

Endovascular Treatment of Innominate Artery Occlusion With Simultaneous Vertebral and Carotid Artery Distal Protection: Case Report

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OBJECTIVE: Atherosclerotic stenosis or obstruction of the innominate artery is rare. Traditional surgical management is a technically demanding intervention with acceptable, but not negligible, rates of morbidity and mortality. Endovascular approaches to supraaortic lesions have been successful and are now the preferred treatment for stenoses of the brachiocephalic vessels. The use of cerebral protection devices in subclavian and innominate interventions is less established.

CLINICAL PRESENTATION: A 58-year-old woman had Takayasu giant cell arteritis with a history of a left middle cerebral artery stroke 3 weeks after undergoing placement of a left common carotid artery (CCA) stent and right innominate artery stent in 1998. She recently presented with worsening dizziness, ataxia, and right arm numbness and was referred to the endovascular neurosurgery service for management.

INTERVENTION: Initial angiography revealed left CCA stenosis and right innominate occlusion. The patient initially underwent left CCA angioplasty, planned as a staged procedure. This was followed by recanalization of the right innominate artery through an approach using both femoral arteries and the right brachial artery. This 3-site technique allowed simultaneous distal protection of both the right cervical vertebral and carotid arteries.

CONCLUSION: Reopening a chronically occluded innominate artery risks an embolic shower through both the right vertebral and carotid arteries. Using multiple sites of arterial access, distal protection devices can be deployed in both the cervical vertebral and carotid arteries to reduce the risk of stroke.

KEY WORDS: Angioplasty, Distal protection, Stenting

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Atherosclerotic obstruction of the innominate artery is rare. However, subclavian and innominate artery obstruction is an important cause of symptomatic cerebrovascular ischemia and may be associated with significant morbidity.¹ Symptoms often include those associated with posterior circulation cerebral ischemia that result from the reversal of flow in the vertebral artery. Arm ischemia can occur from claudication related to exercise or distal embolization. Traditional surgical management is a technically challenging intervention with acceptable, but not negligible, rates of morbidity and mortality.^{2,3}

ABBREVIATIONS: CCA, common carotid artery; ECA, external carotid artery; ICA, internal carotid artery; PTA, percutaneous transluminal angioplasty

Endovascular approaches to supraaortic lesions are successful and are now the preferred treatment for stenoses in the brachiocephalic vessels.⁴ However, occlusions in the supraaortic branches can be more technically challenging and may carry a significant risk of embolic complications. During endovascular treatment of subclavian artery disease, retrograde flow in the ipsilateral vertebral artery may prevent embolization in the posterior circulation. The risk of embolization is higher, however, with antegrade flow. Embolic protection devices are often used during percutaneous transluminal angioplasty (PTA) and stenting of the extracranial carotid artery. The use of cerebral protection devices in subclavian and innominate interventions is less established.

We present a technique for angioplasty and stenting of the innominate artery with simulta-

neous distal protection of the vertebral and carotid arteries via an ipsilateral brachial and bilateral femoral artery approach.

CASE REPORT

A woman with a history of Takayasu giant cell arteritis had undergone PTA and stenting of the origins of her left common carotid artery (CCA) and right innominate artery 10 years earlier. Three weeks after the procedure, she had experienced a stroke that left her with left hemiparesis. Now at 58 years old, she sought treatment after experiencing increasing dizziness, ataxia, and right arm numbness for 3 or 4 weeks and was referred to the endovascular neurosurgery service for management.

Initial angiography revealed 70% in-stent stenosis of the left CCA and occlusion of the right innominate artery and left subclavian artery (Figure 1A). Her right external carotid artery (ECA) was supplied via collateral circulation from the left ECA (Figure 1B). A cervical angiogram showed retrograde flow in her right ECA down to the carotid bifurcation with antegrade flow in the right internal carotid artery (ICA). Additional collaterals to the right ECA were supplied by deep cervical and muscular branches from the right cervical vertebral artery. The right anterior intracranial circulation was supplied by the limited flow through the right ICA as well as from the left ICA across the anterior communicating artery (Figure 1, A-C). The vertebral arteries were supplied by deep cervical muscular branches and the posterior communicating arteries via retrograde flow through the basilar artery.

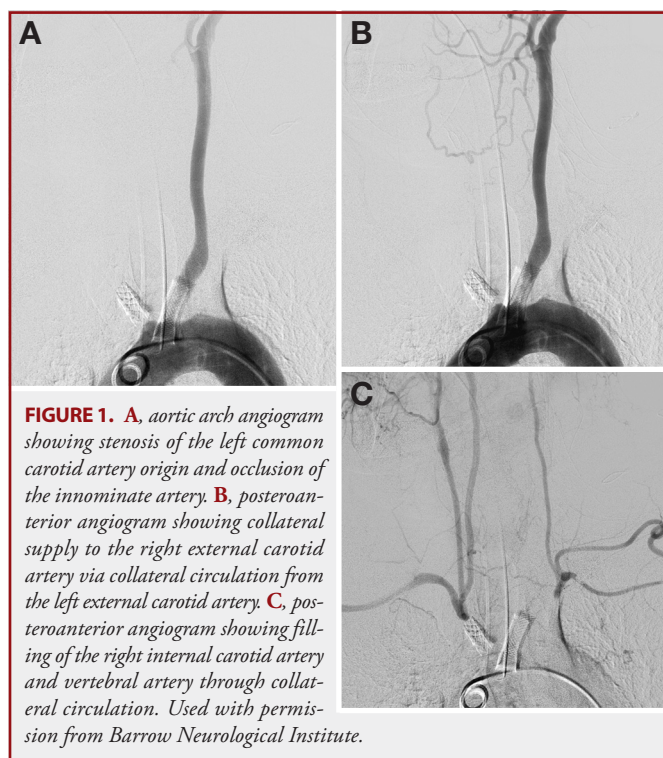


FIGURE 1. **A,** aortic arch angiogram showing stenosis of the left common carotid artery origin and occlusion of the innominate artery. **B,** posteroanterior angiogram showing collateral supply to the right external carotid artery via collateral circulation from the left external carotid artery. **C,** posteroanterior angiogram showing filling of the right internal carotid artery and vertebral artery through collateral circulation. Used with permission from Barrow Neurological Institute.

As part of a staged procedure, we planned to address the left CCA stenosis and then open the occluded right innominate artery. On day 1, the patient underwent successful PTA of the origin of her left CCA. Postoperatively, she was treated with heparin, aspirin, and clopidogrel and did well. Two days later, she returned to the endovascular suite for recanalization of the right innominate artery with the concomitant use of distal protection devices in her right vertebral artery and right ICA.

Under general anesthesia and neurophysiological monitoring that included somatosensory evoked potentials, electroencephalography, and brainstem auditory evoked responses, triple arterial access was obtained. An 8-French sheath was placed into the right femoral artery, a 6-French sheath was placed into the left femoral artery, and a 5-French sheath was inserted into the right brachial artery. A 5-French angiographic catheter was navigated from the right femoral sheath into the origin of the left CCA, which was patent on angiography with good flow through the left CCA, ECA, and ICA. An angiography catheter was then positioned proximal to the occluded right innominate artery to attempt to identify a small channel to cross into the right innominate artery. If successful, we would have crossed into the innominate and then deployed distal protection via the right brachial sheath. However, despite multiple attempts, we were unable to navigate a wire into the right innominate artery through the aortic arch. A 5-French diagnostic angiography catheter was navigated from the right brachial sheath into the right subclavian artery and positioned near the carotid and vertebral artery origins. Angiography showed that the caliber of the right vertebral and carotid arteries was normal (Figure 2, A and B). A stiff-glide exchange-length wire was then navigated through the occluded stent in the innominate artery into the aortic arch. The position of the wire within the stent was confirmed with multiple views on biplanar angiography and fluoroscopy. The wire was snared via the right femoral catheter (6-French Straight Envoy guide catheter; Codman Neurovascular, Miami Lakes, Florida) and was withdrawn through the right femoral sheath, traversing the descending aorta, aortic arch, and right subclavian artery. The distal end of the wire was pulled into the subclavian artery out of the right brachial sheath.

In our initial attempt to obtain distal protection, a 4.5-mm Accunet distal protection device (Abbot Laboratories, Abbot Park, Illinois) was navigated via the right brachial sheath into the subclavian artery. However, as a result of the tortuosity, we were unable to navigate the turn into the right CCA. The 5-French sheath was then exchanged for a 6-French sheath, and a 6-French Envoy MPD catheter (Codman Neurovascular) was navigated into the distal right CCA. An EZ filter wire (Boston Scientific, Natick, Massachusetts), 3.5 to 5.5 mm on a 300-cm wire, was navigated via the right brachial sheath and 6-French Envoy MPD catheter into the right ICA and was deployed without complication. The guide catheter was then removed, in an exchangelike fashion, over the 300-cm exchange-length EZ filter wire. To gain distal protection of the right vertebral artery, an Accunet 5.5 × 190-cm distal protection device was navigated through the brachial sheath, without a guide catheter, into the right vertebral artery (Figures 3 and 4).



FIGURE 2. Posteroanterior (A) and lateral (B) views of right subclavian angiogram showing filling of the right vertebral artery and right common carotid artery, internal carotid artery, and external carotid artery. Used with permission from Barrow Neurological Institute.

The stiff-angle glide wire that was within the right femoral sheath and a 6-French Envoy Guide Catheter (Codman Neurovascular) were used to navigate a Blue Max angioplasty balloon that was 4 cm long with a 6-mm diameter (Boston Scientific). The balloon was positioned within the old stent and across the occluded segment of the innominate artery. Balloon position within the stent was confirmed with multiple views on biplanar fluoroscopy. Angioplasty of the innominate artery was performed without complication. Angiography via a 5-French catheter through the left femoral sheath showed that the innominate artery was open with improved blood flow. Two Zilver 10 × 20-mm, self-expanding open, nitinol stents (Cook Inc, Bloomington, Illinois) were deployed across the area of stenosis in a telescoping fashion. The Blue Max balloon was re-navigated into the origin of the

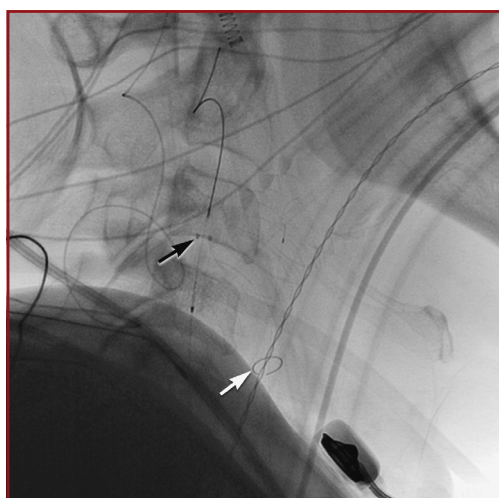


FIGURE 3. Lateral unsubtracted angiographic view showing distal protection devices in both the right vertebral artery (black arrow) and right internal carotid artery (white arrow). Used with permission from Barrow Neurological Institute.

innominate artery and inflated without complication (Figure 5A). After angioplasty and stenting, angiography via the right innominate artery showed improved patency of and flow through the vessels. Antegrade flow was present in the right CCA and right vertebral artery, with reversal of flow through the basilar artery (Figure 5B). Moreover, vertebrobasilar steal was no longer present.

The patient remained intubated and was admitted to the intensive care unit, where blood pressure was maintained at her baseline blood pressure (normotensive). She remained on a heparin infusion as well as on daily aspirin and clopidogrel. The patient was extubated the next morning. On postoperative day 2, the heparin was discontinued, and the patient was prescribed only aspirin (325 mg) and clopidogrel (75 mg) daily. Computer tomography of the brain was performed immediately after the procedure, and magnetic resonance imaging was performed the next day.

Follow-up angiography at 1 month confirmed antegrade flow in the right CCA and right vertebral artery. There was no evidence of stenosis in either the left CCA or innominate artery. Ninety-day follow-up showed that clinically, the patient continues to be symptom free.

DISCUSSION

Surgical revascularization⁵⁻⁷ has been the standard therapy for symptomatic obstruction of the innominate artery. Technical success is high, however, major complications including stroke and death have been reported with an overall complication rate of 13% to 19%.^{5,7-9} Percutaneous transluminal angioplasty with stenting is an alternative to surgery for the treatment of symptomatic artery stenosis. Percutaneous transluminal angioplasty was first reported in 1980 as an alternative to surgical revascularization.^{10,11} Studies revealed initial success rates equal to those of surgery, with lower rates of periprocedural morbidity, death, and stroke.¹²⁻¹⁵ However, the use of PTA alone to treat obstruction of the innominate artery has uncertain long-term patency and high failure rates.¹²⁻¹⁵ Stent has improved overall technical success rates to 92% to 100% with 2- to 5-year patency rates, which is comparable to surgical results (ranging from 77% to 89%).^{5,6,16-18} Although PTA with stenting improved recanalization of occlusions, this subset of patients remains difficult to treat.^{5,6,16-18}

Embolic protection devices are commonly used during PTA and stenting of the extracranial carotid artery. The use of cerebral protection devices in subclavian and innominate interventions is less established, and there are no reports on distal protection of the concomitant vertebral and carotid arteries. With the encouraging results associated with the use of embolic protection devices in the treatment of isolated carotid artery stenoses, we are further reminded of the importance of providing cerebral protection.¹⁹ A systematic review of studies reported the incidence of minor stroke, major stroke, or death within 30 days of carotid angioplasty and stent placement with or without distal protection.²⁰ The combined 30-day stroke and death rate in both symptomatic and asymptomatic patients was 2% in patients treated with distal protection compared with 6% in patients treated without dis-

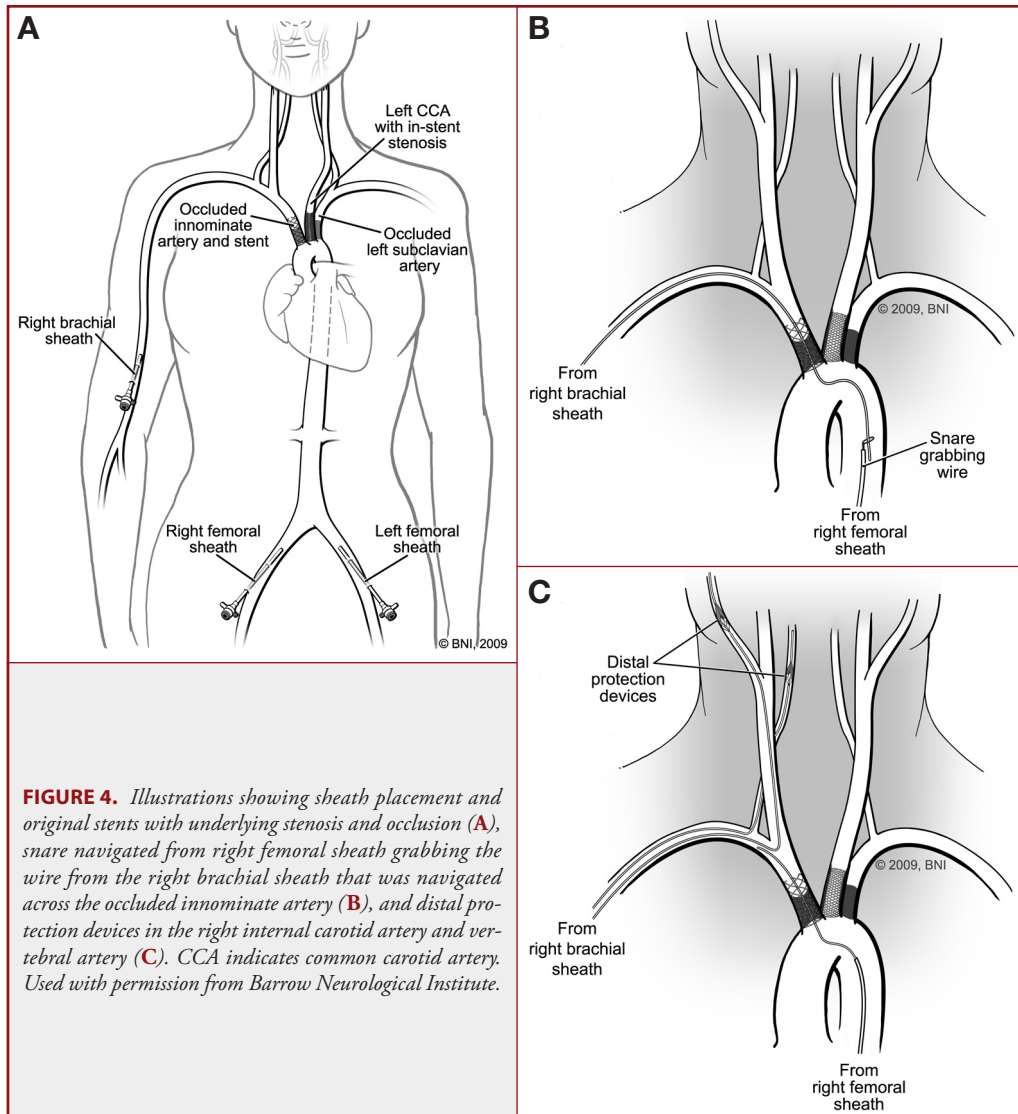


FIGURE 4. Illustrations showing sheath placement and original stents with underlying stenosis and occlusion (A), snare navigated from right femoral sheath grabbing the wire from the right brachial sheath that was navigated across the occluded innominate artery (B), and distal protection devices in the right internal carotid artery and vertebral artery (C). CCA indicates common carotid artery. Used with permission from Barrow Neurological Institute.

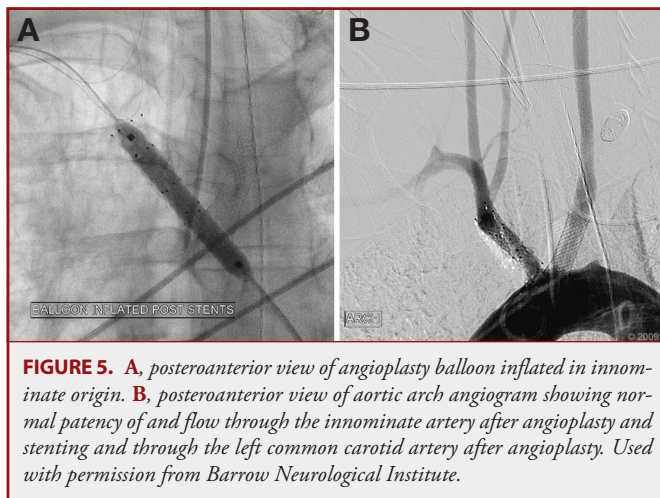


FIGURE 5. A, posteroanterior view of angioplasty balloon inflated in innominate origin. B, posteroanterior view of aortic arch angiogram showing normal patency of and flow through the innominate artery after angioplasty and stenting and through the left common carotid artery after angioplasty. Used with permission from Barrow Neurological Institute.

tal protection. This effect was mainly due to a decrease in the strokes. Another report analyzed 80 patients randomly assigned to carotid artery stent placement in the Endarterectomy Versus Angioplasty trial, which compared carotid artery stent placement (with or without distal protection) with carotid surgery in patients with symptomatic carotid stenosis.²¹ The safety committee recommended stopping carotid artery stent placement without protection, because the 30-day rate of stroke was 3.9 times higher than that of carotid artery stent placement with distal protection. However, recent reports suggest that carotid stenting without distal protection may be just as safe.²²

The data on posterior circulation embolic events are just as strong. Among the 407 patients in the New England Medical Center Posterior Circulation Ischemic Event Registry, the most common site for symptomatic lesions was the extracranial vertebral artery.²³ Moreover, intraarterial embolism is a common mechanism of brain infarction in patients with vertebral artery occlusive disease. Qureshi et al²⁴ found that distal embolism after vertebral artery stenting may cause perioperative ischemic complications.

Studies using transcranial Doppler ultrasonography in patients undergoing subclavian and vertebral artery stenting documented no embolic signals in any patient before angioplasty. However, embolic signals were detected in 58% of patients during or after PTA.²⁵ These signals were detected despite the routine administration of antiplatelets and heparin.

Earlier reports showed that the risk of embolization during PTA of the innominate artery is low but not zero.¹⁵ Embolic particles may be created at almost any step of the procedure. The balloon/stent dilation performed using high pressure is considered to be one of the most embolic steps of the procedure. The large stent struts may allow small pieces of debris to pass. There are several means of decreasing the risk of cerebral embolism, including medications such as antiplatelet drugs, and the use of distal protection devices (Huttl et al¹³).

Some surgeons attempting recanalization of the innominate artery protect the carotid artery with a balloon or surgically by exposing the CCA. In the latter scenario, the intravascular maneuver is not performed through the axillary artery as we did, but through the carotid artery, which is clamped distal to the insertion site. In our case of innominate occlusion, the right carotid axis was involved. The retrograde blood flow in the right vertebral artery made the ramifications of an embolic event less serious; however, the antegrade flow in the ICA was a concern. The major deterrents and complications related to endovascular cerebral protection are usually related to instability of the wire system during delivery of balloons or stents. This instability is particularly a concern when the sheath or guiding catheter position at aortoostial lesion sites is not selective, making the wire position unstable. We thought that if we could obtain distal endovascular protection, it would provide an additional safety measure. The insertion of the filter devices via brachial access enabled us to achieve a stable filter position without interfering with the planned angioplasty and stenting procedure. Use of a guide catheter assisted with navigation into the right CCA. Moreover, use of an exchange-length distal protection device allowed the guide catheter to be removed safely without compromising the position of the filter. The distal protection device was easy to navigate into the right vertebral artery. However, a more oblique origin may have required the use of a guide catheter and exchange-length filter as well.

This technique provides stable and secure positioning of protection devices, and it should be considered for the treatment of stenosis or occlusion of the innominate artery. This technique requires 3 points of access. Specifically, the brachial artery was used to pass a stiff exchange-length wire through the occlusion and into the descending aorta. The right femoral artery was used to ensnare this wire and pull it out the groin. We could then pull the wire down so that its stiff end rested just above the occluded innominate segment. Doing so allowed enough room to pass the protection devices via the brachial approach. Access via the contralateral femoral artery allowed us to navigate a diagnostic catheter into the aortic arch and to perform control angiography while angioplasty was performed over the stiff exchange wire that exited from the right groin. This case is the first report of simultaneous distal protection of the vertebral and carotid arteries during recanalization of a chronically occluded innominate artery.

Disclosure

The authors have no personal financial or institutional interest in any of the drugs, materials, or devices described in this article.

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COMMENTS

Stiefel et al report a case of endovascular innominate artery recanalization with simultaneous vertebral and carotid artery distal protection

via a triple access method. This is an elegant technique that, to our knowledge, has not been previously reported in the literature. Although there is still some controversy in the literature regarding the efficacy of distal protection devices in decreasing the risk of embolic events,¹⁻³ there is a widely held belief that the revascularization of a chronically occluded vessel carries with it a not insignificant risk of periprocedural embolic event. The authors' decision to use distal protection devices is hence very sound. Recanalization of the innominate artery is challenging because of the necessity of providing dual simultaneous distal protection to the ipsilateral carotid and vertebral arteries, which requires multiple sites of access. Atherosclerotic disease of the innominate and other vessels should not be overlooked during stroke workup and should be considered for revascularization in select cases.

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1. Pandey AS, Koebbe CJ, Liebman K, Rosenwasser RH, Veznedaroglu E. Low incidence of symptomatic strokes after carotid stenting without embolization protection devices for extracranial carotid stenosis: a single-institution retrospective review. *Neurosurgery*. 2008;63(5):867-873.
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In this case report, Stiefel et al detail a technique that allows for distal protection of both the vertebral and the carotid artery during revascularization of an occluded innominate trunk. Innominate trunk revascularization can be technically challenging because of the unstable position of the

guiding wire, but this problem is circumvented by using the technique herein described. Moreover, the risk of distal emboli is reduced by having distal protection of both the carotid and the vertebral artery. Once again, this report illustrates that challenging problems can be solved by the creative use and combination of various endovascular devices and techniques.

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Stiefel et al report an interesting case of a patient with Takayasu arteritis and symptomatic chronic innominate artery occlusion. They used a sophisticated method (triple access, dual distal protection of vertebral and carotid arteries) for direct revascularization of the innominate artery with good clinical and angiographic results. It is noteworthy that revascularization of chronically occluded major vessels is now technically feasible and may in part replace even more involved surgical bypass procedures. At our institution, we have been successful so far with endoluminal revascularization of chronic vertebral and carotid occlusion. However, the risks vs the benefits need to be carefully weighed. Direct manipulation of the aortic arch, particularly in a patient with an inflammatory disease, bears the risk of aortic dissection, rupture, and death. Further, it is questionable whether, in this case, additional distal protection for the vertebral artery was needed. Although in theory this makes sense, in reality it takes time for the subclavian steal effect to reverse; distal protection within the vertebral artery may be superfluous because the flow in the vertebral artery is still retrograde during the initial opening of the innominate artery. Additionally, distal protection in the vertebral artery may increase the risk of dissection. Overall, this procedure demonstrates an excellent outcome by a highly skilled team.

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