Mechanical thrombectomy of symptomatic carotid stenosis with free-floating thrombus in a patient with COVID-19 using transcarotid artery revascularization

Ali B. Ali, MD, Samuel H. Hui, MD, and Nicolas J. Mouawad, MD, MPH, MBA, RPVI, Bay City, Mich

ABSTRACT
Carotid stenosis with free-floating thrombus is associated with ipsilateral neurologic deficits as a result of cerebrovascular accident or ischemic stroke. Arterial thrombosis and thrombus instability have shown an association with coronavirus disease 2019. Immediate evaluation is essential to assess and prevent thrombus propagation. Traditionally, transfemoral stenting has been performed as minimally invasive intervention. In the present report, we have described the successful use of transcarotid artery revascularization on retrograde flow, aspiration of the thrombus using Penumbra (Penumbra Inc, Alameda, Calif) mechanical thrombectomy, and transcarotid arterial revascularization stenting in a patient with a confirmed case of coronavirus disease 2019. (J Vasc Surg Cases Innov Tech 2021;7:725-9.)

Keywords: Carotid artery stenosis; COVID-19; Free-floating thrombus; Mechanical thrombectomy; TCAR; Transcarotid artery revascularization

Free-floating thrombus (FFT) is a relatively rare event. It usually presents as an acute emergency and requires prompt attention because delay will expose patients to devastating neurologic complications. The current and definitive management of FFT has remained controversial. The surgical outcomes with carotid endarterectomy (CEA) and medical management with anticoagulation therapy have revealed similar outcomes.1 An association of coronavirus disease 2019 (COVID-19) with thromboembolism through mechanisms of hypoxia, inflammation, and diffuse intravascular coagulation has been described.2 Transcarotid artery revascularization (TCAR) has been established as a method of carotid revascularization currently indicated for high-risk patients and has been shown to have a low risk of perioperative thrombus embolization.3 The use of mechanical thrombectomy (MT) alone was reported to result in the risks of thrombus fragmentation and embolization, especially in an unstable plaque.4 We have described the case of a COVID-19–positive patient who had presented with symptomatic carotid stenosis with FFT and an ipsilateral neurologic deficit treated with MT under a TCAR neuroprotective flow reversal technique.

CASE REPORT
A right-handed 73-year-old man had presented with altered mental status, expressive aphasia, and right upper extremity ataxia. The COVID-19 test was positive. The patient was transferred immediately to the COVID-19 intensive care unit and underwent evaluation for stroke. His medical history was significant for hypertension and hyperlipidemia.

Computed tomography (CT) of the head, CT angiography, and magnetic resonance imaging (Fig 1) showed an acute to subacute infarction in the left postcentr gyrus. CT angiography of the patient showed no large vessel occlusion; however, a 60% stenosis of the left internal carotid artery (ICA) was identified, with a tail of a nonocclusive FLT lying centrally within the proximal 3 cm of the left ICA (Fig 2). Neurology and neurointerventional radiology were consulted, and ticagrelor, aspirin, and a statin were started.

A repeat head CT on day 2 revealed subarachnoid hemorrhage (SAH). Neurologic surgery recommended continuing the antiplatelet therapy. Regarding the patient’s COVID-19 status, his oxygen saturation was in the high 80s to low 90s with 4 L of oxygen. The patient had elevated D-dimer and COVID-19 markers (Table).

We proceeded with TCAR flow reversal. MT using a Penumbra catheter (Penumbra Inc, Alameda, Calif), and stent placement rather than traditional CEA because of the patient’s high risk and proximal thrombus location. We also did not choose medical therapy owing to concerns for anticoagulation therapy regarding the SAH and the risks of hemorrhagic transformation. The neurology and neurosurgery teams agreed to the plan after a repeat head CT scan confirmed stable imaging findings and accepted the use of procedural anticoagulation therapy as long as protamine reversal was achieved. Nasotracheal intubation, mandibular subluxation, and, even, lateral mandibulotomy

From the Division of Vascular and Endovascular Surgery, McLaren Health System, Bay City, Michigan, USA.

Correspondence: Nicolas J. Mouawad, MD, MPH, MBA, RPVI, McLaren Bay Heart and Vascular, 1900 Columbus Ave, Bay City, MI 48708 (e-mail: nmouawad@gmail.com).

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were discussed owing to the proximal location of the FFT. However, because of his current COVID-19 status and acute stroke, we decided to consider percutaneous MT with neuroprotection using a flow reversal technique. The patient underwent surgery after confirming its safety with the multidisciplinary team 4 days after his presentation. The patient provided written informed consent for the report of his case and imaging studies.

**SURGICAL TECHNIQUE**

General endotracheal intubation was initiated with simultaneous real-time electroencephalography and percutaneous radial arterial hemodynamic monitoring. A left TCAR approach was performed in the standard fashion with an initial angiogram demonstrating ICA stenosis with a luminal FFT (Fig 3, A). TCAR sheaths were inserted, and flow reversal was achieved using the ENROUTE transcarotid neuroprotection system (Silk Road Medical Inc, Sunnyvale, Calif) on high flow. No significant electroencephalographic changes were identified during carotid clamping or reversal of flow compared with the baseline values.

A CAT-8 MT catheter (Penumbra Inc) was then advanced through the 8F arterial sheath, and suction thrombectomy was started while flow reversal was maintained. The catheter was then advanced in antegrade fashion through the ICA. This process was performed three times, and a large flow channel was obtained. An angiogram was performed after MT suction (Fig 3, B). The distal ICA was engaged with a 0.014-in. wire, and the ICA stenotic portion was dilated using a 5.5-mm balloon, followed by stenting with an ENROUTE 9-mm × 40-mm stent (Silk Road Medical Inc). The neuroprotection process was continued for a further 2 minutes to prevent debris from flowing cranially. A repeat angiogram was performed, which showed complete resolution of any luminal irregularity, brisk antegrade flow, and satisfactory stent positioning (Fig 3, C). The remainder of the procedure was completed in standard fashion, with protamine sulfate used to reverse the anticoagulation. The patient emerged from anesthesia with no new neurologic sequelae or cranial nerve injury. A 1.2-cm thrombus was noted in the suction canister. On pathologic microscopic examination, it was compatible with thrombus (Fig 4). Dual antiplatelet therapy and a statin were continued, and the patient was transferred to the COVID-19 intensive care unit. Constant improvement in the right lower limb was noted. He was more oriented and able to speak, although with some mild expressive and receptive components. No postoperative sequelae or thromboembolic events were noted in the perioperative period, and the patient was discharged on postoperative day 2. He was seen in follow-up at 6 months with a widely patent stent and resolved neurologic concerns.

**DISCUSSION**

Extrapulmonary manifestations of COVID-19 have been previously reported. Major manifestations have included venous and arterial thromboembolism causing acute ischemic stroke. However, the management of FFT is still understudied, and no set guidelines regarding the timing, best approach, or intervention exist. TCAR has been shown to result in a low incidence of perioperative strokes and cranial nerve injuries. The two ROADSTER (safety and efficacy study for reverse flow used during carotid artery stenting procedure) studies, both single-arm clinical trials, demonstrated a low perioperative stroke risk for TCAR of <2%, with a lower risk of cranial nerve injuries than reported for CEA. Multiple studies have shown a similar perioperative stroke risk of

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**Table.** Focused laboratory test results for our patient

| Laboratory test       | Result (status) |
|-----------------------|-----------------|
| D-dimer, mg/dL        | 2.10 (high)     |
| ESR, mm/h             | 42 (high)       |
| CRP, mg/dL, mg/L      | 4.9; 49 (high)  |
| INR                   | 1.48 (high)     |
| PTT, seconds          | 27.9 (normal)   |
| IL-6, pg/mL           | 22.6 (high)     |
| Procalcitonin, ng/mL  | 0.08 (normal)   |
| Platelet count, ×10^12/µL | 441 (mildly high) |

CRP, C-reactive protein; ESR, erythrocyte sedimentation rate; IL, interleukin; INR, international normalized ratio; PTT, partial thromboplastin time.
TCAR compared with traditional CEA, with a lower risk of myocardial infarction despite the higher baseline comorbidities for the TCAR patients. However, compared with transfemoral carotid artery stenting, the outcomes of TCAR were significantly better with significantly shorter procedure times.

Alternative interventions for our patient were discussed, including transfemoral carotid artery stenting. However,
we were uncomfortable proceeding for two reasons. First, this technique requires traversing the unstable FFT to deploy a distal embolic protection device. Second, placing the stent without adjunctive thrombectomy in our estimation would have resulted in “cheese grating” of the thrombotic material. With TCAR flow reversal, these risks are mitigated. Additionally, in a case series of patients with COVID-19 and carotid artery stenosis treated with MT, the use of MT with antegrade flow of the carotid artery was shown to cause thrombus propagation intracranially, probably owing to the unpredictability in COVID-19 thrombus stability. Finally, the use of anticoagulation therapy alone was deemed risky for our patient because of concerns regarding the SAH and hemorrhagic transformation.

The choice of anesthesia can be challenging for patients with COVID-19 for whom positive pressure ventilation remains common despite the tension between balancing the risk to patients and providers that places both groups at high risk of periprocedural complications. Our facility generally uses monitored anesthesia care for both groups at high risk of periprocedural complications. Balancing the risk to patients and providers that places the stent without adjunctive thrombectomy in our estimation would have resulted in “cheese grating” of the thrombotic material. With TCAR flow reversal, these risks are mitigated. Additionally, in a case series of patients with COVID-19 and carotid artery stenosis treated with MT, the use of MT with antegrade flow of the carotid artery was shown to cause thrombus propagation intracranially, probably owing to the unpredictability in COVID-19 thrombus stability. Finally, the use of anticoagulation therapy alone was deemed risky for our patient because of concerns regarding the SAH and hemorrhagic transformation.

The constant advancements in endovascular devices and techniques have been advocating for minimally invasive management of vascular stenosis and thrombosis to becoming common practice. A previous study by our team used the same technique in a patient with an anatomically high lesion and at high risk because of age but without COVID-19. Another study by Mareedu et al. described the use of TCAR retrograde flow and carotid artery stenting to treat an FFT with a high anatomic lesion. The use of a large-bore aspiration catheter to treat an FFT during reversal flow is a novel technique. We believe it is a safe endovascular option for complicated high-risk patients with this type of presentation.

CONCLUSIONS

First, patients with FFT can present with fluctuating neurologic symptoms. Second, our study has shown that TCAR is an option for treating FFT in patients presenting with a high risk of hemorrhagic transformation and contraindications to medical therapy, although further study is required. Finally, the association between FFT and COVID-19 also requires further studies to delineate the correlation.

REFERENCES

1. Bhatti AF, Leon LR Jr, Labropoulos N, Rubinas TL, Rodriguez H, Kalman PG, et al. Free-floating thrombus of the carotid artery: literature review and case reports. J Vasc Surg 2007;45:199-205.
2. Klock FA, Kruip MJA, van der Meer NJM, Arbous MS, Commers DAMPJ, Kant KM, et al. Incidence of thrombotic complications in critically ill ICU patients with COVID-19. Thromb Res 2020;191:145-7.
3. Kwolek CJ, Jaff MR, Leal JI, Hopkins LN, Shah RM, Hanover TM, et al. Results of the ROADSTER multicenter trial of transcarotid stenting with dynamic flow reversal. J Vasc Surg 2015;62:1227-34.
4. Kaesmacher J, Boeckh-Behrens T, Simon S, Maegerlein C, Kleine JF, Zimmer C, et al. Risk of thrombus fragmentation during endovascular stroke treatment. AJNR Am J Neuroradiol 2017;38:991-8.
5. Cui S, Chen S, Li X, Liu S, Wang F. Prevalence of venous thromboembolism in patients with severe novel coronavirus pneumonia. J Thromb Haemost 2020;18:1421-4.
6. Avula A, Nalleballe K, Narula N, Sapozhnikov S, Dandu V, Toom S, et al. COVID-19 presenting as stroke. Brain Behav Immun 2020;87:115-9.
7. Kashyap VS, Schneider PA, Foteh M, Motaganahalli R, Shah R, Eckstein HH, et al. Early outcomes of the ROADSTER 2 study of transcarotid artery revascularization in patients with significant carotid artery disease. Stroke 2020;51:2620-9.
8. Kashyap VS, King AH, Foteh MI, Janko M, Jim J, Motaganahalli RL, et al. A multi-institutional analysis of transcarotid artery revascularization compared to carotid endarterectomy. J Vasc Surg 2019;70:125-9.
9. Cappellini CA, Zheng H, Lamb KM, Sooppan R, Coffey J, Luo RQ. Outcomes of transcarotid artery revascularization and carotid endarterectomy at a single institution. Ann Vasc Surg 2021;73:292-35.
10. Malas MB, Daikour-Ardi H, Kashyap VS, Eldrup-Jorgensen J, Wang CJ, Motaganahalli RL, et al. Transcarotid revascularization with dynamic flow reversal versus carotid endarterectomy in the Vascular Quality Initiative surveillance project. Ann Surg. doi:10.1097/SLA.0000000000004496.
11. Wang A, Mandigo GK, Yim PD, Meyers PM, Lavine SD. Stroke and mechanical thrombectomy in patients with COVID-19: technical observations and patient characteristics. J Neurointerv Surg 2020;12:648-53.
12. Giragani S, Balani A, Agrawal V. Stentriever thrombectomy with distal protection device for carotid free-floating thrombus: a technical case report. J Neurointerv Surg 2017;9:e33.
13. Mouawad NJ, Hui S. Mechanical thrombectomy of symptomatic acute carotid stent thrombosis using transcarotid artery revascularization neuroprotection flow reversal technique. Ann Vasc Surg 2021;70:565.e15-9.

14. Mareedu R, Hwang J, Vyakaranam S, Inkollu S. Use of transcarotid artery revascularization to treat symptomatic carotid artery stenosis associated with free-floating thrombus. Ann Vasc Surg 2021;70:568.e1-3.

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