Recanalization of an Acute Middle Cerebral Artery Occlusion Using a Self-Expanding, Reconstrainable, Intracranial Microstent as a Temporary Endovascular Bypass

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Background and Purpose—Although self-expanding intracranial microstents have been used to treat acute middle cerebral artery (MCA) stroke, there are disadvantages associated with placing a permanent endovascular implant. We describe a technique in which a reconstrainable stent was used to provide a temporary endovascular bypass to achieve MCA recanalization without permanent stent implantation.

Methods—A 55-year-old male presented with acute onset left hemiplegia (National Institutes of Health Stroke Score (NIHSS) of 20. Angiography showed an occluded right cervical internal carotid artery (ICA), a patent anterior communicating artery (ACOMM), and embolic occlusion of the right middle cerebral artery (MCA), M1 segment.

Results—Working through a 6F guide-catheter positioned in the left cervical ICA, an SL-10 microcatheter, and 0.014-inch Synchro-2 microwire were manipulated across the anterior communicating artery and into the right M1 segment occlusion. 5 mg of abciximab and 3 mg tPA were infused directly into the thrombus through the microcatheter. Mechanical thrombolysis using the microwire and microcatheter was ineffective in achieving any recanalization. An Enterprise stent (4 \times 22 \text{ mm}) was delivered across the occlusion site and partially unconstrained. The unconstrained portion of the stent expanded and acted as a temporary bypass, to circumferentially displace and structurally disrupt the M1 thrombus, producing immediate revascularization of the right territory MCA. After approximately 20 minutes, the Enterprise stent was reconstrained and removed. Final angiography demonstrated excellent filling of the right M1 and distal MCA branches. The patient improved to an NIHSS of 7, regaining movement of his left upper and lower extremities.

Conclusions—The temporary endovascular bypass technique yielded immediate and durable revascularization of an acutely occluded middle cerebral artery without the disadvantages associated with the placement of a permanent endovascular stent. (Stroke. 2008;39:1770-1773.)

Key Words: acute stroke | cerebral revascularization | stent

Numerous endovascular strategies have been used to achieve the recanalization of occluded intracranial arteries in the setting of acute ischemic stroke. Despite the proliferation of devices and techniques, complete MCA recanalization is achieved in only about 50\% of cases, and the existing techniques are time-consuming, often requiring more than 1 hour to achieve recanalization, and all are associated with potential serious adverse events.

Self-expanding intracranial stents, which are commercially available for the treatment of cerebral aneurysms and intracranial atherosclerotic disease, have been used off-label with high levels of success to recanalize occluded intracranial vessels.\(^1-5\) However, there are important disadvantages associated with the permanent implantation of self-expanding intracranial stents in the setting of acute ischemic stroke, including those associated with the need for long-term platelet inhibition and delayed in-stent stenosis.\(^6,7\) Furthermore, with embolic occlusion, the affected artery is structurally normal and does not require a permanently implanted stent.

We describe a novel technique in which a reconstrainable self-expanding intracranial microstent was successfully used to achieve the immediate recanalization of an occluded right MCA that was refractory to pharmacological thrombolysis with intravenous (IV) tissue plasminogen activator (tPA), intraarterial (IA) tPA, IA abciximab, and mechanical manipulation. This temporary endovascular bypass technique capitalizes on all of the advantages of stenting without the disadvantages associated with the placement of a permanent endovascular device.
Materials and Methods

Patient Presentation
Fifty-five–year–old right handed male developed acute onset of left arm and leg weakness. He was assessed at a local hospital. Computed tomography showed a hyperdense right MCA sign and no hemorrhage. He was administered a bridging dose of IV tPA (40 mg) and transferred to our institution. He arrived 4 hours after the onset of symptoms with a National Institutes of Health Stroke Score (NIHSS) of 20. He had dense left arm and leg weakness, a left facial droop, and neglect. Computerized tomography angiography showed an occluded right cervical internal carotid artery (ICA), a patent anterior communicating artery with occlusion of the right M1 segment of the middle cerebral artery. There was no evidence of hemorrhage or a large cortically-based completed infarction on plain computerized tomography of the brain. The decision was made to proceed with IA therapy. Two physician consent was obtained for the procedure because the family was not present and could not be located. Before the use of the Enterprise stent, a representative of our Institutional Review Board (IRB) was urgently contacted and informed of the emergency use situation. After the case, the patient’s family was notified of the off-label use of the Enterprise, and written reports were provided to our IRB as well as the manufacturer (Cordis Neurovascular, Johnson and Johnson).

Intervention
The patient was immediately taken to the angiography suite and general endotracheal anesthesia was instituted. Diagnostic angiography was performed, confirming complete occlusion of the proximal right cervical ICA. Injection of the left vertebral artery showed minimal leptomeningeal collateral filling over the right hemisphere. A 6-French 90-cm Envoy guiding catheter (Cordis Neurovascular) was placed into the left cervical ICA at the C2 level. Angiography showed patency of the anterior communicating artery with filling of the right distal carotid terminus and proximal M1 segment of the right middle cerebral artery (Figure 1). A complete embolic occlusion of the M1 segment of the right MCA was present. (Figure 1, arrow).

Figure 1. Anterior-posterior projection left internal carotid artery injection showing cross-filling via the anterior communicating artery with occlusion of the M1 segment of the right middle cerebral artery at the level of the anterior temporal artery. The occlusion is shown by the arrow.

An SL-10 microcatheter (Boston Scientific) was manipulated over a Synchro-2 0.014 microwire (Boston Scientific) across the anterior communicating artery and into the right MCA under fluoroscopic roadmap control. IA abciximab (5 mg) and tPA (3 mg) were infused directly into the thrombus. Mechanical thrombolysis was performed with multiple passes of the microcatheter and microwire through the thrombus. These measures were ineffective in achieving recanalization over a 25-minute period.

The SL-10 was then exchanged for a Prowler Plus Select microcatheter (Cordis Neurovascular). A 4×22 mm Enterprise stent (Cordis Neurovascular) was introduced into the microcatheter and delivered across the site of occlusion (Figure 2). Approximately two-thirds of the stent was unconstrained across the M1 thrombus (Figure 3). The unconstrained portion of the stent expanded, acting as a temporary bypass to circumferentially displace and structurally disrupt the occlusive thrombus. This immediately restored robust flow across the anterior communicating artery, through the right M1 and into the distal right MCA circulation (Figure 4a through 4c). An additional 5 mg of abciximab was administered through the guiding catheter and the partially expanded Enterprise was left in position for 20 minutes. The Enterprise stent was then reconstrained and removed, and an additional 2 mg of abciximab and 2 mg of tPA were administered through the microcatheter.

Figure 2. Dual roadmap through the guide catheter in the left internal carotid artery and the microcatheter distal to the thrombus in the right middle cerebral artery. The proximal and distal extent of the thrombus in the M1 segment is demarcated by the arrows. The Enterprise stent has been positioned across the thrombus under roadmap control and on this image remains constrained within the microcatheter.

Figure 3. Native anterior-posterior projection showing the Enterprise stent (4.5 mm×22 mm) in the right MCA. The distal and proximal markers of the stent are shown by the arrows. The distal marker of the Prowler Plus microcatheter is shown by the arrowhead. The distal marker is positioned just proximal to the midpoint of the centering marker. The proximal aspect of the centering marker (to the right of the image) represents the “point of no return” after which the stent can no longer be reconstrained.
Results
Angiography performed after the removal of the Enterprise stent and Prowler Plus microcatheter demonstrated excellent reperfusion of the right MCA distribution (Figure 5). Immediately after the procedure, the patient was substantially improved, regaining movement of the left upper and lower extremities. The patient improved to an NIHSS of 7, was able to ambulate with assistance, and was ultimately discharged to an acute rehabilitation facility 7 days later.

Discussion
Commercially available self-expanding intracranial microstents (SES), approved under a Humanitarian Device Exemption (HDE) for the treatment of aneurysms and atherosclerosis, have been used with success for the recanalization of acute intracranial occlusions refractory to other measures. The available SES are unsheathed from their delivery microcatheters, opening distally to proximally. When positioned properly (distal to the leading edge of the occluding embolus) the stent opens to circumferentially displace the occluding clot, immediately reestablishing a channel of flow within the occluded vessel. Once flow is reestablished, the high local concentration of prothrombotic factors in the region of thrombus is immediately dissipated, creating a physiology favoring recanalization and thrombus dissolution. The SES also functions to trap the majority of the thromboembolic material against the wall of the parent vessel. This material (trapped between the SES and parent vessel wall) typically lyses over time (minutes) in response to the restoration of blood flow, the mechanical disruption produced by the outward radial force of the SES, and pharmacological thrombolysis with antiplatelet (typically IIb/IIIa inhibitors) and in some instances thrombolytic medications.

The application of SES in acute stroke appears to have several advantages compared to other interventional techniques. First, stenting has a very high reported rate of successful recanalization. Second, whereas other techniques often take hours to achieve recanalization, SES implantation typically produces immediate recanalization with robust reperfusion of the compromised territory. Third, SES deployment is less technically demanding and operator dependant than other revascularization strategies—particularly in comparison to thrombus retrieval devices such as the Merci retriever (Concentric Medical) and “The Alligator” (Chestnut Medical).

At the same time, there are important disadvantages to stenting in the setting of acute stroke. The implantation of a permanent intracranial SES requires immediate and prolonged therapy with multiple antiplatelet agents. Typically this consists of an intraprocedural IIb/IIIa inhibitor followed by immediate postprocedural loading with both aspirin and clopidogrel and prolonged dual antiplatelet therapy (for a minimum of 8 to 12 weeks). In the peri procedural period, the risk of clinically significant parenchymal hemorrhage, particularly when thrombolytic agents have been given, is likely increased by the addition of antiplatelet agents. In the postprocedural period, patients whose stroke is attributed to atrial fibrillation or a hypercoaguable state, may require long-term anticoagulation with warfarin. The combination of an anticoagulant (to prevent recurrent thromboembolism) with 1 or more antiplatelet agents (for stent prophylaxis) in a patient who has suffered cerebral ischemic injury is likely to

Figure 4. a, Native image. Anterior-posterior projection showing the Enterprise stent across the area of occlusion. The arrowheads depict the thrombus that has been pushed up against the wall of the vessel. b, Anterior-posterior projection showing the thrombus macerated and pushed up against the vessel wall. There is distal flow past the partially deployed stent. c, Left internal carotid injection branch run (anterior-posterior projection) showing immediate flow restoration through the right M1 segment of the middle cerebral artery filling via the anterior communicating artery after partial deployment of the Enterprise stent.

Figure 5. Final left internal carotid injection (anterior-posterior projection), after reconstainment and removal of the Enterprise stent, showing complete recanalization of the right middle cerebral artery occlusion with restoration of antegrade flow.
be associated with a high risk of hemorrhage. The placement of any intracranial stent, either for aneurysm treatment or atherosclerotic disease, may induce in stent stenosis or restenosis.7,12–14 If symptomatic, in-stent stenosis may require more aggressive medical, surgical, or endovascular intervention. In acute embolic stroke to an otherwise normal intracranial vessel, with permanent stenting, we run the risk of exchanging one disease process (acute embolic occlusion) for another (intracranial in-stent stenosis).

The temporary endovascular bypass technique capitalizes on all of the advantages of permanent stenting while avoiding many of the disadvantages. Like stenting, the temporary bypass strategy has the potential to provide immediate robust recanalization. Unlike a fully deployed stent, the device may be reconstrained and repositioned if necessary to optimize flow restoration. If the vessel reoccludes after reconstraint, the device can be redeployed to restore perfusion, and additional lytic agents can be administered as needed. Because the device is ultimately removed, there are no requirements for long-term antiplatelet medications (provided that the underlying artery is structurally normal). Finally, because no permanent stent is placed, there would be no risk of in-stent stenosis.

Summary
The temporary endovascular bypass technique using the Enterprise stent represents a novel strategy to achieve immediate recanalization of an occluded brain artery without the disadvantages and risks associated with permanent stent implantation.

Disclosures
Dr Fiorella is a shareholder in Revasc Inc, and has received significant research support from Boston Scientific. The other authors report no conflicts of interest.

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