Ultrasound-Enabled Noninvasive Management of Inadvertent Carotid Cannulation

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ABSTRACT

Introduction: Despite ultrasound use, accidental carotid cannulation is possible during placement of a central venous catheter (CVC), requiring operative repair of the carotid artery and removal of the catheter.

Case Presentation: We report 2 cases—a 59-year-old Hispanic man and an 86-year-old white man—of inadvertent placement of a CVC into the left common carotid artery, removed via a pull-and-pressure technique under real-time ultrasound guidance. No complications occurred and follow-up imaging was negative for fistula creation, hematoma, or cerebral infarcts.

Discussion: Prior cases have reported accidental carotid cannulations that required operative repair. Our discussion focuses on the complications of removal of CVCs from the common carotid, and the utility, feasibility, and safety of using real-time ultrasound guidance in the removal.

Conclusion: While operative removal of CVCs accidentally placed in the carotid is recommended, an ultrasound-enabled pull-and-pressure technique may prevent complications and avoid need for surgical repair in critically ill patients.

BACKGROUND

Approximately 6 million central venous catheters (CVC) are inserted every year in the United States.[1] The current reported incidence of arterial cannulation is between 0.1% and 1%.[2] Ultrasound-enabled central venous cannulation has become the standard of care endorsed by multiple medical societies as well as the Agency for Healthcare Research and Quality.[3] Two meta-analyses have indicated that ultrasound-guided insertion of central lines led to greater first pass success and fewer complications when compared to a blind landmark technique.[4-5] However, accidental arterial cannulation is possible even with the use of ultrasound guidance.[6] This is more likely to occur in emergent conditions and in patients who are severely hypotensive and/or hypoxic where the pulsatility and color of blood may be difficult to determine. Underrecognized, it may lead to vessel dilation and catheter insertion leading to significant arterial injury/risk of stroke, and other complications. A video analysis of accidental arterial cannulations indicated that the short axis view provides a false sense of security to the practitioner and allows for potentially dangerous accidental arterial cannulation.[3] The recommendation from the Society for Vascular Surgery in cases of accidental arterial cannulations is to keep the catheter in place and urgently seek assistance of vascular surgeons for operative repair of the artery.[7] Past experiences of pull-and-pressure technique have been reported to be associated with significant complications including stroke and hemorrhage.[7]

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Materials and Methods

Two patients who had accidental carotid cannulation in the past 10 years at our institution were identified. This case report received exemption from the Institutional Review Board. Their clinical courses were reviewed, and information regarding their past medical history, comorbid disease, physical examination, laboratory investigation, and imaging results were recorded.

Case 1

A 59-year-old Hispanic man with type 2 diabetes and obesity was transferred to our hospital for management of cardiogenic shock post-myocardial infarction. An intra-aortic balloon pump was placed through a right femoral vein and a hemodialysis catheter

through the right internal jugular vein. He was then transferred to our hospital for evaluation of a mechanical cardiac device implantation. On admission, he was hemodynamically unstable with systolic blood pressures ranging from 60 to 80, on dobutamine, epinephrine, vasopressin and norepinephrine drips, and an intra-aortic balloon pump at 1:1 augmentation. The patient was anticoagulated with heparin. He was ventilated mechanically with high ventilator settings of 100% and 10 cm of positive end expiratory pressure, yet remained hypoxic with oxygen saturation ranging from 87% to 93%. A decision was made to place an 9 French Cordis introducer and Swan-Ganz catheter for hemodynamic monitoring. Ultrasound guidance utilizing the Seldinger technique was used to access the left internal jugular vein (LIJV). Dark red blood was aspirated, and manometry estimation of vessel pressure was performed and believed to be venous, as there was no pulsatility. The wire was visualized with ultrasound in the short-axis view and verified to be in the LIJV.

After the Swan-Ganz catheter was transduced, the wave form observed correlated with the systemic arterial waveform and pressures. Vascular surgery was consulted. A duplex ultrasound confirmed the catheter sheath had pierced the anterior and posterior walls of the left interior jugular and entered the left carotid artery (Figure 1).

The patient was considered extremely high risk for operative morbidity and mortality, as even transport to the operating room would have been a logistic challenge. Therefore, after multidisciplinary discussions, and based on the recommendation of the senior vascular surgeon, it was decided to proceed with ultrasound-guided compression and removal of the catheter—an ultrasound-enabled "pull-and-pressure" technique. The catheter was pulled, and the ultrasound technician held sonographic compression for 60 minutes with real-time visualization of the carotid and internal jugular vessels. Post ultrasound-enabled compression images were acquired after 60 minutes of compression and 24 hours later. No color flow was noted between the internal jugular vein and carotid artery, and therefore, there was no evidence of fistulous connection (Figure 2). The patient recovered hemodynamically over several days and was able to maintain a normal neurologic exam. A computed tomography (CT) head obtained after the event for mechanical circulatory assist device evaluation work-up

Figure 1. Central Venous Sheath in the Carotid Artery Before Removal and Compression

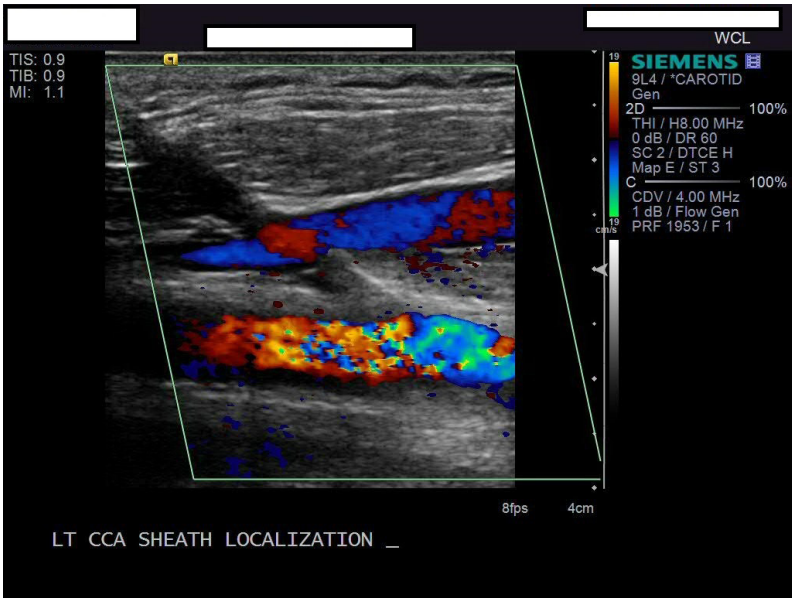
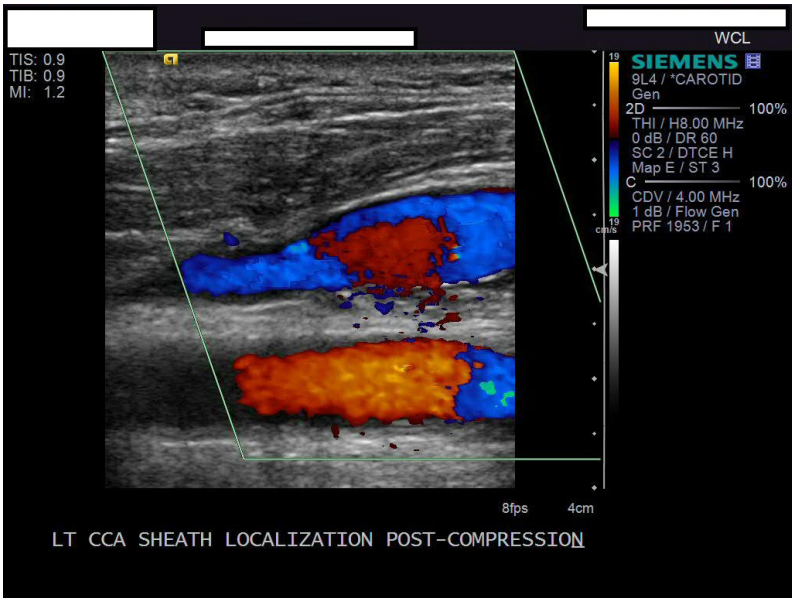


Figure 2. Internal Jugular and Carotid Artery After Removal of Venous Sheath and Ultrasound-Enabled Compression



revealed no infarcts. However, in the following 2 weeks, the patient deteriorated again with septic and cardiogenic shock and was deemed ineligible for a mechanical circulatory assist device and comfort care measures were initiated.

Case 2

Our second case involves an 86-year-old white man with atrial fibrillation, pulmonary hypertension, congestive heart failure, mitral stenosis, previous aortic valve replacement with porcine valve, and 2-vessel coronary artery bypass graft. He presented to our institution with lightheadedness and was found to have atrial fibrillation with rapid ventricular response. He was admitted to the cardiology service and was found to have a severely calcified mitral valve. Cardiac catheterization revealed 60% stenosis of the left anterior descending artery. Two days after cardiac catheterization, the patient became hypotensive and was transferred to the intensive care unit. Invasive monitoring and active resuscitation efforts were initiated.

While placing an 8 French Cordis introducer using the Seldinger technique, the vein was cannulated under ultrasound guidance, but dark pulsatile bleeding was noted. The needle was withdrawn and manual pressure held over the puncture site. Cannulation with a needle was attempted a second time and again dark pulsatile bleeding was noted.

With a history of tricuspid regurgitation and pulmonary hypertension, venous cannulation can encounter dark, pulsatile bleeding. Ultrasound-guided confirmation of LIJV guidewire cannulation was obtained and the introducer was advanced into the vessel. Upon transducing the introducer, an arterial waveform and pressures were noted. Vascular surgery was consulted. The patient was deemed too unstable for immediate transport to the operating room for catheter removal and carotid artery repair. Resuscitation efforts were ongoing and ultrasound-guided compression of the arteriotomy was performed by the interventional radiology technician and physician.

The ultrasound technician first performed a diagnostic ultrasound, which included visualization of the path of the catheter into the carotid artery and the arterial insertion site. No active extravasation was noted, nor thrombus formation. The catheter was removed with the ultrasound probe directly over the arteriotomy site, which allowed for pressure to be maintained in a directed fashion over the arteriotomy and allowed confirmation of distal arterial flow. Pressure was maintained for 45 minutes. Completion ultrasound showed no evidence of pseudoaneurysm or arteriovenous fistula and confirmed a patent subclavian artery. The patient ultimately developed acute renal failure and refused hemodialysis. He passed away 6 days after his cardiac catheterization procedure.

DISCUSSION

The occurrence of cannulation of the carotid artery when placing a CVC has significantly decreased with utilization of real-time point-of-care ultrasound. In 2006, a study by Karakitsos et al demonstrated the incidence of carotid cannulation by landmark method was 10.6% vs 1.1% in the ultrasound group.[8] The standard of care now is to place CVCs with ultrasound guidance. In this case series, one CVC was placed by a staff physician assistant and a cardiology fellow, both with attending direct supervision. Both operators had received formal ultrasound training. We advocate that all staff, residents, and allied health professionals performing CVC have formal ultrasound training. If the operator questions whether the CVC has been inadvertently placed in the artery, there are several ways to troubleshoot: manometry, pressure transduction, and blood gas analysis (sent with a guidewire remaining in the vessel held by the operator, with further cannulation proceeding if analysis shows venous blood). The operator should abort the line if there is concern or there is verification that the line has been placed in the arterial system prior to dilatation. When a complication does occur, there are generally 2 possible methods of removing the catheter: "pull-and-pressure" or vascular surgical repair. The "pull-and-pressure" method carries a high rate of complications. In 2008, Guilbert et al retrospectively reviewed the literature of cases with catheter-related cervical-thoracic arterial injury.[7] Complications were experienced by 47% who had the cannula initially removed via pull-and-pressure method, whereas none of the patients with catheters removed by initial vascular surgical approach suffered complications. In a retrospective analysis of 3 large institutions in Canada involving 13 patients, five had the catheter removed via the pull-and-pressure method, and all suffered major complications.[7] Complications include development of a hematoma, airway obstruction, stroke, and false aneurysm, especially when the site of arterial trauma cannot be effectively compressed. However, use of ultrasound to enable pull-and-pressure while direct visualization of the arterial injury site has not been described previously.

A multidisciplinary team approach to management of complications is vital in order to maximize clinical effectiveness. In both cases, extensive discussions were held among the intensive care unit, vascular surgery, and ultrasound radiology teams. Risks and potential of failure were assessed in detail. Due to high risk of operative intervention with hemodynamic and respiratory instability, the teams agreed upon ultrasound-enabled compression of the arteriotomy site under direct visualization. The phased array probe was used in a longitudinal direction without compromising distal arterial flow. Of note, the ultrasound-enabled compression was held for at least 45 minutes in both cases while visualizing the interior jugular and carotid vessels simultaneously. In the majority of the literature, compression was held from anywhere between 15 and 30 minutes. Immediate follow-up color Duplex was obtained to evaluate for hematoma or arteriovenous (AV) fistula. We also obtained a follow-up duplex 24 hours later to confirm the absence of vascular pathology (eg, development of an AV fistula). It is important to remember that complications can occur later, and

repeat imaging should be considered in any symptomatic patient who suffers an inadvertent arterial cannulation on follow-up. Iatrogenic carotid-jugular fistulas can cause systemic embolization, infection and, with time, high output cardiac failure. The duration of follow-up is not clearly known, and cases of AV fistula have been described over several months or even years.[9,10]

Given the nature of patients who generally receive CVC, most who are hemodynamically unstable, we propose an ultrasound enabled "pull-and-pressure" method for removal of venous cannula placed in the carotid artery inadvertently. The proposed method is time-intensive, staff-intensive, and operator-dependent for acquisition of images. Yet in the critical care setting, ultrasound is the standard of care with any procedure and initial assessment of most patients, making it rapidly available. The ultrasound-guided method of pulling an inadvertent carotid cannulation during CVC placement could sufficiently and effectively reduce not only the complications related to the pull and press method, but also avoid operating room exploration and the costs and staff associated with such procedure. Good communication between the operative team, vascular surgery and radiology is vital. Endovascular or surgical treatment should still be the first line approach in inadvertent carotid artery cannulation. However, in a restricted group of patients who have hemodynamic instability and high risk of operative intervention, ultrasound-enabled pull-and-pressure technique can be considered. Thorough and serial neurologic evaluation should be done after injury/repair to assess for signs of acute ischemia.

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REFERENCES

1. Bowdle A. Vascular complications of central venous catheter placement: evidence-based methods for prevention and treatment. *J Cardiothorac Vasc Anesth.* 2014;28(2):358-368. doi:10.1053/j.jvca.2013.02.027.

2. Reuber M, Dunkley LA, Turton EP, Bell MD, Bamford JM. Stroke after internal jugular venous cannulation. *Acta Neurol Scand.* 2002;105(3):235-239.

3. Blaivas M. Video analysis of accidental arterial cannulation with dynamic ultrasound guidance for central venous access. *J Ultrasound Med.* 2009;28(9):1239-1244.

4. Randolph AG, Cook DJ, Gonzales CA, Pribble CG. Ultrasound guidance for placement of central venous catheters: a meta-analysis of the literature. *Crit Care Med.* 1996;24(12):2053-2058.

5. Hind D, Calvert N, McWilliams R, et al. Ultrasonic locating devices for central venous cannulation: meta-analysis. *BMJ.* 2003;327(7411):361. doi:10.1136/bmj.327.7411.361.

6. Stone MB, Hern HG. Inadvertent carotid artery cannulation during ultrasound guided central venous catheterization. *Ann Emerg Med.* 2007;49(5):720. doi:10.1016/j.annemergmed.2006.11.030.

7. Guilbert MC, Elkouri S, Bracco D, et al. Arterial trauma during central venous catheter insertion: case series, review and proposed algorithm. *J Vasc Surg.* 2008;48(4):918-925. doi:10.1016/j.jvs.2008.04.046.

8. Karakitsos D, Labropoulos N, De Groot E, et al. Real-time ultrasound-guided catheterisation of the internal jugular vein: a prospective comparison with the landmark technique in critical care patients. *Crit Care.* 2006;10(6):R162. doi:10.1186/cc5101.

9. el-Shahawy MA, Khilinani H. Carotid-jugular arteriovenous fistula: a complication of temporary hemodialysis catheter. *Am J Nephrol.* 1995;15(4):332-336. doi:10.1159/000168859.

10. Sato O, Tada Y, Sudo K, Ueno A, Nobori M, Idezuki Y. Arteriovenous fistula following central venous catheterization. *Arch Surg.* 1986;121(6):729-731.

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