Transcarotid arterial revascularization is feasible and safe with concomitant inferior vena cava occlusion

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ABSTRACT

Transcarotid artery revascularization (TCAR) has risen as a promising minimally invasive intervention for high-risk patients with favorable anatomy. TCAR's noninferiority to carotid endarterectomy regarding stroke is reliant on its flow reversal technology and lack of aortic arch manipulation. We present the case of a 79-year-old man with a chronically occluded inferior vena cava who safely underwent staged bilateral TCAR for bilateral high-grade carotid artery stenosis. Although chronic inferior vena cava occlusion alters flow mechanics, we suspect that any pressure gradient facilitating retrograde flow from the carotid artery to the femoral vein provides neuroprotective benefits. (J Vasc Surg Cases Innov Tech 2024;10:101414.)

Keywords: TCAR; Chronic IVC occlusion; Staged bilateral TCAR; Bilateral carotid artery stenosis

Asymptomatic high-grade carotid artery stenosis poses a significant risk factor for stroke.[1] Although the gold standard for carotid artery stenosis treatment is carotid endarterectomy (CEA), novel minimally invasive techniques have been developed to mitigate the occurrence of complications in high-risk surgical patients.[1-3] These techniques include transfemoral carotid artery stenting and transcarotid artery revascularization (TCAR). Of these techniques, TCAR has shown no significant differences in stroke outcomes in the perioperative period compared with CEA.[4] Therefore, TCAR has risen as a promising intervention for high-risk patients with favorable anatomy.[3] TCAR's promising results are largely attributed to its flow reversal system that relies on the gradient in pressure between the internal carotid artery (ICA) and femoral vein. However, little is known regarding the clinical and anatomic factors that would predict for intolerance or an inability to successfully initiate flow reversal. We present the case of a 79-year-old male patient with a chronically occluded inferior vena cava (IVC) who successfully underwent staged bilateral TCAR for bilateral high-grade carotid artery stenosis. The patient provided written informed consent for the report of his case details and imaging studies.

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CASE REPORT

We present the case of a 79-year-old man with a history of hypertension, chronic kidney disease stage 4, hypercholesterolemia, 50 pack-year smoking history, and ruptured abdominal aortic aneurysm after endovascular aneurysm repair (EVAR). At the time of the diagnosis, the patient presented to the vascular clinic for follow-up after EVAR 3 months prior. The patient endorsed intermittent headaches and dizziness. The physical examination findings were remarkable for bilateral carotid artery bruits on auscultation. Surveillance computed tomography of the abdomen and pelvis showed the EVAR in a good position with no vascular abnormalities. Given the concern for carotid artery stenosis from the physical examination, a bilateral carotid duplex ultrasound scan was obtained. The carotid duplex ultrasound scan showed bilateral >80% stenosis of the ICAs, with a left proximal ICA velocity of 407/133 cm/s (ratio, 4.63) and right proximal ICA of 391/133 cm/s (ratio, 7.38). Given the patient's chronic kidney disease, magnetic resonance (instead of computed tomography) angiography of the head and neck was then obtained to better characterize the patient's anatomy. No stroke was identified, and the presence of severe carotid artery stenosis was confirmed. Given the excellent recovery after the abdominal aortic aneurysm rupture, few comorbidities, lack of end-stage renal disease, and excellent functional status, we elected to proceed with left TCAR and staged right TCAR at a later date. Subsequently, it was recommended the patient continue aspirin 81 mg daily and atorvastatin 80 mg daily and begin clopidogrel 75 mg daily 1 week before the intervention.

In the operating room, under conscious sedation, the left common carotid artery (CCA) was exposed in standard fashion. The patient was systemically heparinized. Attention was turned to the right common femoral vein, which was accessed under ultrasound guidance. Given the difficulty with advancement of the access 0.035-in. wire, a right leg venogram (Fig 1, *A*) was then obtained, which revealed an occluded right common iliac vein vs IVC. Attention was turned to the left common femoral

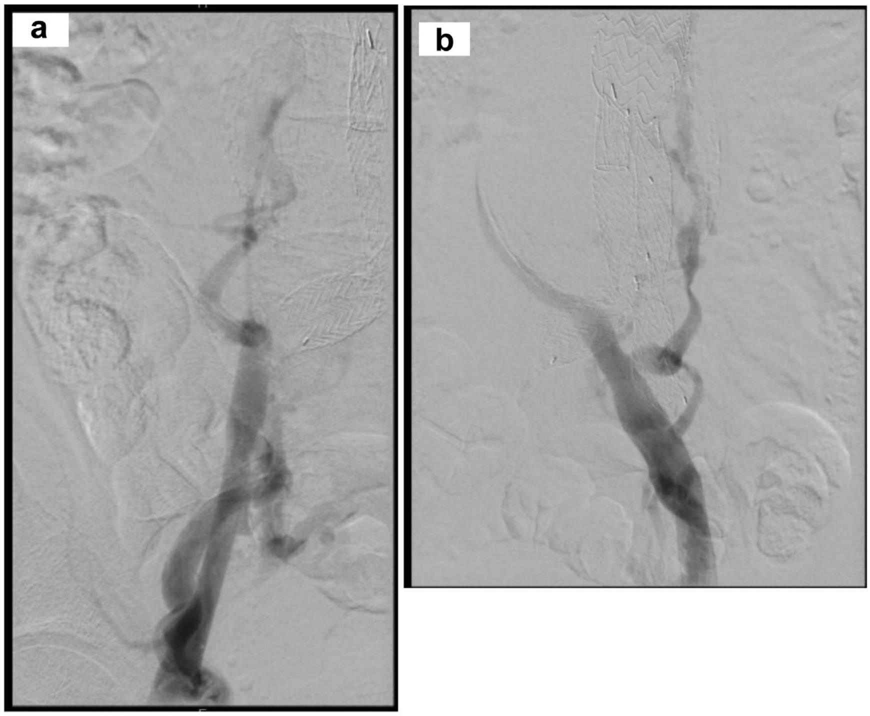

Fig 1. A, Right iliofemoral vein venogram. **B,** Left iliofemoral vein venogram. Both demonstrating chronically occluded inferior vena cava (IVC).

vein, which was accessed under ultrasound guidance. Again, difficulty with advancement of the access 0.035-in. wire prompted a left leg venogram (Fig 1, *B*), which was notable for an occluded IVC. An 8F short venous sheath was placed, and a 0.035-in. braided wire was advanced into the ipsilateral iliofemoral vein. Attention was turned to the left carotid artery, where a 0.035-in. wire and 8F short carotid sheath were placed. To confirm a suitable pressure gradient for flow reversal, before contrast-enhanced imaging of the carotid artery, the flow reversal system was established without occlusion of the carotid artery using the EnRoute system (Silk Road Medical). We did not measure the femoral venous pressure; however, under direct visualization, initiation of high-flow reversal demonstrated adequate flow reversal.

A carotid arteriogram was then performed (Fig 2). We then occluded the proximal CCA and initiated the Silk Road flow reversal system to the femoral vein access. In accordance with our standard protocol, flow reversal using high flow was confirmed. We crossed the severe stenosis of the ICA using a 0.014-in. EnRoute wire, performed predilation balloon angioplasty of the ICA, and deployed a Cordis EnRoute Silk Road 10-mm × 40-mm bare metal, self-expanding stent. A completion arteriogram demonstrated the stent opposed to the carotid artery wall without signs of thrombus formation or dissection. The endovascular procedure was then terminated. The procedure time was 95 minutes, with 8 minutes of flow reversal. No immediate intraoperative complications occurred.

Postoperatively, the patient recovered well and continued taking aspirin 81 mg daily and clopidogrel 75 mg daily. Enoxaparin 40 mg was initiated during the hospital stay for deep vein thrombosis prophylaxis. A carotid duplex ultrasound scan was performed on postoperative day 1. The patient was discharged on postoperative day 2 and continued dual antiplatelet therapy. The patient was followed up 2 weeks after the operation, and his neurologic examination findings were normal. At 5 weeks postoperatively, the patient was seen virtually. A carotid duplex ultrasound scan showed no evidence of significant stenosis within the left ICA. At 3 months postoperatively, the patient underwent right TCAR in similar fashion using right common femoral artery access for flow reversal. A Cordis Silk Road 10-mm × 40-mm self-expanding bare metal stent was used, with predilation using a Cordis Aviator monorail balloon. The flow reversal time was 12 minutes using the Silk Road flow reversal system. The patient tolerated the procedure well. At 1 month of follow-up, we elected to discontinue clopidogrel and have the patient continue with aspirin alone. Due to the minimal lower extremity swelling, no intervention was planned for his chronic IVC occlusion. The patient remains scheduled for follow-up.

DISCUSSION

It has been established that surgically fit asymptomatic patients with high-grade stenosis benefit from CEA with best medical therapy to prevent ipsilateral stroke.[2,5] However, patients at high risk of adverse outcomes due to medical or anatomic reasons can be offered best medical therapy with carotid artery stenting or best medical therapy alone. Of the carotid artery stenting approaches, transfemoral carotid artery stenting

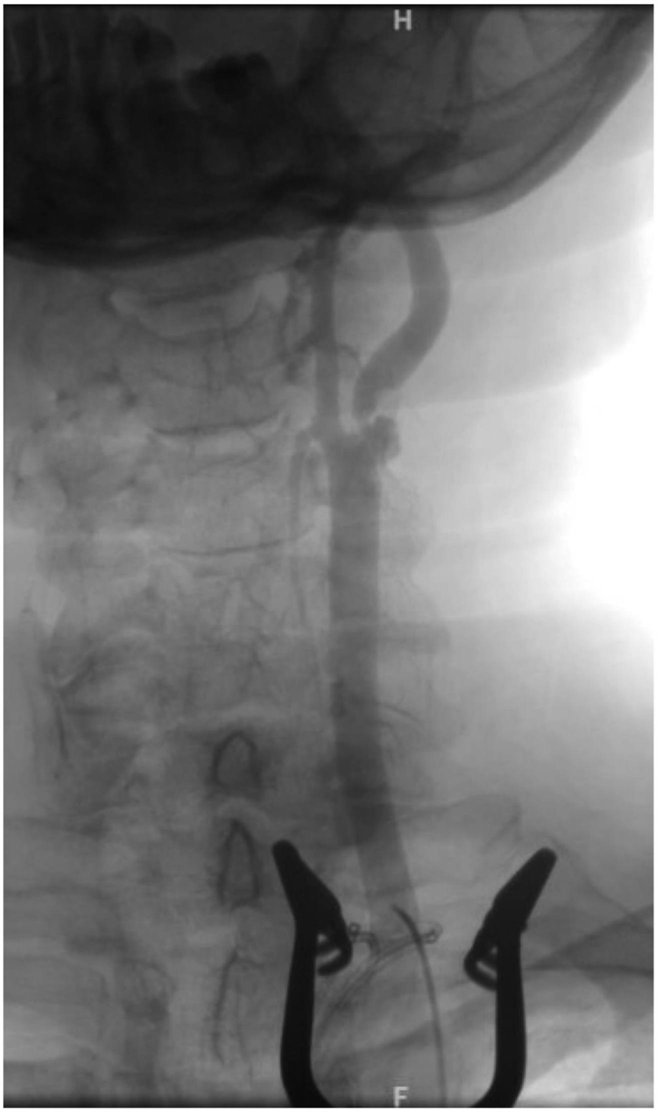

Fig 2. Left carotid artery arteriogram before carotid artery stent deployment demonstrating severe internal carotid artery (ICA) stenosis.

demonstrates an increased risk of periprocedural cerebral embolization, as demonstrated by large prospective trials (eg, SPACE [stent-protected angioplasty versus carotid endarterectomy], EVA-3S [endarterectomy versus angioplasty in patients with symptomatic severe carotid stenosis]) and randomized controlled trials (eg, ICST [international carotid stenting trial], CREST [carotid revascularization endarterectomy versus stenting trial]).[6–11] This prompted investigation into devices that would reduce the incidence of macro- and microemboli during carotid artery stenting.

TCAR has demonstrated noninferiority to CEA when evaluating the composite outcomes of stroke, myocardial infarction, and death.[4,12-15] TCAR is a hybrid approach that eliminates the need to traverse the aortic arch and provides neuroprotection through flow reversal.[16] The flow reversal system is a large-bore, low-resistance circuit that creates an arteriovenous shunt between the CCA and femoral vein. The flow line has an incorporated flow regulator that allows for regulation of blood flow (ie, high, low, or cessation of flow) through an extracorporeal filter.[17] This system provides embolic neuroprotection by occluding the proximal CCA without prior instrumentation or lesion crossing and allows for retrograde blood flow from the contralateral cerebral hemisphere through the circle of Willis to the femoral vein. Thus, its effectiveness is based on an adequate pressure gradient between the higher retrograde carotid artery blood pressure and the lower venous pressure that would help direct macro- and microemboli away from the brain.[18,19]

Although studies have reported on the effectiveness of the EnRoute neuroprotection system in the presence of compromised systolic blood pressure, no studies, to the best of our knowledge, have evaluated the effects of venous hypertension on the effectiveness of flow reversal.[20] One study by Teter et al[21] evaluated the factors associated with intolerance to flow reversal and how cases were managed. In their retrospective review, 297 cases were evaluated. Despite an intolerance to flow reversal (ie, signs of altered level of consciousness, hemodynamic instability, change in neurologic examination findings, change in respiratory status, shortness of breath, dizziness), TCAR cases were successfully completed by adjusting the flow rate from high to low. There was no increased risk of stroke in these patients. However, no factors contributing to intolerance could be determined. In our case, we describe a patient with a chronically occluded IVC who safely underwent staged bilateral TCAR with flow reversal for very severe carotid artery stenosis. Although the chronic IVC occlusion likely decreased the pressure gradient from the CCA to the femoral vein, our patient tolerated the procedure well. Therefore, we suspect that any pressure gradient that permits retrograde flow from the CCA to the femoral vein will provide neuroprotection because it directs macro- and microemboli away from the brain.

CONCLUSIONS

TCAR's lack of aortic arch manipulation and novel flow reversal technique creates a viable minimally invasive approach to carotid artery revascularization. Of these features, flow reversal is thought to be the primary mechanism to prevent periprocedural cerebrovascular embolism. We show that chronic occlusion of the IVC did not preclude adequate flow reversal and still permitted safe use of TCAR in a patient with >80% stenosis of bilateral carotid arteries.

DISCLOSURES

None.

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