"TCAR or nothing": the only options for some complex carotid stenosis

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ABSTRACT

Transcervical carotid artery revascularization has emerged as an alternative to carotid endarterectomy and transfemoral carotid artery stenting. We present four cases for which we believe transcervical carotid artery revascularization was the only option to treat the lesions. Each case presented with specific technical challenges that were overcome by intraoperative planning that allowed for safe deployment of the Enroute stent (Silk Road Medical) with resolution of each patient's stenosis. (J Vasc Surg Cases Innov Tech 2024;10:101404.)

Keywords: Carotid stenting; Carotid surgery; Endovascular surgery; TCAR

Transcervical carotid artery revascularization (TCAR) was developed more than one decade ago as an alternative to both carotid endarterectomy (CEA) and transfemoral carotid artery stenting (TFCAS). The outcomes are similar to those with CEA, with a stroke rate lower than that with TFCAS.[1-5] TCAR allows access to high internal carotid lesions not easily reached with CEA and avoids a potentially tortuous and diseased aortic arch and access vessels, which limits the effectiveness of TFCAS. Perhaps the greatest advantage of TCAR is the use of flow reversal, which allows for cerebral protection before crossing the culprit lesion. Flow reversal reduces the occurrence of microembolization, the main complication of TFCAS.[6-8] The main limitations imposed by TCAR are the length and status of the common carotid artery (CCA) "runway" and possible problems with hostile neck anatomy from prior surgery or radiation.[9-11] Although ischemia during flow reversal is a theoretical concern, this has rarely been encountered in clinical applications of the technique.[12-14]

We illustrate four cases for which we believe TCAR presented the best and, possibly, only option to treat the carotid lesion. In each of these cases, intraoperative challenges were encountered and overcome. We believe these cases illustrate that applications of TCAR can be expanded with proper planning and intraoperative decision making.

CASE REPORT

Patient 1

Symptomatic preocclusive carotid stenosis; long, heavily calcified, high lesion. An 85-year-old man presented with amaurosis fugax and 99% left internal carotid artery (ICA) stenosis and heavily calcified plaque extending well into the CCA. His medical history included coronary artery disease, diabetes mellitus type 2, hypertension (HTN), hyperlipidemia (HLD), chronic kidney disease, and chronic obstructive pulmonary disease requiring home oxygen. His surgical history included coronary artery bypass grafting, transcatheter aortic valve replacement, pacemaker placement, watchman procedure, coronary angioplasty (percutaneous coronary intervention) twice, and prior right TFCAS for stroke in July 2021 at another institution. Computed tomography angiography (CTA) of the head and neck showed a heavily calcified lesion extending from the mid-CCA to above the angle of the mandible and second cervical vertebral body (Fig 1). Because of the long-segment heavily calcified and nearly occlusive lesion, TCAR was chosen instead of TFCAS due to the high probability for distal embolization when placing a filter. We also elected to perform TCAR instead of CEA due to the surgically high clamp zone, as previously described.

Intraoperative steps and decision making. A standard TCAR approach and wire access using the Enroute 0.014-in. wire to the ICA above the lesion was obtained. A 7 × 20-mm balloon would not pass through the stenosis. After serial dilation with 2 × 20-mm and 2.5 × 20-mm coronary balloons, we still could not pass 3- or 4-mm angioplasty balloons due to a lack of support. To obtain more support, we placed a longer 0.014-in. Whisper wire (Abbott Cardiovascular) through the lesion and advanced a 6F, 45-cm-long sheath through the 8F Silk Road sheath to just below the lesion, creating a coaxial system. With this additional support, we were able to

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Presented at the Thirty-sixth Annual Meeting of the Eastern Vascular Society, Philadelphia, PA, September 29 to October 1, 2022.

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2468-4287

https://doi.org/10.1016/j.jvscit.2023.101404

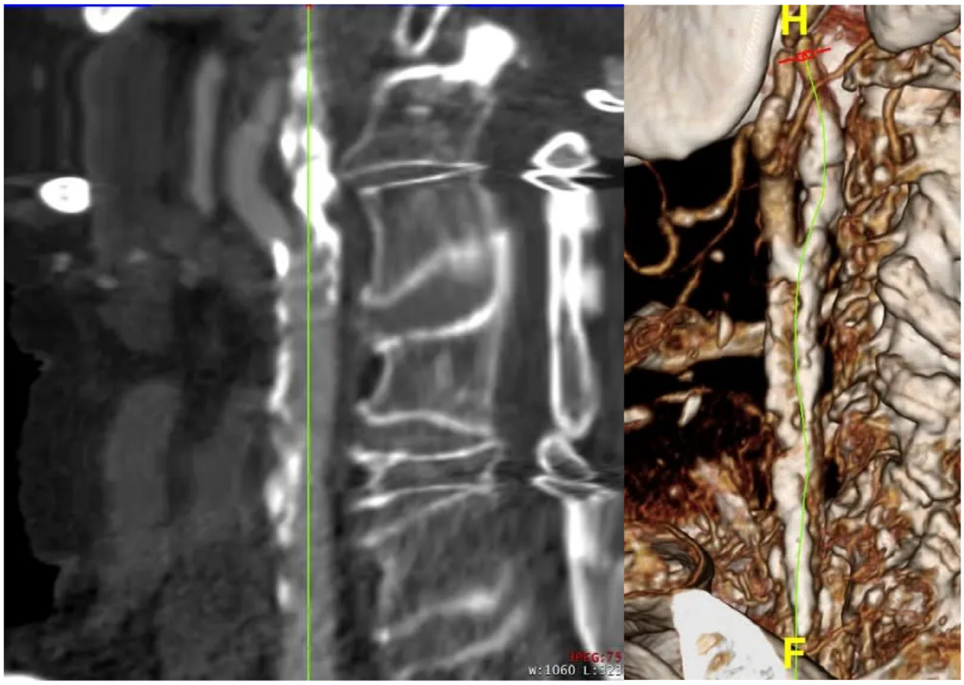

Fig 1. Computed tomography angiography (CTA) demonstrating a heavily calcified lesion extending from the mid-common carotid artery (CCA) to above the angle of the mandible and second cervical vertebral body.

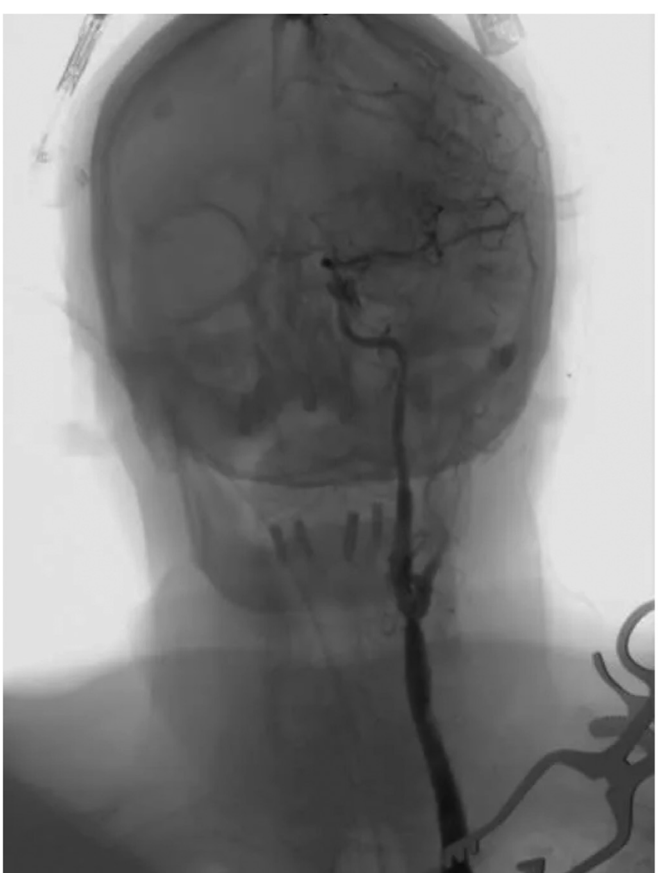

Fig 2. Angiography after stent placement showing no residual stenosis.

serially dilate the lesion under flow reversal to ≤7 mm. A 7 × 40-mm Enroute stent (Silk Road Medical) was placed from the bifurcation to the ICA and postdilated with a 7 × 20-mm balloon, followed by an 8 × 40-mm self-expanding stent to treat the CCA lesion. Completion angiography revealed no residual lesions (Fig 2). The patient was discharged on the first postoperative day without complications.

Patient 2

High preocclusive calcified lesion (string sign). An 85-year-old man presented with a preocclusive ICA lesion found on CTA after a fall. There was no evidence of stroke on imaging or examination. The patient was receiving dual antiplatelet therapy and a statin. His medical history included HTN, HLD, coronary artery disease, and percutaneous coronary intervention 3 months prior. CTA of the head and neck showed 99% stenosis vs occlusion involving the origin of the right ICA and extending above the first cervical vertebral body, with a 50% left ICA stenosis and calcific stenosis of the left vertebral artery. The patient presented with a high risk for CEA due to cervical spine immobility combined with a high cervical lesion at the level of the first cervical vertebral body and above the angle of the mandible. Due to a 99.9% occlusive lesion, TCAR was chosen instead of TFCAS due to risk of the likely inability to safely pass a filter.

Intraoperative steps and decision making. Standard TCAR access was obtained. A right cervical carotid angiogram in multiple orthogonal views demonstrated a patent

Fig 3. Carotid angiogram demonstrating a patent right common carotid artery (CCA) with 99% stenosis of the origin of the internal carotid artery (ICA).

Fig 4. Angiography of intraluminal confirmation after crossing the preocclusive lesion.

right CCA with 99% stenosis of the origin of the ICA (Fig 3). After traversing the lesion, we needed to verify the intraluminal position. To do this, a modified Quick-Cross catheter (Philips) was required. Due to the short length of the Enroute guidewire, the Quick-Cross catheter was shortened by amputating its proximal end and attaching an angiocatheter to the distal catheter for contrast injection during digital subtraction angiography. This allowed us to verify that we were in the lumen after crossing the lesion (Fig 4). The lesion was dilated with a 6 × 40-mm Viatrac angioplasty balloon (Abbott Cardiovascular), followed by stenting using an 8 × 30-mm self-expanding Enroute stent from the ICA to just above the carotid bifurcation and then a 9 × 30-mm Enroute self-expanding stent to extend the repair into the distal CCA. Completion angiography showed no further significant stenosis and a patent ICA (Fig 5).

Patient 3

TCAR for a symptomatic common carotid lesion after attempted TFCAS. A 74-year-old man with prior neck surgery and radiation was followed up in our practice with >70% asymptomatic left CCA stenosis and contralateral carotid occlusion. He experienced a left hemispheric transient ischemic attack, characterized by right upper extremity numbness and paresthesia. His medical history included deep vein thrombosis/pulmonary embolism, oropharyngeal squamous cell carcinoma with bilateral neck dissection and tracheostomy, radiation, and cervical spinal stenosis after fusion. On examination, the patient presented with a woody neck after prior radiation. CTA revealed a type 3 bovine arch with left >70% CCA stenosis and occlusion of the contralateral carotid and vertebral arteries (Fig 6).

Intraoperative steps and decision making. We initially attempted TFCAS, because the left CCA lesion resulted in a short runway for TCAR and the patient's irradiated and woody neck increased the morbidity of an open procedure. Due to distal ICA tortuosity (Fig 7), we were unable to pass the filter wire for cerebral protection during TFCAS. It was difficult to maintain the sheath position with a bovine arch and proximal CCA lesion; thus, percutaneous transluminal angioplasty alone was performed. Follow-up duplex ultrasound revealed a residual

Fig 5. Completion angiography showing no further significant stenosis and a patent internal carotid artery (ICA) after stent placement.

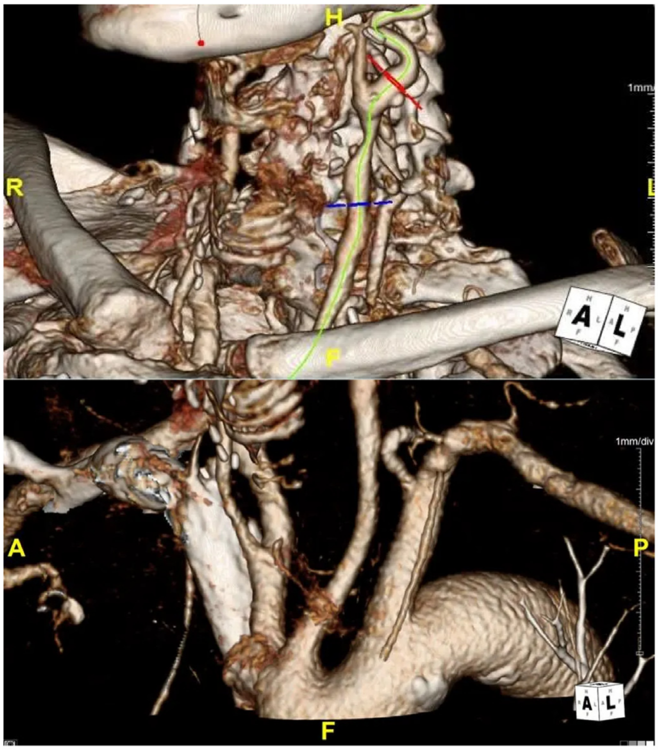

Fig 6. Computed tomography angiography (CTA) of the neck showing a type 3 bovine arch with common carotid artery (CCA) stenosis and distal internal carotid artery (ICA) tortuosity.

70% stenosis in his only patent carotid artery. After failed TFCAS for this now symptomatic lesion, we elected to cutdown at the base of a previously irradiated neck and perform TCAR. Although the length of time for CCA dissection increased, TCAR was performed successfully in this case with a shortened runway of 3.8 cm. During the initial access with the 4F sheath, extra care was taken to ensure no displacement of the sheath by the assistant while the primary operator was exchanging or advancing the wires due to a high propensity for paradoxical movement of the sheath and the risk of losing access.

Patient 4

Near occlusive in-stent stenosis of CCA in a hostile neck with a short runway. A 78-year-old man developed in-stent stenosis of a CCA lesion treated at another institution with TFCAS in 2018. His medical history included pacemaker placement for sick sinus syndrome, prior stroke, HTN, HLD, a parotid tumor treated by right parotidectomy with radical neck dissection and radiation, and TFCAS. CTA showed soft plaque in the CCA. The traditional runway starting in the CCA between the heads of the sternocleidomastoid muscle approximated 1.1 cm. The patient proved at high risk for CEA due to prior neck surgery after parotidectomy with radical neck dissection and radiation and a poor candidate for TFCAS due to the near occlusion with soft plaque at high risk of embolization when placing a filter.

Intraoperative steps and decision making. A review of the CTA suggested that approaching the CCA in the suprasternal notch would provide an adequate runway for stent delivery (Fig 8). The right CCA was accessed in the suprasternal notch between both medial heads of the sternocleidomastoid muscle, allowing for a 4.1-cm runway and an adequate distance to treat the low-lying CCA lesion (Fig 9).

DISCUSSION

TCAR was developed more than one decade ago to combine the best features of CEA and TFCAS and avoid their respective pitfalls. The benefits are especially pronounced for elderly patients aged >75 years and those with multiple medical comorbidities.[15,16] Several studies have shown that despite patients having a higher medical risk, those undergoing TCAR tend to have favorable outcomes regarding myocardial infarction and stroke compared with CEA and TCFAS, making it a widely accepted alternative method.[17,18] Owing to the proximity of the access site to stent placement and the shorter length of the flow reversal circuit, TCAR provides more effective reversal in the internal and external carotid arteries than did the previous transfemoral flow reversal technologies.[8,19] The flow reversal technology also proves

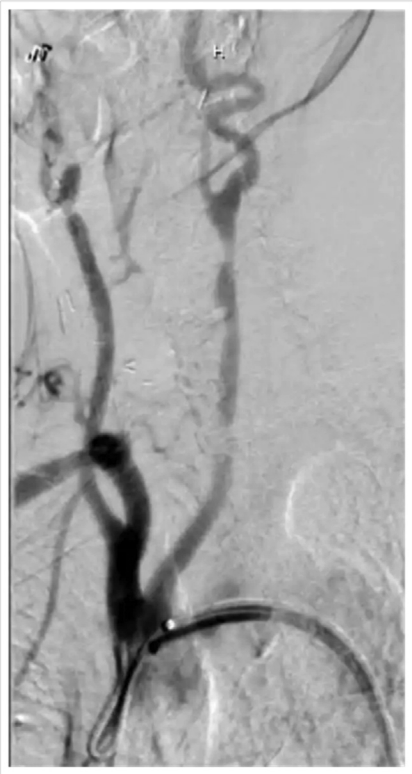

Fig 7. Angiography demonstrating distal internal carotid artery (ICA) tortuosity.

favorable for TCAR compared with TFCAS for heavily calcified lesions, because embolic protection is initiated before crossing the lesion for filter placement.[20] Heavy calcification was associated with a higher risk of adverse events in the ROADSTER (safety and efficacy study for reverse flow used during carotid artery stenting procedure) trials. However, in our experience, noncircumferential calcification tends to tolerate balloon angioplasty to the intended balloon size, often despite a heavy calcium burden. Our practice uses preoperative CTA with three-dimensional reconstruction for operative planning. We size the balloon one to one with the diameter of the ICA to aggressively predilate and only postdilate when necessary. We avoid postdilation because of concern for a "cheese grater" effect, increasing the risk of embolization once the stent is in place. If the lesion appears to contain circumferential calcium, intravascular lithotripsy is considered before stent placement to optimize stent expansion. We remain conservative in the application of intravascular lithotripsy due to the prolonged inflation times and associated potential for hypotension, bradycardia, and asystole with baroreceptor stimulation. The flows in the system can be regulated intraoperatively between a low and high setting with a very low incidence of intolerance to reversal in clinical practice.[12] Several clinical trials have established the safety and efficacy of this

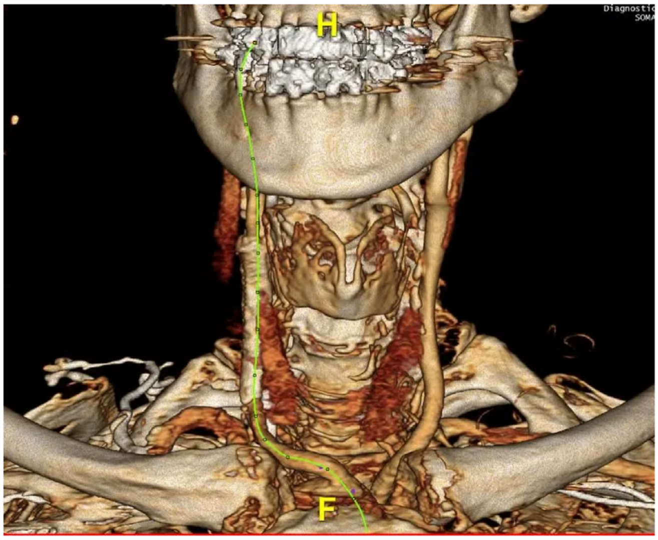

Fig 8. Computed tomography angiography (CTA) of the neck revealing the proximity of the proximal right common carotid artery (CCA) to the sternal notch.

procedure, and it is now approved for use for both high-risk and normal-risk patients who otherwise have indications for carotid revascularization.[8,17,18,21,22] The major limitations of TCAR include difficult dissection in cases of a hostile neck from prior surgery or radiation and the lack of a suitable length of CCA "runway" to place the device and allow for safe stent deployment.[11,23,24]

The anatomy associated with an increased incidence of complications after CEA includes lesions that extend to the level of C2 or above and extensive scarring due to radiation or prior surgery creating a "hostile neck."[23] These features were present in each of our patients. For patients 1 and 2, CEA would have been difficult or impossible due to the distal extent of the lesion; thus, endovascular treatment was the only option. Due to the severity of stenosis in these two patients, it is likely that a distal embolic protection device required with TFCAS could not have been placed in either patient without extensive lesion manipulation. We took advantage of the ability of TCAR to provide embolic protection via flow reversal before lesion traversal and believe this contributed to our good outcomes.[6,7]

Treatment of preocclusive lesions can present a technical challenge during carotid stenting.[11,25] As shown with our first two patients, sequential dilation and crossing the lesion on multiple occasions can be required. The ability to cross a heavily calcified or preocclusive lesion multiple times under flow reversal is a major advantage of TCAR.[7] However, the 0.014-in. wire included with the Enroute device is short to keep most of the catheter exchanges close to the access site. This is advantageous in most cases but can present a problem when longer catheters or standard balloons are required. We encountered this twice in our series. In

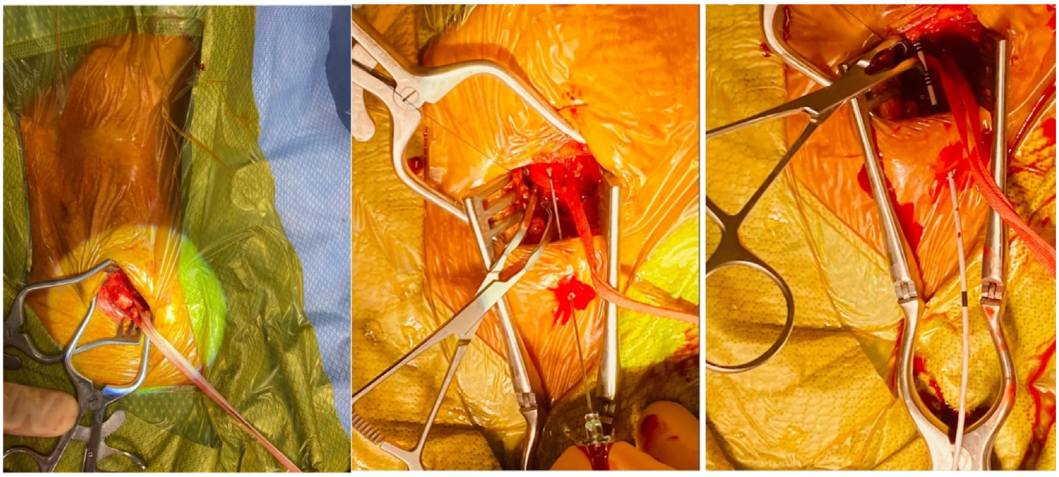

Fig 9. Suprasternal notch access of the proximal right common carotid artery (CCA), creating an extended runway for stent delivery.

one case, we used an alternative exchange length for 0.014-in. wires to allow for placement of longer sheaths (patient 1). For the second patient, we modified the catheters to accommodate the length limitations of the Enroute wire intended for a monorail system.

The cases for patients 3 and 4 in our series demonstrate that TCAR can be successfully performed even in the presence of hostile neck anatomy. That carotid artery dissection can be limited to the CCA low in the neck limits the danger of injury to cranial nerves.[26,27] Based on our experience, we do not believe that hostile neck anatomy should be considered a contraindication to TCAR.

Extensive CCA disease has been considered a relative contraindication to TCAR when the "runway" is <5 cm.[11] In patient 3, we were able to complete stent deployment despite a "short runway" simply by using extra precautions to avoid sheath movement. In patient 4, the anatomy allowed for access to the CCA in the suprasternal notch. For both patients, prior neck surgery and radiation mitigated against CEA. For patient 3, we initially chose TFCAS but were unable to establish a stable proximal sheath position or deploy an embolic protection device due to distal ICA tortuosity. TCAR was the only option for this 70% stenosis with contralateral carotid artery and vertebral artery occlusion.[28] For patient 4, we believed that the embolic potential of the recurrent symptomatic CCA lesion presented an increased risk for TFCAS. In this case, a novel approach to the CCA through the suprasternal notch allowed us to successfully perform TCAR. Another option would have been an extension graft sewn onto the proximal CCA, analogous to those used to obtain iliac access for endovascular aneurysm repair deployment but, again, would have required navigating the dissection through a radiated neck. In addition, sewing a conduit in this case added technical difficulties with the dissection in a radiated neck, including an increased CCA clamp time to sew in the conduit. If the conduit is sewn in over a shunt, this also carries any risks associated with shunt placement, including dissection and embolization.

CONCLUSIONS

These four cases are presented to demonstrate that, in addition to being an alternative to CEA and TFCAS, TCAR could, in fact, be the only option for treatment of some complex lesions. In our case series, we demonstrated successful 30-day outcomes with no postoperative strokes, hematoma, cranial nerve injuries, myocardial infarctions, or deaths. Careful preoperative planning and intraoperative troubleshooting can result in success with the technique.

DISCLOSURES

None.

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