Rescue of immediate post-transcarotid artery revascularization carotid stent thrombosis due to clopidogrel resistance using flow-reversal and aspiration thrombectomy

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ABSTRACT

An 84-year-old patient developed immediate thrombosis of his carotid stent in recovery after transcarotid artery revascularization. In the present report, the technical details about intraoperative management for neurovascular rescue using the transcarotid artery revascularization flow-reversal system are described. The patient was determined to have clopidogrel resistance. Intraoperative medical management is also discussed. The current alternative intravenous and oral antiplatelet therapies such as glycoprotein IIb/IIIa and P2Y12 inhibitors are explored. The debate regarding preoperative antiplatelet resistance testing remains ambiguous, and increasing studies have demonstrated the safety and efficacy of alternatives to clopidogrel. Despite an unpredictable and devastating complication, the patient's outcome was successful using contemporary strategies. (J Vasc Surg Cases Innov Tech 2023;9:1-5.)

Keywords: Acute carotid stent thrombosis; Cangrelor; Clopidogrel resistance; Ticagrelor; Transcarotid artery revascularization (TCAR)

Early acute carotid stent thrombosis (ACST) in the immediate postoperative period is a rare surgical emergency (0.59%) that continues to be a significant concern even as stenting technologies have evolved to include transcarotid artery revascularization (TCAR).[1] Various technical and clinical failures can contribute to ACST; however, one issue that has remained vexing is antiplatelet resistance.[2] Antiplatelet regimens have been derived from cardiology literature, and clopidogrel resistance has been well-documented.[1-3] Previously an alternative therapy, ticagrelor is now a first-line treatment in cardiology guidelines owing to the lower incidence of resistance.[3] A new intravenous P2Y12 inhibitor, cangrelor, has been used successfully as a bridging agent in recent multidisciplinary studies.[4-7] Even with TCAR developed to increase the safety and accessibility of carotid interventions for the high-risk population, early ACST remains an acute concern. This report describes a patient who developed early ACST after TCAR and subsequent aspiration thrombectomy for neurovascular rescue using the TCAR flow-reversal system (ENROUTE; Silk Road Medical). A discussion of the intra- and postoperative medical management of antiplatelet therapy in the setting of clopidogrel resistance is also included. The patient provided written informed consent for the report of his case details and imaging studies.

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CASE REPORT

An 84-year-old Mexican man presented to the emergency department with transient left arm numbness and weakness at 7 hours after the initial onset and a National Institutes of Health stroke scale score of 1. His medical history included well-controlled type 2 diabetes, hypertension, and prior tobacco abuse. Magnetic resonance imaging revealed two areas of right frontoparietal cortical infarction, and computed tomography angiography of the head and neck revealed 80% stenosis of the right internal carotid artery (ICA), with 0% contralateral ICA stenosis. The plaque demonstrated minimal calcification and the circle of Willis was intact, except for the A1 segment of the right anterior cerebral artery. The patient's ejection fraction was 68.5%. However, because his carotid artery lesion was anatomically high and he was of advanced age, the patient was offered right-sided TCAR. The patient gave informed consent to proceed.

The patient received aspirin 81 mg, clopidogrel 75 mg, and atorvastatin 80 mg for 3 days before surgery. The right-sided TCAR was uneventful (Fig 1). The patient was neurologically intact upon awakening, moving all four extremities to command, and was transferred to recovery in stable condition.

However, 30 minutes after arrival, the patient demonstrated significant lethargy, left facial droop, and left arm and leg hemiplegia. Computed tomography angiography demonstrated no intracranial hemorrhage; however, the right ICA stent was occluded (Fig 2). His family provided consent for an emergent

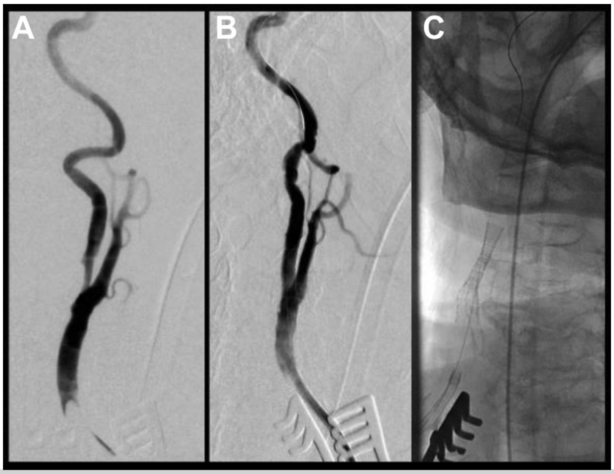

Fig 1. Initial transcarotid artery revascularization (TCAR). **A,** Preintervention angiogram. **B,** Completion angiogram. Note the "wire bias" causing vessel "accordioning." **C,** Orthogonal view of carotid artery stent.

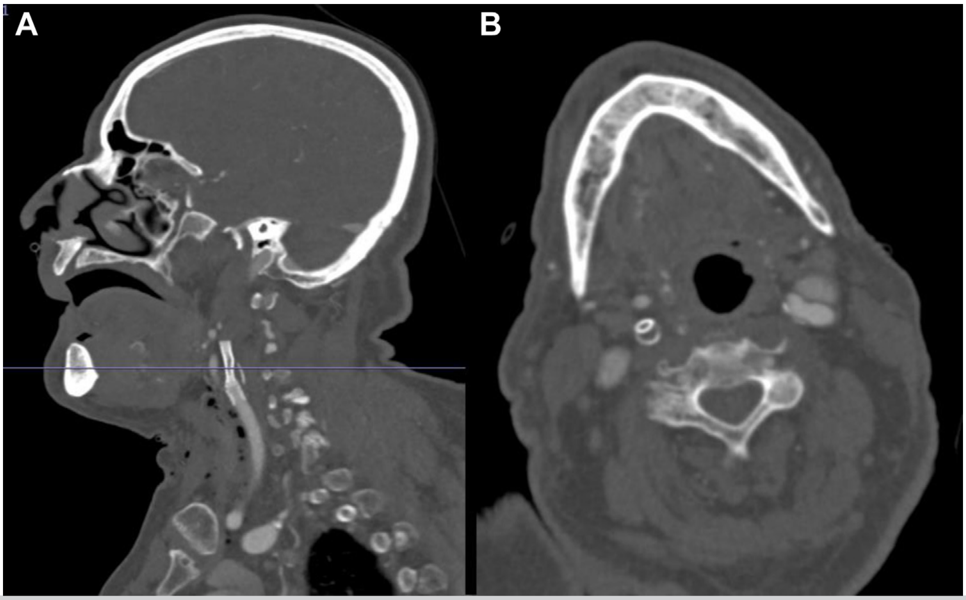

Fig 2. Immediate postoperative computed tomography angiogram of the head and neck demonstrating right internal carotid artery (ICA) stent occlusion after initial transcarotid artery revascularization (TCAR). **A,** Sagittal image selected to demonstrate lack of contrast opacity within the distal stent compared with the common carotid artery (note: not center-lined). **B,** Axial image demonstrating the occluded portion of the stent with the most apparent narrowing; however, it was not significantly narrow (<50%) compared with the distal aspect of the stent within the ICA.

return to the operating room. Reoperation was performed within 2 hours of initial symptom onset.

The patient was reheparinized, and an activated clotting time >270 seconds was maintained. The prior incision was used for repeat exposure and vascular control. The patient's right common carotid artery was punctured again, superior to the earlier TCAR access site, and the initial angiogram demonstrated the occluded ICA and a reconstituted distal cavernous segment. The "stop-short" technique was readily used for ENROUTE sheath placement and flow-reversal initiated. The ENROUTE sheath's 0.035-in. J wire was used to place a 40-cm angled 5F catheter distal to the stent to prevent wire passage between the struts. Using a 0.014-in. hydrophilic-tipped wire and 0.018-in. microcatheter, the distal ICA was navigated to the cavernous segment and luminal placement confirmed via angiogram (subsequent angiograms were performed with a 3-minute delay after each mechanical manipulation; Fig 3). The 6F Pronto V4 Extraction Catheter (Teleflex), which was the only aspiration device our hospital had available emergently, was used for embolectomy, with aspiration of copious fresh thrombus and platelet aggregates (Fig 4).

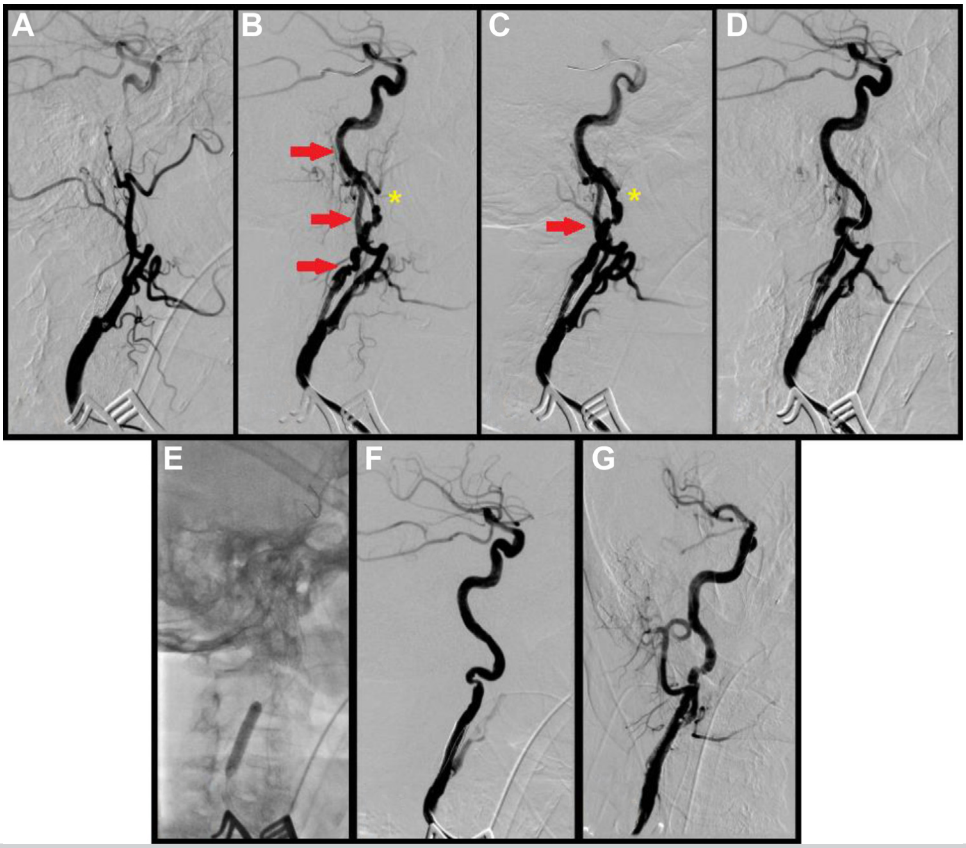

Fig 3. Rescue procedure. **A,** Initial angiogram demonstrating carotid artery stent occlusion and reconstitution of the distal cavernous internal carotid artery (ICA). **B,** Angiogram after initial aspiration thrombectomy passes. **C,** Subsequent progression angiogram after additional thrombectomy passes. **D,** Angiogram after targeted aspiration thrombectomy (at *yellow asterisks,* seen in panels **B** *and* **C**) and nitroglycerin injection. Note the residual thrombus within the carotid artery stent. **E,** Predilation balloon angioplasty of carotid stent. **F** and **G,** Completion angiograms, orthogonal views. *Yellow asterisks* indicate thrombus within distal ICA; *red arrows,* areas of vasospasm.

After multiple passes, little material was aspirated. Thus, an angiogram was performed. The angiogram demonstrated some areas of vasospasm and one area of thrombus, which was aspirated in a targeted fashion. Next, the angled 5F catheter was placed distal to the areas of vasospasm to allow for retrograde treatment with 100 μg of nitroglycerin (diluted 1:1 by volume with heparinized saline (10,000 U/L), administered over 30 seconds) via a Tuohy-Borst adapter. A subsequent angiogram demonstrated improvement. Before continuing with the stent interventions, 8 mg of intravenous dexamethasone was given, and cangrelor was initiated per the manufacturer's recommendations (30 μg/kg initial bolus; 4 μg/kg/min infusion rate).

Residual material appeared present within the stent. Thus, it was predilated, and the relining stent deployed. Angiography demonstrated that the stent was satisfactorily placed and widely patent on orthogonal views. However, one distal area of mild vasospasm was present, even with the wire pulled back to remove "wire bias." Another focal injection of 100 μg nitroglycerin was given. The completion angiogram demonstrated modest improvement but looked otherwise satisfactory; thus, no further interventions were pursued, and the procedure was concluded in standard fashion (Table). Copious platelet aggregate debris was observed in the ENROUTE filter. The patient was neurologically intact upon awakening and was transferred to recovery in stable condition.

The patient was transitioned to ticagrelor with a 180-mg initial bolus dose, with cangrelor discontinued 2 hours afterward. A platelet function assay tested using a preoperative blood sample during the rescue procedure was found to be within the normal range (84 seconds; reference range, 54-181 seconds). No other preoperative samples were available for analysis. However, postoperative TEG (thromboelastography) platelet mapping (Haemoscope Corp) indicated excellent platelet inhibition on ticagrelor, with a net global clot strength of 1.3 kdyn/s (reference range, 4.6-10.9 kdyn/s). The remainder of the patient's clinical course was uneventful, and he was discharged on postoperative day 2. On follow-up, the patient was neurologically intact and doing well with ticagrelor and statin treatment.

DISCUSSION

Rescue of early ACST has been described with surgical stent explantation and endarterectomy, as well as

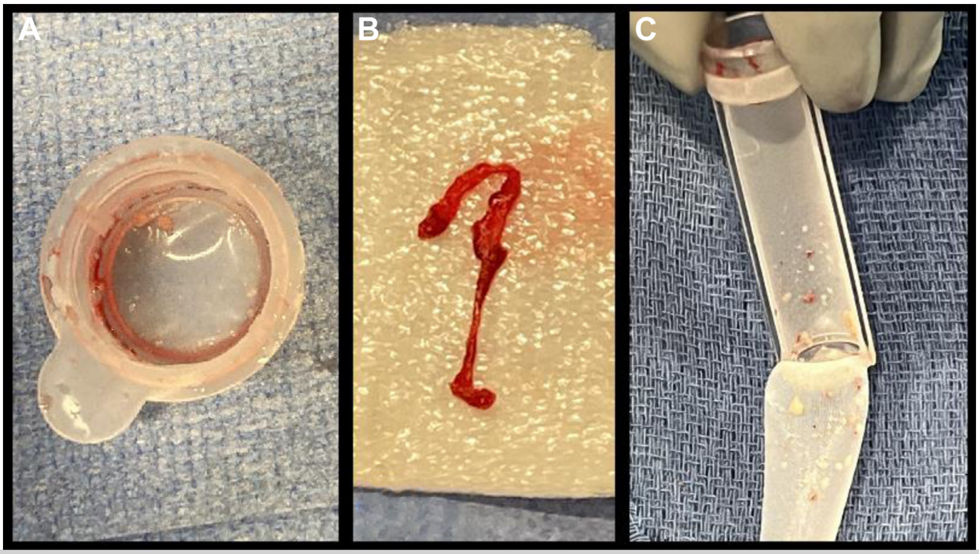

Fig 4. Rescue procedure specimens. **A,** Aspirated platelet aggregates. **B,** Aspirated thrombus. **C,** ENROUTE filter contents with platelet aggregates.

Table. Details of initial transcarotid artery revascularization (TCAR) and rescue procedure

Detail	Initial TCAR	Rescue procedure
Anesthesia	General	General
Initial heparin bolus, U	7000	7000
Predilation diameter, mm	5	5.5
ENROUTE stent size, mm	9 × 30	10 × 30
Postdilation	No	No
Protamine reversal, mg	30	None
Operative time, minutes	55	163
Carotid flow reversal time, minutes	9	47
Contrast volume, mL	30	60
Radiation dose, mGy	22	370
Fluoroscopy time, minutes	2.3	24.5
Estimated blood loss, mL	40	200

endovascular techniques with distal embolic protection.[8-10] Parodi et al[11] described the first flow-reversal technique for thrombotic carotid intervention in 2005 using his novel system, and other investigators have described using the ENROUTE system for nonocclusive carotid thrombus intervention.[12-14]

In the present case, the ENROUTE system was used as an adjunct for embolic protection to facilitate swift revascularization in a case of post-TCAR early ACST. In contrast to transfemoral and radial access, reexposure and common carotid artery access bypassed the technical difficulties associated with aortic and great vessel navigation.[15,16]

Intravenous antiplatelet options are few, and aside from glycoprotein IIb/IIIa inhibitors (ie, eptifibatide, abciximab, tirofiban), the option of cangrelor offers an intravenous formulation within the same P2Y12 inhibitor family as the oral regimens recommended for carotid artery stenting. The pharmacodynamic profile of cangrelor includes its rapid onset (2 minutes) and short half-life (3-6 minutes), making it advantageous for intraoperative and bridging uses.[4,17] In addition to the proven safety profile described in the cardiology literature regarding the hemorrhagic risk, its use has been described in neurointerventional literature with positive results.[5-7] Cangrelor has a lower risk of intracranial hemorrhage compared to abciximab. Furthermore, it has the advantage over eptifibatide and tirofiban in that it does not require renal-adjusted dosing.[18,19] Dexamethasone has been shown in animal studies to have a stabilization effect on the blood–brain barrier. Thus, it might have a role in the reduction of cerebral edema and, potentially, hyperperfusion syndrome and intracranial hemorrhage after carotid revascularization.[20-22] Steroid use for stroke remains under investigation.[23,24]

The surprising frequency of clopidogrel resistance has led to the increased study of ticagrelor as the oral antiplatelet of choice for carotid stenting.[25-27] Preoperative testing for clopidogrel resistance via functional, TEG, or genetic testing is not currently universally recommended.[3] However, until ticagrelor becomes a first-line recommendation for carotid artery stenting (as it has for cardiac stenting), testing for clopidogrel resistance should be considered.

CONCLUSIONS

The evolution of carotid artery stenting techniques and the advancement of pharmacologic options have afforded us the ability to reexamine our current standard of care and the opportunity to explore new therapeutic options to treat ACST, a devastating and feared postoperative complication.

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