Is ultrasound guidance sufficient?

Central venous catheter malpositioning despite ultrasound-guided placement

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Abstract

Introduction: real-time ultrasound guidance has reduced the complications of central venous catheterization; however, catheter tip malpositioning persists and may be associated with device malfunction and thromboembolic events.

Case presentation: we present two cases of "U-shaped" malpositioning of central venous catheters placed under ultrasound guidance, one through the right subclavian and the other through the left internal jugular, which required immediate relocation after x-ray confirmation. Both patients recovered without complications.

Conclusion: recent literature shows residual malpositioning despite the use of ultrasound, indicating that immediate verification improves with the addition of a second bedside method, such as intracavitary electrocardiography, an agitated saline contrast study, or central venous pressure measurement. These cases illustrate the limitations of only using ultrasound and support the implementation of combined algorithms to reduce adverse events. **(Acta Med Colomb 2026; 51. DOI: https://doi.org/10.36104/amc.2026.4804).**

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Introduction

Central venous catheter (CVC) placement is essential in the intensive care unit for vasoactive drug infusion, hemodynamic monitoring, and parenteral nutrition. Since 2020, the guidelines have recommended using real-time ultrasound as a first-line technique, as it is associated with fewer complications and greater first-attempt success (1-3). However, using ultrasound during puncture does not guarantee optimal placement of the catheter tip: recent meta-analyses and cohort studies report mechanical malpositioning in 3 to 15% of insertions, even under ultrasound guidance (4, 5).

The consequences of malpositioning include catheter dysfunction, arrhythmias, thromboses, and even cardiac tamponade (3). In light of this limitation, various bedside verification methods have emerged as immediate complements, including intracavitary electrocardiography, the agitated saline test, central venous pressure waveform analysis, and contrast echocardiography (6-8). Recent comparative tests support the high precision of the modified method with electrocardiographic guidance (9).

Below, we describe two cases of "U-shaped" malpositioning after ultrasound-guided cannulation and discuss the need to combine ultrasound with a second verification method to optimize the safety of the procedure.

Case presentation

Case 1

A male patient in his 80s with a history of hypertension and recent urological surgery was admitted to the intensive care unit due to postoperative respiratory failure related to vasodilatory shock. A right subclavian central venous catheter was placed under ultrasound guidance; horizontal placement of the needle and guidewire within the vessel was confirmed by ultrasound. Subcostal ultrasound verification showed central flow; however, the anteroposterior chest x-ray showed a malpositioned catheter with a retrograde "U-shaped" trajectory and cephalic advancement of the distal end (Figure 1). With this finding, the catheter was withdrawn and repositioned properly, with subsequent verification.

Case 2

A female patient in her 70s with a history of diabetes mellitus, chronic kidney disease, and hypertension was admitted for post-cardiorespiratory arrest syndrome. She underwent emergency cannulation of the left internal jugular vein under ultrasound guidance, with confirmation of horizontal guidewire placement. The chest x-ray revealed a similar cephalic malpositioning (Figure 2). The catheter was removed, and a

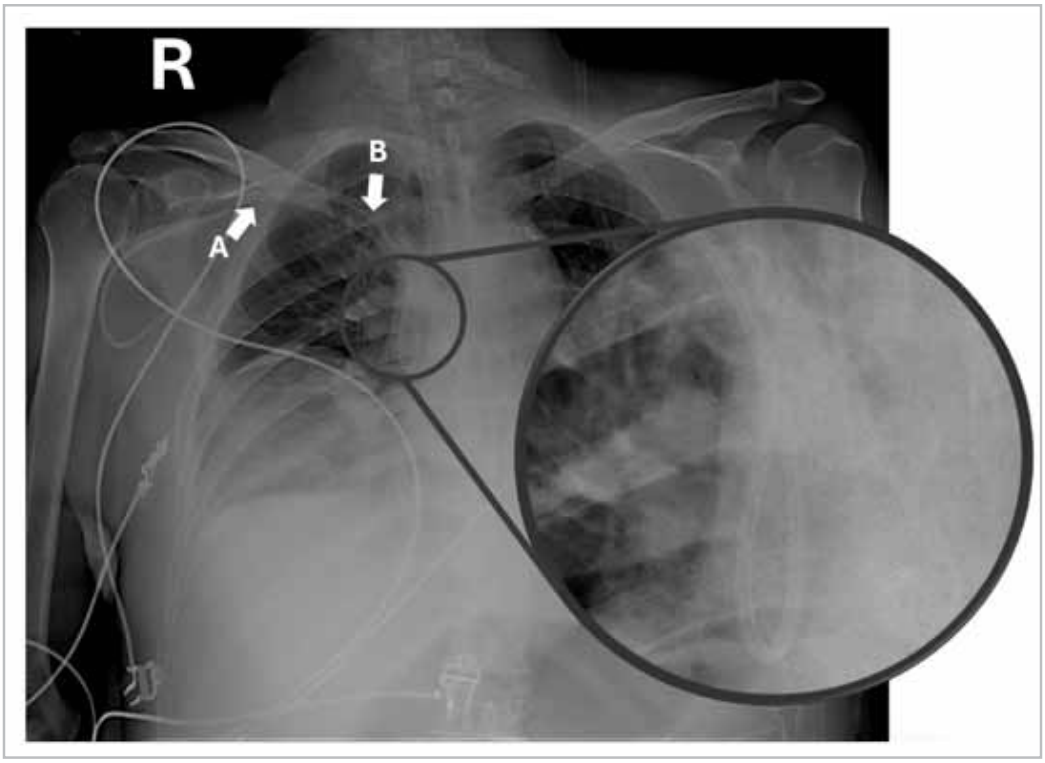


Figure 1. *Anteroposterior chest X-ray. Arrow A indicates the entry point of the central venous catheter (CVC), arrow B indicates the initial cephalic trajectory; the circle with a magnifying glass highlights the "U-shaped" retrograde loop toward the neck.*

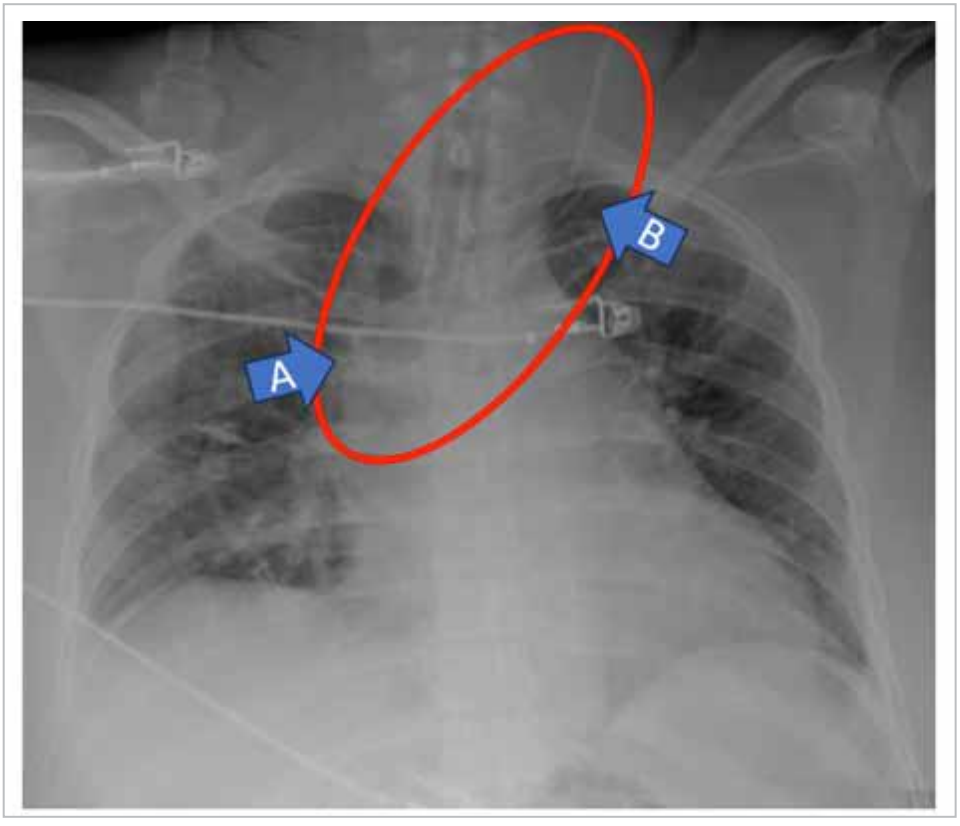


Figure 2. *Anteroposterior chest X-ray. Arrow A shows the retrograde "U-shaped" curve of the left jugular central venous catheter; arrow B indicates the tip. The red oval demarcates the aberrant cephalic trajectory.*

new CVC was placed, confirming its position with a combined technique (ultrasound and follow-up X-ray).

Both patients were discharged from the unit in stable clinical condition with no complications attributable to the catheter.

Discussion

Both cases show that, while ultrasound-guided catheterization reduces the incidence of pneumothorax, hematomas, and arterial puncture, it does not eliminate the risk of the catheter tip taking aberrant trajectories once it leaves the transducer's visual field (4, 5). In both patients, the initial puncture was correct; the error occurred while advancing the catheter and navigating intrathoracically, which supports the need for additional immediate verification.

The available evidence reports that various complementary bedside methods allow confirmation of central positioning and help detect malpositioning with high precision. Intracavitary electrocardiography identifies the cavo-atrial junction through P-wave enlargement, with an approximate sensitivity of 97% (6). The agitated saline test (rapid atrial swirl sign) allows microbubbles to be seen in the right atrium, with sensitivities and specificities approaching 90-96% (7). Central venous pressure wave analysis and contrast echocardiography also achieve high diagnostic levels (10, 11). In contrast, techniques like portable X-ray, while widely available, have lower diagnostic performance, with lower sensitivity and specificity, along with delayed confirmation (12). Continuous fluoroscopy provides almost total precision but has limited use outside of specialized areas (13). Venous blood gas comparison is an indirect alternative when other tools are not available (14). All these modalities are summarized in Table 1, along with their sensitivity and level of scientific evidence.

Previous reports, like Schummer et al. and Rossetti et al.'s, have documented similar malpositioning even under ultrasound guidance, mainly retrograde "U-shaped" trajectories or cephalic advances after technically correct punctures. These findings highlight the persistence of unseen factors during intrathoracic navigation and operator-dependent variability. Recent observational studies report 2 to 8% incidences of aberrant trajectories despite the systematic use of ultrasound, most often in left subclavian and jugular access (15, 16). Controversy also persists regarding the lack of standardized immediate verification, limited accessibility of intracavitary electrocardiography in resource-restricted settings, and the still insufficient role of training programs for ultrasound identification of the catheter tip (17, 18). These gaps justify the adoption of combined algorithms adapted to each institutional setting, as well as the need for prospective Latin American studies to evaluate their actual impact on the safety of critically ill patients.

Together, these findings emphasize that the safety of central venous catheterization depends not only on the guidance technology used but also on dynamic verification of the position and ongoing training of the operator.

Based on the above, we propose a simple institutional algorithm: 1) ultrasound guidance for the puncture; 2) immediate confirmation using intracavitary electrocardiography or the agitated saline test, depending on the cardiac rhythm and availability; and 3) selective use of X-rays to rule out pleuropulmonary complications or when ultrasound is not available. This strategy aligns with recent reviews that underscore the value of a dual modality for reducing complications and avoiding treatment delays (19).

Table 1. *Published sensitivity and specificity for the main bedside techniques to verify the CVC tip (2017-2024).*

Technique	Sensitivity / Specificity (%)	Source
Ultrasound + bubble test (RASS)	89 - 90	Bou Chebl R, et al. *J Ultrasound Med*. 2017;36:2503-2510.
Intracavitary ECG	97 - 80	Xang X, et al. *Ann Palliat Med*. 2021;10:10228-10235.
Central venous pressure wave	97.5 -100	Chua CKZ, et al. *Aust Crit Care*. 2024;37:628-631.
Biplane ultrasound (short + long axis)	100 - 68	Smit JM, et al. *Crit Care*. 2018;22:65.
CE-TTE (contrast echo) & TEE	CE-TTE 97-90 TEE 97-98	Vezzani A, et al. *Crit Care*. 2022;26:94.
Chest X-ray	85 - 50	Coleman M, et al. *S Afr J Radiol*. 2023;27:e2587.
Continuous fluoroscopy	Precision ≈ 100 (with direct guidance).	Galante O, et al. *Crit Care Med*. 2017;45:e994-e1000.
Central venous gas comparison	86 - 78	Sánchez-Muñoz JJ, et al. *Investig Clin*. 2021;62:219-229.

CVC: central venous catheter; ECG = electrocardiogram; CE-TTE: contrast echocardiography- transthoracic echocardiography; TEE: transesophageal echocardiography. Main immediate verification techniques for central venous catheters (CVCs) described in the recent literature, with their respective sensitivity and specificity along with their source.

Limitations

This is a small series without long-term follow-up. However, the findings are consistent with the available literature and reinforce the clinical applicability of the proposed algorithm.

Conclusion

Central venous catheter malpositioning can occur despite ultrasound-guided cannulation. Systematic incorporation of a second bedside verification method facilitates early detection and safe catheter replacement, optimizing the care of critically ill patients.

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