ELSEVIER

Hybrid Stent-Graft Repair of an Iatrogenic Complex Proximal Right Common Carotid Artery Injury

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Background: Iatrogenic carotid trauma requires early diagnosis and adequate treatment. Classic open repair may be technically challenging if trauma is in base of the neck. We present a case of an iatrogenic carotid pseudoaneurysm treated with endovascular repair.

Methods: An 87-year-old woman presented with a pulsatile neck mass 10 days after coronary artery bypass graft surgery. A computed tomographic angiogram showed a 1.6 × 1.0 × 2.0-cm pseudoaneurysm arising from the posterior wall of the proximal right common carotid artery. Endovascular management was considered, and a percutaneous angiogram demonstrated an arteriovenous fistula in addition to the pseudoaneurysm. Through a cervical cut-down, retrograde percutaneous access was obtained through the common carotid artery, which allowed easier access to the area of trauma owing to vessel tortuosity. Subsequently, a 5 mm × 2-cm Viabahn was deployed. The postdilation angiogram showed a significant endoleak that kept filling the pseudoaneurysm. A second 6 mm × 5-cm Viabahn was placed and successfully postdilated with a 6 mm × 4-cm balloon. No endoleaks or fistulas were noted on the completion angiogram.

Results: The patient remains asymptomatic after 15 months. Follow-up images showed thrombosis of pseudoaneurysm.

Conclusion: Endovascular treatment with self-expanding stent-grafts and open cut-down access are excellent options to treat major vessel injuries at the base of the neck, where anatomy and cumbersome access make open surgery a more difficult option.

Carotid trauma secondary to central vein catheter placement is a preventable iatrogenic complication, and requires early diagnosis and treatment. Stroke and severe hemorrhage can be associated with wrong or delayed decisions and treatment. The classic approach to repair neck injuries is open surgery, but it can be challenging when the carotid puncture is in the base of the neck, which often requires sternotomy or clavicle resection. Endovascular treatment is a minimally invasive alternative to treat these difficult-to-access lesions.

We present a case of complex carotid artery trauma pseudoaneurysm secondary to a venous access complication in an elderly woman who underwent recent open heart surgery. Endovascular treatment was successfully done with two self-expanding stent-grafts used to cover the injury site.

CASE REPORT

History and Physical Examination

An 87-year-old woman was referred to us with a pulsatile mass in her neck. She had a medical history significant for hypertension, coronary artery disease, arthritis, and lumbar spine compression fracture. The patient was transferred to our facility with a pulsatile mass in her right neck 10 days after coronary artery bypass that

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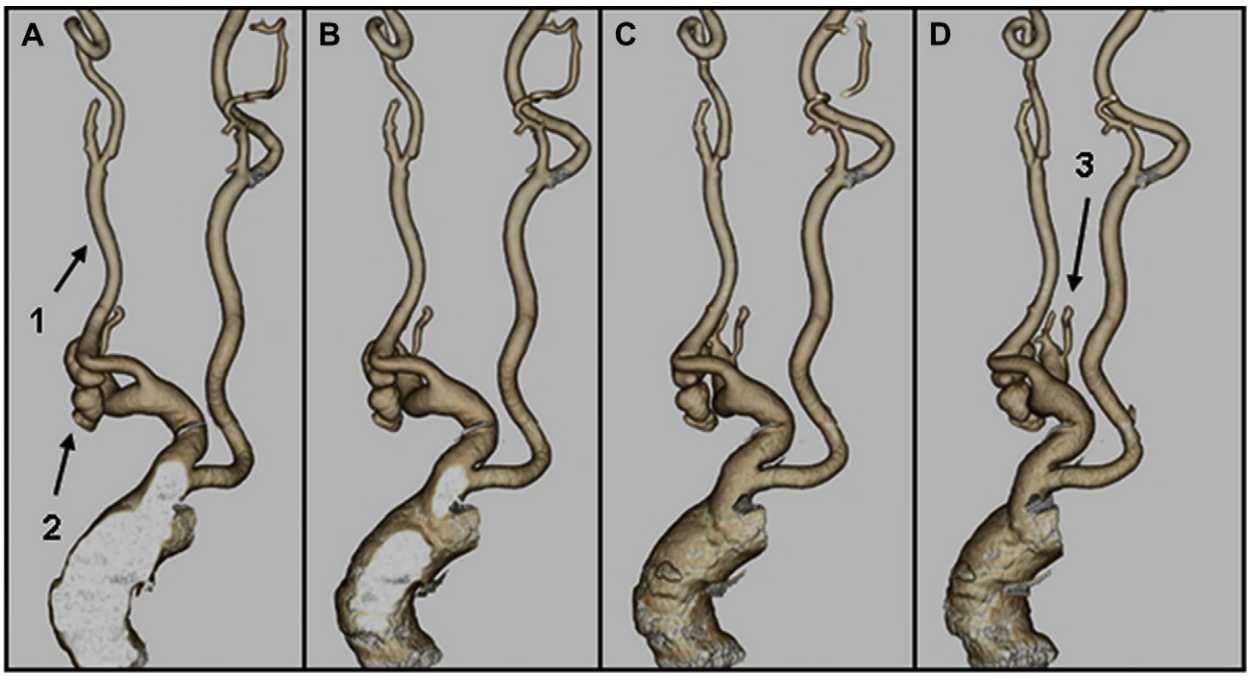

Fig. 1. Brain and chest computed tomographic angiograms with multiplanar reconstruction in different angles (**A**, **B**, **C** and **D**) showing bovine type I arch, with no significant stenosis (*arrow* 1 in **A**). There was a 1.6 × 1.0 × 2.0-cm pseudoaneurysm associated with the proximal right common carotid artery (CCA) (*arrow* 2 in **A**); it extended from the dorsal aspect of the right CCA pointing inferiorly (*arrow* 3 in **D**).

was done at another institution. It was noted that during central venous catheter access for her open heart surgery, she had difficult access with a possible arterial puncture. There is no information documenting whether the puncture attempt was ultrasound guided. Her initial symptoms were right-sided chest heaviness, but she denied any symptoms of dizziness, weakness, numbness, amaurosis, and difficulty swallowing or breathing. On physical examination, a loud continuous right neck and supraclavicular bruit was easily found. Her cardiac and lung examinations were normal, and her chest wall had a healing sternotomy incision. She had palpable peripheral pulses, and a slightly right greater supraclavicular pulse.

Images

A computed tomographic (CT) angiogram was obtained, which demonstrated a 1.6 × 1.0 × 2.0-cm narrow neck pseudoaneurysm arising from the posterior wall of the proximal right common carotid artery (CCA) at the level of the suprasternal notch (Fig. 1). The aortic arch had a normal branching pattern, and there was no significant stenosis bilaterally in the proximal brachiocephalic vessels, carotids, or vertebrobasilar circulation.

Hospital Course

The patient was taken to the endovascular operating suite for a diagnostic angiogram and possible intervention. She was administered 150 mg of clopidogrel before surgery. We obtained access through the right common femoral artery with an 18-G needle, followed by the placement of 0.035-inch floppy guidewire and a 5-F sheath. The patient was systemically heparinized, and we obtained an arch arteriogram (Fig. 2A) followed by a selective innominate cannulation with a Vitek catheter (Cook Inc, Bloomington, IN) and right common carotid angiogram (Fig. 2B, C). The angiogram showed a bovine type I arch, with the innominate artery taking off the ascending aorta, and a complex right common carotid injury consisting of a pseudoaneurysm coming off the proximal CCA (Fig. 2B) and an arteriovenous fistula (AVF) between the CCA and internal jugular vein (Fig. 2C). A decision was made to treat this with a covered stent-graft to avoid a redo sternotomy, as the lesion was too inferior to access through a neck incision. Initial attempts were made to place a stiff wire in the external carotid artery and then the subclavian artery to gain traction for upsizing to a large sheath for stent-graft deployment. However, given the tortuosity and type I aortic arch, we were unable to place the sheath, as increased energy forced the catheter to continue to pop out (Fig. 3A). Therefore, a decision was made to attempt retrograde repair with a stent-graft through a right CCA cut-down. A small longitudinal incision was made, and artery control was obtained of the distal right CCA, superior to the pulsatile mass. A small longitudinal incision was made and a small hematoma was found far enough away from the pseudoaneurysm to avoid inadvertent

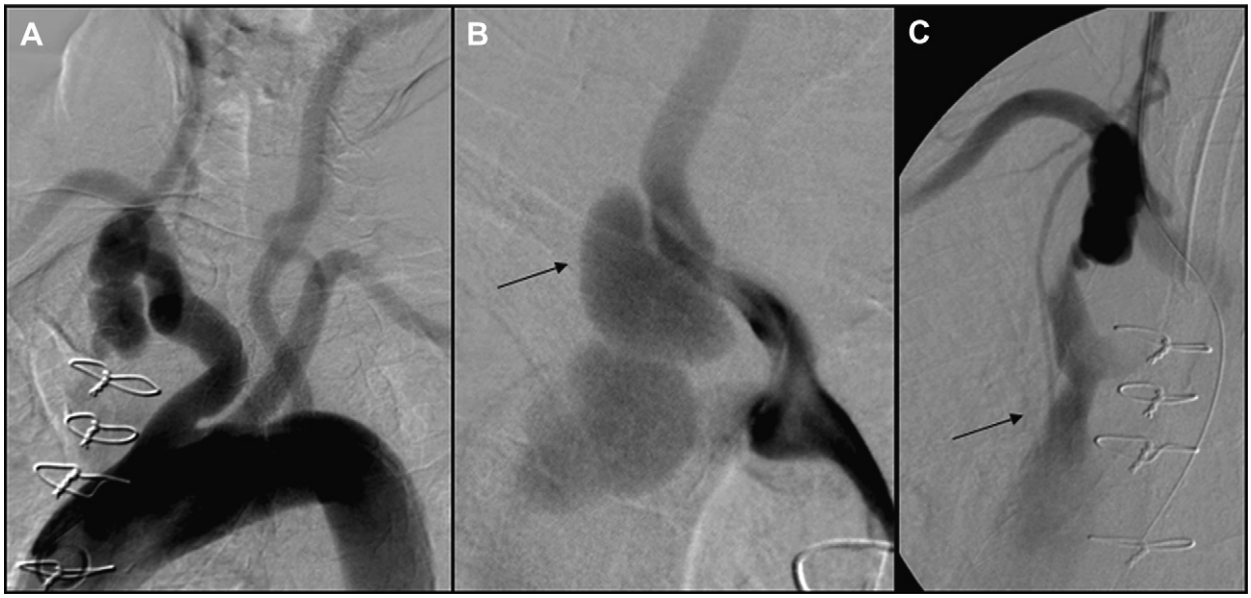

Fig. 2. Arch angiogram (**A**) and selective right carotid angiogram (**B, C**) with a better description of pseudoaneurysm coming off the proximal CCA (**B**) and an arteriovenous fistula between the CCA and internal jugular vein not seen before (**C**).

entry. Artery control was obtained on the distal right CCA, superior to the pulsatile mass.

We then cannulated the CCA with a micropuncture technique, followed by placement of a 0.035-inch stiff glide and a 5-F sheath. We obtained an arteriogram proximally and distally (Fig. 3B). An 8-F sheath was then placed, followed by a 5 mm × 2-cm Viabahn self-expanding stent-graft (Gore, Flagstaff, AZ) stent-graft. Postdilation angiogram demonstrated there was an incomplete seal, both proximally and distally (Fig. 3C). Therefore, a second 6 mm × 5-cm Viabahn was placed and postdilated with a 6 mm × 4-cm balloon. A postangiogram demonstrated a patent right carotid stent in position, with minimal extrusion into the innominate artery, and no evidence of endoleak, pseudoaneurysm, or AVF (Fig. 4A, B). A purse-string suture was placed and the catheter removed. We used protamine to reverse the effects of the anticoagulant and closed the incision.

The patient tolerated this procedure well, and she was transferred to the regular nursing floor in a neurologically intact state. On postoperative day 1, she complained of left arm swelling. Ultrasonography showed deep vein thrombosis in the left basilic, brachial, axillary, subclavian, and jugular veins related to a peripherally inserted central catheter line. She was then anticoagulated with warfarin and discharged to a skilled nursing facility on postoperative day 4 in stable condition.

Surveillance

At 1 month postoperative examination, she remained neurologically intact, and a CT angiogram demonstrated the stent in good position, with a thrombosed pseudoaneurysm and no evidence of AVF or endoleak. Duplex examination found no areas of stenosis, and follow-up CT angiogram is shown in Figure 5. The patient is currently on aspirin and warfarin and remains asymptomatic, with no deficit at 15 months of follow-up.

DISCUSSION

Placement of central venous catheters is a routine procedure in hospitalized patients. More than 5 million are installed each year in the United States,[1,2] the most common sites being the internal jugular, subclavian, and femoral veins. However, related iatrogenic complications can be serious, especially when adjacent arteries are involved, being a frequent cause of claims in North America.[3]

Proper techniques for cannulation are important to prevent complications, such as patient position (supine, hands at the sides, a soft bolster placed in the interscapular space, the head turned away from site of insertion), placing the bed in the Trendelenburg position, adequate hydration, use of finder needles, proper needle insertion technique (landmarks, depth, angles), duplex ultrasonography, and chest X-ray confirmation of placement. Anatomical landmarks may not correlate with vessel location in the neck.[4] Complications can be lowered with ultrasound guidance.[5–7]

Arterial puncture is usually easy to identify, as while puncturing the neck, one of the following

Fig. 3. Unfavorable anatomy was responsible for failure to advance sheath through groin access into right CCA (**A**). Later, retrograde access through neck cut-down made possible a new angiogram with a pigtail catheter (**B**) and the deployment of a 5 mm × 2-cm Viabahn. Postdilation angiogram **(C)** showed a significant endoleak that kept filling the pseudoaneurysm.

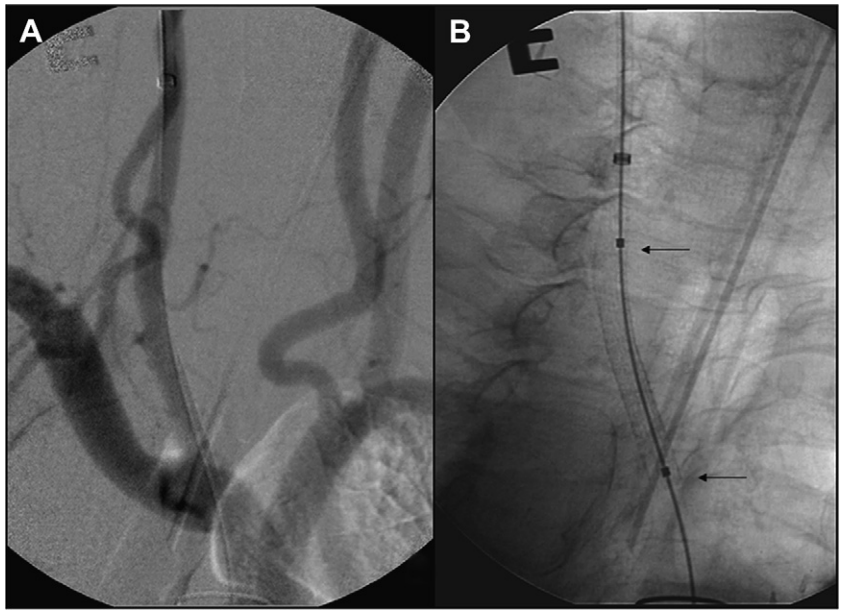

Fig. 4. A second 6 mm × 5-cm Viabahn (**B**, in between *arrows*) and successfully postdilated with a 6 mm × 4-cm balloon. No endoleak or fistula in completion angiogram (**A**).

may appear: pulsatile flow into the syringe, bright-red color of blood, or spontaneous elevation of the syringe plunger. However, these signs may be absent in patients with profound hypoxemia, hypovolemia, hypotension, or marked arterial desaturation. In these situations, auxiliary

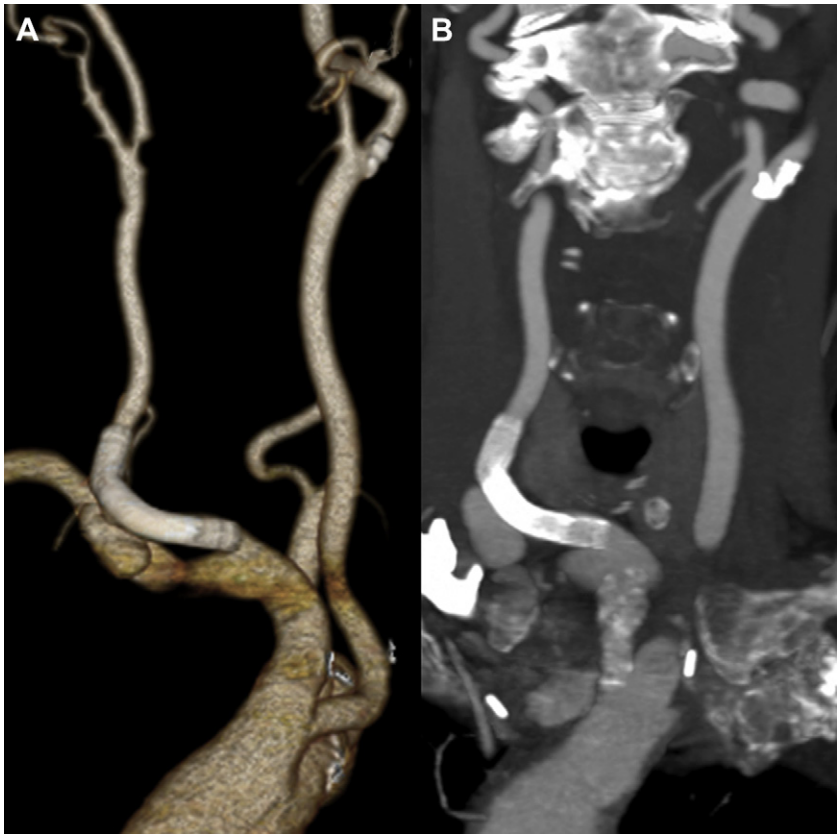

Fig. 5. Follow-up computed tomographic angiogram three-dimensional volume rendering (**A**) and Maximum Intensity Projection (MIP) (**B**) images show carotid covered stent-graft patent, pseudoaneurysm thrombosed, and no arteriovenous fistula. Right internal carotid stenosis was previously seen in Figure 1.

diagnostic techniques are helpful, including blood gas evaluation and pressure transduction.[8] Physical findings suggesting arterial injury include hematoma, ecchymosis at the puncture site, tracheal deviation, vocal chord palsy, a palpable thrill, or an audible bruit. Our patient presented with the last of these findings.

Carotid artery puncture is the most frequent arterial complication associated with jugular vein access (mean: 5.9%, range: 0.5−11.4%),[7] whereas inadvertent puncture of the subclavian and innominate arteries is rarely seen. The incidence varies depending on the vein accessed, technique, and experience of the operator.[9] McGee and Gould[8] reported arterial puncture rates ranging from 6.3% to 9.4% on attempting jugular vein cannulation, which is more than subclavian vein, (3.1−4.9%) but less than femoral vein (9−15%).

Arterial injuries vary from uncomplicated arterial puncture managed with manual compression to severe hemorrhage, stroke, or death. Outcome depends on severity of initial injury; inadvertent arterial puncture with a small needle is usually benign[9−11] and occurs in 5% of cases (0−11%),[12] whereas devastating complications result from arterial entry of large-caliber cannulas (incidence of 0.1−0.8%).[7] This can lead to expanding hematomas, which can potentially obstruct the airway,[13] or cause a hemothorax,[14,15] pseudoaneurysm,[15] AVF,[16] or stroke.[7,17−20] Embolic stroke after carotid puncture with a 20-G or 21-G needle has been described in patients with significant carotid atherosclerotic plaque.[7,21,22]

Treatment for inadvertent arterial cannulation with small cannulas is best done by withdrawing the cannula and holding pressure. For catheters $\geq$7F, arterial cut-down and repair, closure devices, or endoluminal techniques should be promptly used to prevent stroke or expanding hematoma.[5] Endovascular therapy is a less-invasive and potentially better option to treat arterial trauma below or behind the clavicle, such as in the proximal carotid and subclavian arteries. If a subsequent carotid pseudoaneurysm develops, the patient will need urgent treatment to prevent distal

thromboembolism, possible enlargement with vessel occlusion, or rebleeding with intracranial or extracranial hemorrhage.[23,24]

Published data on endovascular therapy of iatrogenic CCA injuries are scarce. Most arterial injuries of aorta and great vessels treated with endovascular therapy are due to blunt trauma (74%), and iatrogenic injuries occur in only 4% of the published cases.[25]

Endovascular treatment of carotid pseudoaneurysms is more common from lesions in the internal,[23,26] rather than the common, carotid.[27]

Penetrating injuries of the neck have a clinical and anatomical division into the upper (zone III), middle (zone II), and lower (zone I) parts of the neck.[28] Zone I, including the thoracic inlet, up to the level of the cricothyroid membrane, is treated as an upper thoracic injury. Zone III, above the angle of the mandible, is treated as a head injury. Zone II injuries, between zones I and III, are treated with selective surgical exploration.[29] Patients who are in profound shock, those exsanguinating from the neck injury, and those in an evolving stroke require immediate exploration. If immediately available, angiography is recommended in all zone I and III injuries to establish the site of the injury and, thus, to plan the preferable endovascular approach.

For the patient reported here, we opted to perform endovascular treatment to avoid a redo sternotomy and possible clavicle resection for approach. The extension of the pulsatile neck mass, recent false aneurysm formation, and venous hypertension secondary to AVF led us to initially attempt transfemoral access. We used a covered stent-graft, as opposed to coils, as it is less likely to rupture the already damaged artery, and provides treatment for both a large pseudoaneurysm and an AVF. In this circumstance, a covered stent-graft allowed us to avoid the morbidity from a major surgical approach. We did have to use a hybrid approach with a cut-down, which is a nice alternative if anatomic considerations preclude a percutaneous approach.

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