Management of Inadvertent Carotid Artery Sheath Insertion During Central Venous Catheter Placement

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IMPORTANCE Inadvertent carotid sheath insertion during central venous catheter placement could lead to serious complications.

OBJECTIVE To describe management of inadvertent carotid artery sheath insertion placed intraoperatively during attempted jugular venous cannulation for pulmonary artery catheter placement.

DESIGN, SETTING, AND PARTICIPANTS In a retrospective medical record review of patients from hospitals affiliated with Baylor College of Medicine, Houston, Texas, a total of 12 patients over 11 years who sustained intraoperative carotid artery introducer sheath placement during attempted jugular vein cannulation for pulmonary artery catheter placement were identified. Six patients underwent immediate carotid artery exploration with sheath removal and primary repair. The remaining 6 patients underwent percutaneous closure using a suture-mediated closure device. Treatment outcomes of these 2 groups were analyzed.

MAIN OUTCOMES AND MEASURES Technical success, duration of treatment, stroke, return to the operating room, and long-term outcomes.

RESULTS Technical success was achieved in all patients in both groups. The intended operations were aborted in all patients following catheter removal and carotid artery closure. The mean (SD) durations of treatment for the operative and endovascular groups were 32 (12) minutes and 6 (3) minutes, respectively (P = .03). No neurological deficit occurred in either group. The intended operations were all subsequently performed, and the mean delays of operation in the operative and endovascular groups were 5 and 3 days, respectively (P = .20). Follow-up carotid duplex showed no injury of the repaired artery in either group. During a mean follow-up of 42 months, no complications or neurological deficits were noted in either patient cohort.

CONCLUSIONS AND RELEVANCE Inadvertent carotid artery sheath placement during attempted central venous cannulation for pulmonary artery catheter insertion mandates catheter removal and repair of the carotid artery puncture site. The closure device permits percutaneous repair of the carotid artery expeditiously. Our experience showed this treatment modality to be as safe and effective as operative repair.

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Pulmonary artery catheters are widely used in the management of the critically ill patient. More than 2 million are sold annually in the United States. Also, more than 5 million central venous catheters (CVCs) are placed each year in the United States. The overall complication rate of CVC placement is approximately 15%.\(^1\) Arterial puncture during internal jugular vein cannulation is reported to be between 6.3% and 9.4%.\(^1\) Fortunately, the incidence of arterial cannulation is less than 1%.\(^2\)

With the increasing use of ultrasonographic guidance during CVC placement, higher rates of success on the first attempt and a decrease in the complication rates have been reported.\(^3\) As a result, the use of ultrasonographic guidance for CVC placement is one of the 11 practices listed by the Agency for Healthcare Research and Quality to improve patient care.\(^4\)

The larger the catheter inserted in the carotid artery is, the higher the complication rates are. Some authors recommend surgical removal of all catheters equal to or larger than 7F because manual compression is associated with devastating complications.\(^5\) The pulmonary artery catheter has a 7F catheter body and requires an 8.5F introducer sheath, which is much larger than the 5F to 7F CVC. Arterial injury can result in the development of hematoma, pseudoaneurysm,\(^6\) arteriovenous fistula,\(^7\) stroke,\(^8\) and death.\(^9,10\) Traditionally, this potentially lethal injury has been treated with open surgical repair. Endovascular treatment with a covered stent has been reported to treat this potentially life-threatening complication.\(^9,10\) The use of a closure device to treat inadvertent arterial injuries percutaneously has been limited to the subclavian artery.\(^10,11\) We were unable to find any data published on this technique to treat iatrogenic carotid artery injuries. We examine our data comparing iatrogenic carotid artery repair using an open surgical approach vs endovascular closure using a suture-mediated closure device.

Methods

A retrospective medical record review was performed at the hospitals affiliated with Baylor College of Medicine, Houston, Texas, to identify patients with inadvertent pulmonary artery catheter placement in the carotid artery from January 1, 2001, to December 30, 2011. This was performed using Current Procedural Terminology codes 35201 (open artery repair in the neck) and 36100 (introduction of needle or catheter, carotid or vertebral) as well as review of the anesthesia morbidity and mortality database. Institutional review board approval was obtained. We identified patients who underwent either surgical repair or endovascular repair using a suture-mediated closure device.

Our policy is to systemically treat all patients with misplaced catheters in the carotid artery with heparin. All the consultations were intraoperative while the patient was already under general endotracheal anesthesia. For open repair, we perform a cut down following the sheath down to the common carotid artery (CCA). Once proximal and distal control is obtained, the CCA is clamped, the sheath is removed, and the puncture site is closed primarily. It is advisable to let the carotid artery bleed to eliminate any clot or debris prior to establishing flow to the brain. The technique for percutaneous closure of the arteriotomy using a suture-mediated closure device is similar to femoral artery closure. We perform ultrasonography to evaluate the CCA atherosclerotic disease, amount of calcifications, and whether thrombus has begun to form around the catheter. Four of the 6 cases underwent carotid angiography using portable imaging (Figure 1) in addition to ultrasonography. We were unable to determine whether carotid angiography was performed because the findings on ultrasonography were inconclusive or if it was done to evaluate intracranial circulation. Based on the imaging findings, a decision is made whether to proceed with endovascular closure or open repair. The percutaneous closure of the carotid puncture site is performed using the Proglide 6F suture device (Abbott Vascular). A wire is passed into the sheath and into the descending thoracic aorta under fluoroscopy, followed by sheath removal and manual compression. Then, the closure device is placed over the wire and the sutures are deployed to close the arteriotomy. Pressure is held for 10 minutes while protamine sulfate is given. Prior to extubating the patient, ultrasonography is performed to confirm adequate closure with no thrombus or flap in the CCA.

We evaluated technical success, duration of treatment, and neurological deficit between the 2 treatment modalities. All patients were evaluated with carotid duplex postoperatively. The data were analyzed using Stata version 11.2 statistical software (StataCorp LP). \(P < .05\) was considered statistically significant.

Results

A total of 12 patients with inadvertent placement of an introducer sheath (8.5F) in the CCA during attempted jugular vein cannulation were identified. Adequate documentation that the procedure was performed using ultrasonography was found in only 2 cases. Six patients underwent operative exploration with sheath removal and primary repair of the arterial puncture site. The remaining 6 patients underwent successful percutaneous closure. Technical success was achieved in all patients in both treatment modalities. The intended operations were aborted in all patients following catheter removal and carotid artery closure. The mean (SD) durations of treatment for the operative and endovascular groups were 32 (12) minutes and 6 (3) minutes, respectively \((P = .03)\). No neurological deficit occurred in either group. The intended operations were all subsequently performed with mean (SD) delays of 5 (2) days in the operative group vs 3 (1) days in the endovascular group \((P = .20)\). Follow-up carotid duplex showed no thrombus or dissection in the CCA in either group. All patients had a carotid duplex performed by the vascular laboratory immediately after carotid artery repair, and all had least 1 additional study during the 42-month follow-up period. During the mean follow-up of 42 months, no complications or neurological deficits were noted in either patient cohort related to the iatrogenic carotid artery repair.

Discussion

Inadvertent placement of the carotid artery sheath could result in devastating complications, especially if the sheath is re-
moved and manual compression is done. Surgical repair is preferred for catheters of 7F or larger. There are multiple reports on percutaneous closure of an inadvertent subclavian artery puncture during central line placement. To our knowledge, this is the first report of treatment of inadvertent carotid artery sheath insertion using a percutaneous closure device as a treatment modality. Six of the 12 cases were percutaneously closed using the Proglide closure device.

Most CVCs are placed at the bedside using a blinded, external landmark-guided technique. Based on computed tomographic evaluation by Lim et al., the internal jugular vein was reported to be lateral to the carotid artery in 85.2% of the cases. Lim and colleagues found that in 69.5% of the cases, the internal jugular vein was less than 1 mm from the carotid artery. This clearly supports the use of ultrasonography during CVC placement. The overall complication rate of CVC placement is around 15% and arterial puncture during internal jugular vein cannulation is reported to be between 6.3% and 9.4%. Devastating cerebrovascular accidents, death, hematomas, pseudoaneurysms, and arteriovenous fistulas from inadvertent carotid artery sheath insertion have been reported. Once this injury is identified, the best approach is to leave the catheter in place and take the patient to the operating room, if not already there, for removal and repair. This is our policy regardless of sheath size. This group describes 9 of 11 cases that were treated with surgical exploration vs removal and external application of pressure. In 2 patients, the cannula was removed from the carotid artery and pressure was applied for more than 15 minutes. One patient developed a large hematoma requiring endotracheal intubation; subsequently, this patient developed a large pseudoaneurysm requiring surgical repair. The second patient developed massive stroke after pulling the cannula. However, none of the 9 patients who underwent open surgical exploration and catheter removal developed any sequelae related to catheter insertion or removal.

In our series, we confirm the findings by Shah et al. that open surgery is safe and could be done with no complications. We had no cases in which external pressure was applied for comparison. However, we report another treatment modality that is as safe and successful as the open repair but is less invasive and more expeditious. We achieved technical success in all patients in both treatment modalities with no neurological sequelae. The mean (SD) durations of treatment between the endovascular and open approaches were 6 (3) minutes and 32 (12) minutes, respectively (P = .03). Shah et al. reported the successful removal of the carotid cannula and repair of arteriotomy in less than 10 minutes of carotid clamping time. On the other hand, the percutaneous closure is much simpler and requires no surgical cut down or carotid clamping. Follow-up carotid ultrasonography between the 2 groups showed no injury to the repaired carotid artery. During a mean follow-up of 42 months, no complications or neurological deficits were reported. Our endovascular results have been successful due to the protocol we follow (Figure 2). Once we get the consultation, we always ask for full heparinization. The main reason is 2-fold. Many of the patients who have had stroke with catheter removal and manual compression as reported in the literature could have had thrombus formation around the catheter that dislodged and embolized during catheter removal. In addition, with endovascular repair, we are not able to flush the carotid artery like we do in open repair to remove any potential thrombus. However, we do recommend back bleeding the catheter prior to removal. In addition, we perform ultrasonography and occasionally angiography to make
In our protocol, vasculature along the catheter was studied as well as to ensure that the puncture site is disease free and without calcifications. The operator should be comfortable with its use as well as with performing ultrasonography on the carotid artery and interpreting the findings to make sure there is no thrombus around the catheter.

In conclusion, inadvertent carotid artery sheath placement is a rare but potentially devastating complication. We report the use of an endovascular suture-mediated closure device that allows repair of the puncture site expeditiously and safely, similar to the standard open approach. However, we do not advocate the use of this device to treat all iatrogenic carotid artery injuries. The operator should be comfortable with its use as well as with performing ultrasonography on the carotid artery and interpreting the findings to make sure there is no thrombus around the catheter.

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REFERENCES