

# Arterial Placement of Central Venous Catheters: Beyond Prevention to Management

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## Abstract

Arterial misplacement of central venous catheters can often be avoided with the use of real-time ultrasound-guided procedural competency. However, misplacement can still occur and is more likely to occur when the internal jugular vein is located directly above the common carotid artery. The resultant injury to the common carotid artery occurs through the posterior wall of the internal jugular vein. Arterial injury may also occur when the subclavian vein is attempted in a non-ultrasound-guided fashion. Optimal management requires a coordinated evaluation of the catheter misplacement by Interventional Radiology and Vascular Surgery to ensure maximum patient safety during catheter removal. This article reviews the literature on this topic and provides a summary of the best approach to safely remove the misplaced catheter.

## Resume

Le mauvais positionnement artériel des cathéters veineux centraux peut souvent être évité grâce à l'utilisation de compétences procédurales guidées par ultrasons en temps réel. Cependant, un mauvais positionnement peut toujours se produire et est plus susceptible de se produire lorsque la veine jugulaire interne est située directement au-dessus de l'artère carotide commune. La lésion de l'artère carotide commune qui en résulte se produit à travers la paroi postérieure de la veine jugulaire interne. Une lésion artérielle peut également se produire lorsque la veine sous-clavière n'est pas guidée par un ultrason. Une gestion optimale nécessite une évaluation coordonnée du mauvais positionnement du cathéter par la radiologie interventionnelle et la chirurgie vasculaire afin de garantir une sécurité maximale au patient lors du retrait du cathéter. Cet article passe en revue la littérature sur ce sujet et fournit un résumé de la meilleure approche pour retirer en toute sécurité le cathéter mal placé.

## Case Presentation

A 62-year-old man with viral myocarditis and acute renal failure had a 14 French (Fr) left internal jugular dialysis line placed for renal replacement therapy. Following the insertion of the dialysis line, the resident assessed the transduced waveform and correctly identified that it was an arterial pattern. Arterial cannulation of the carotid artery was further supported by

blood gas analysis and chest x-ray (Figure 1). A CT angiogram confirmed that the catheter had been placed into the proximal left common carotid artery within the patient's thoracic cavity posterior to the clavicle and that the arterial cannulation had been through the posterior wall of the left internal jugular vein. Vascular Surgery and Interventional Radiology were consulted urgently. Endovascular options including the use of an arterial

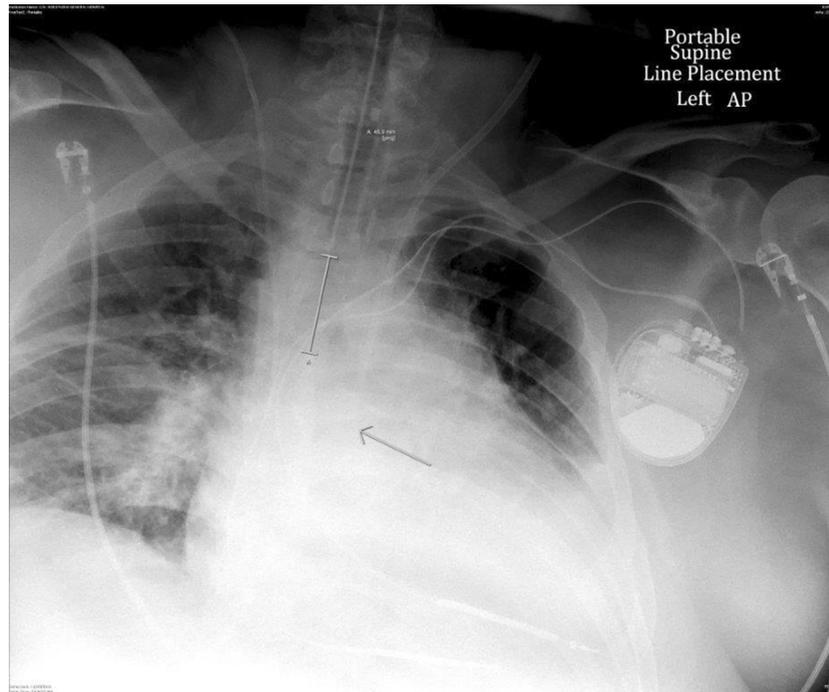


Figure 1. Chest x-ray showing arterial cannulation of the carotid artery.

closure device or the placement of a covered stent combined with venous balloon tamponade options were considered, but, ultimately, an open surgical repair in a hybrid operating room with conventional surgical supplies and endovascular supplies readily at hand was felt to be the safest approach. The surgery was delayed by 48 hours because the patient had been on Apixaban before hospitalization and was felt to be at increased risk of bleeding complications. A heparin infusion was initiated and continued until the surgical intervention. The open surgery successfully removed the catheter without complications and did not require the utilization of the hybrid approach.

Many critically ill patients require the placement of a central venous catheter (CVC) during the course of their hospitalization. Complications associated with internal jugular (IJ) and subclavian vein CVC insertion include pneumothorax (0.1–3%), hematoma (0.1–2.1%), arterial puncture (3.1–9.4%), arterial cannulation (<1%) and guide-wire embolism (<0.1%).<sup>1</sup> The potential consequences of these complications include permanent neurologic disability from cerebral ischemia, airway-threatening hematoma, tension pneumothorax, uncontrolled hemorrhage, emergent cardiovascular surgical interventions requiring general anesthesia, and death. Recognizing that complications from CVC insertion are inevitable despite the procedural competence of the operator necessitates a clear approach to managing these events so that further iatrogenic harm to patients can be minimized.

The traditional means of averting arterial line misplacement include operator attentiveness to the colour and pulsatility of the blood coming from the needle after cannulation but these methods are frequently unreliable in isolation.<sup>2</sup> Real-time ultrasound-guidance is associated with improved success in correct CVC placement with fewer complications (relative risk 0.22 [95% CI: 0.1 to 0.45] and 0.53 [95% CI: 0.41 to 0.69] for IJ and subclavian veins respectively).<sup>3–5</sup> Newer echogenic cannulation needles further improve procedural safety by optimizing distal needle tip visualization during the procedure.<sup>6</sup> Despite the improved safety associated with employing ultrasound-guided procedures, when the common carotid artery is located underneath the IJ vein, operators may still puncture through the posterior wall of the vein resulting in arterial injury or cannulation.<sup>7,8</sup> This recurring complication pattern of injury reinforces the importance of visually confirming the position of the wire in both the cross-sectional and longitudinal ultrasound planes before dilation of the tract before catheter placement.

Management of arterial injuries from attempted CVC placement depends on the extent of the injury, location of the injury, and clinical status of the patient. The incidence of arterial needle puncture during CVC placement is estimated at 3.7 to 12% and is usually promptly recognized and managed with removal of the needle followed by direct manual compression to the cannulation site.<sup>9</sup> While unproven, smaller gauge needles (use of a micropuncture technique) may decrease the risk of

complications from an unintentional arterial puncture during CVC placement.<sup>10,11</sup> More significant arterial injury following tract dilation or catheter placement is estimated to occur at a frequency of 0.1 to 1% and necessitates a more comprehensive workup including specialist consultation due to the higher rates of neurologic or hemorrhagic complications associated with inattentive management of this situation.<sup>9</sup>

Many experienced clinicians believe that misplacement of smaller gauge catheters ( $\leq 7$ Fr triple lumen catheters) can be safely managed with a “pull-pressure” strategy (characterized by “pulling” the catheter out and applying “pressure” for 5–20 minutes) while acknowledging that larger bore catheters require removal with definitive open or endovascular repair. Published literature supports that patients have better outcomes when larger devices are left in situ so that surgical and endovascular expertise can be consulted to determine an optimal removal plan. A 2008 case series and review<sup>12</sup> described 30 cases where accidental large-bore ( $\geq 7$ Fr) cervicothoracic arterial cannulation patients were treated with the “pull-pressure” method ( $n=17$ ) compared to immediate removal by surgery ( $n=13$ ). Eight (47%) of the “pull-pressure” patients experienced complications including hematoma, airway obstruction, false aneurysm, stroke, and death. No complications occurred within the surgical management group. A 2017 systematic review<sup>9</sup> identified 80 case reports of inadvertent arterial injury. Twenty-two percent of these patients were treated with a “pull-pressure” approach resulting in a high proportion of patients (94.6%) experiencing severe complications such as failure to control hemorrhage, embolic stroke, or death. Comparatively, 95% of the patients treated with endovascular interventions experienced favorable outcomes and all 37 patients treated with primary surgical repair resulted in good neurologic outcomes. Strong data is supporting surgical or endovascular repair options for large-bore common carotid arterial injuries.

Management of inadvertent injury to the subclavian artery is complicated by the technical difficulty of accessing the region for primary surgical repair. Injuries to the subclavian artery, proximal carotid artery behind the clavicle, or innominate artery can be intra-thoracic and may require surgical interventions that require clavicular resection, a thoracotomy, or a sternotomy. A variety of covered stents, closure devices (e.g., Angio-seal<sup>TM</sup> and Perclose<sup>®</sup>), and tamponade products have been described to treat complications from CVC insertion resulting in subclavian artery cannulation.<sup>13,14–16</sup> However, closure devices are contraindicated if the injury site involves a branch or there is evidence of underlying arterial dissection and may have limitations such as a maximum French size or puncture site depth in which they can be used. The use of closure devices in this setting is also considered off label. These injuries require urgent CT angiography so that adequate procedural planning may occur to determine the safest

approach to remove the misplaced catheter. As institutional resources and skillsets vary, arterial cannulation events should be discussed with the local vascular surgical specialists. This is especially true for cannulations of  $\geq 7$ Fr, non-compressible sites, and patients on anticoagulation. Surgeons capable of vascular injury repair should be involved in the development of local policies and procedures regarding the surgical or endovascular treatment approach to iatrogenic vascular injuries. Hybrid operating rooms with fluoroscopy capabilities permit the use of combined open surgical and endovascular approaches and act as an ideal setting for bailout options if an initial operative strategy is unsuccessful.

Time to the removal of the misplaced catheter is another factor that confers a safety profile in favor of surgical removal. If greater than 4 hours have transpired since the vessel was cannulated there are fewer complications when catheters are removed surgically. This is because distal embolization events from thrombus build-up on cannulas can be minimized in the surgical setting via distal vascular control or surgical embolectomy if required. However, there is no timeframe for non-surgical removal that is considered completely “safe” so endovascular or surgical removal should always be a consideration.<sup>9</sup>

Inadvertent cervicothoracic artery cannulation during CVC placement is a rare complication that carries a high risk of morbidity and mortality. Addressing the risk of this event begins with prevention strategies that include operator attentiveness and the use of real-time ultrasound guidance. Whenever a catheter is inadvertently placed within an adjacent artery, a time-efficient and expedited management plan should be initiated that includes consultation for surgical removal instead of an uncontrolled “pull-pressure” removal technique. Arterial cannulation with catheters  $\geq 7$ Fr necessitates rapid consultation between the attending team and the most appropriate surgical service (vascular, neurosurgery, general surgery depending on practice setting). Arteriotomy sites that are not easily amenable to surgical exposure may be candidates for newer techniques using endovascular products to improve patient safety. Achieving the goal of safely removing a misplaced catheter requires the timely collaboration of services and should be guided by non-emergent plan development within individual institutions to improve patient safety during this high-risk period.

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