus thrombosis, ultimately leading to the patient’s death. Shah et al.11 documented three cases in which patients experienced neurological symptoms due to arterial misplacement of IJV CVCs. Although one patient experienced a full recovery, another exhibited partial improvement, and the third remained in a deep coma.11 Similarly, Anderson et al.15 reported two pediatric patients who suffered neurological complications due to intracranial CVC malposition, leading to a subdural hematoma and significant mass effect and resulting in death. In our case, the catheter placement resulted in what was likely the cannulation of the marginal sinus (Fig. 4). This occurrence can be attributed to a combination of factors, including poor ultrasound visualization, the patient’s body habitus, and a lack of thorough examination of the postplacement radiograph and chest CT.

Lessons
The management of malpositioned catheters is contingent on several factors, including the catheter’s location, the indication for placement, and the patient’s clinical condition. The CVC can be safely removed if it is not traversing or located within a vulnerable structure. However, when the catheter is positioned within a large and noncompressible artery or vein or when there are concerns regarding vascular injury, careful consideration and further imaging investigations are warranted before catheter removal due to the potential risk of complications, notably uncontrolled hemorrhage, and neurosurgery or vascular surgery consults may be necessary. Exercising caution and avoiding removal in situations of uncertainty is advisable. In our case, upon identifying the inadvertent cannulation, neurosurgery was immediately consulted for evaluation, removal, and potential distal control with embolization. Delays in diagnosis and treatment frequently result in substantial morbidity and death.

Concerns regarding potential distal venous injury within the posterior fossa prompted us to transport the patient to the angiography suite in anticipation of the possible need for embolization. Before catheter removal, we established right femoral arterial access and a 3D venogram of the posterior fossa. Subsequently, the CVC was carefully withdrawn into the sigmoid sinus without complication, and another venous phase run was performed. It was noted that the CVC had likely cannulated the marginal sinus. However, if contrast extravasation into the posterior fossa had occurred, our strategy was to exchange the right IJV catheter for a 6-Fr short sheath and proceed with distal venous embolization using N-butyl cyanoacrylate or Onyx agents. The CVC was successfully removed without complication, and gentle pressure was held with an occlusive dressing.

To mitigate the risk of catheter malposition and migration, the right IJV should be preferred unless contraindicated.4,25 Essential aspects of CVC placement include catheterization of the venous system, accurate orientation of the line placement, and prevention of injury to local anatomical structures. Successful cannulation can be confirmed by blood color comparison, manometry, pressure waveform analysis, blood gas analysis, and ultrasound guidance. It is recommended to obtain a chest radiograph postinsertion to confirm the catheter tip placement and rule out procedural complications.26 However, as demonstrated in our case, there are limitations to such an imaging modality with its two-dimensional projection and the proximity of vessels and mediastinal structures, which can make precise catheter tip localization challenging. Moreover, routine radiography after uncomplicated right IJV CVC placement remains a subject of debate in the literature.27 Our report showcases that relying solely on postinsertion chest radiography to determine the correct placement of the CVC tip is not sufficiently accurate. Thus, exploring alternative methods and modalities that offer higher sensitivity and specificity is essential. It is important to note that simple observation of the patient’s symptoms can also help in the early detection of CVC malposition, such as complaints of neck pain, a “water running” sensation, or headache, which may indicate infusing near intracranial structures.21

In conclusion, CVC placements rank among the prevalent invasive procedures routinely performed in critically ill patients. Clinicians must be vigilant of catheter tip migration and malposition risks, which can lead to severe complications. Once identified, the prompt management of a malpositioned catheter is paramount in reducing morbidity and death and improving patient outcomes. Removing a malpositioned catheter constitutes a critical step, best performed by a specialized team under angiographic visualization.

References


Disclosures

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Author Contributions

Conception and design: Hebert, Amllay, Nowicki, Koo. Acquisition of data: Amllay, Nowicki, Sujijantarat, Koo. Analysis and interpretation of data: Hebert, Amlay, Nowicki, Matouk. Drafting the article: Amllay, Owolo, Nowicki, Antonios. Critically revising the article: Amllay, Owolo, Nowicki, Sujijantarat, Koo, Renedo. Reviewed submitted version of manuscript: Hebert, Amllay, Nowicki, Sujijantarat, Renedo, Matouk. Approved the final version of the manuscript on behalf of all authors: Hebert. Administrative/technical/material support: Amllay. Study supervision: Hebert.

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