CASE REPORT

Aspiration thrombectomy in concert with stent thrombectomy

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SUMMARY

In the SWIFT and TREVO 2 trials, aspiration thrombectomy was not able to be performed. Outside these studies, in post-market application, the interventionist can use aspiration thrombectomy in addition to stent device thrombectomy. This technique is described in detail in the present report. Combined aspiration/stentriever thrombectomy may improve recanalization efforts, simplify a second thrombectomy attempt if necessary and may limit distal embolization.

BACKGROUND

On the basis of the promising revascularization results in the SOLITAIRE FR With the Intention For Thrombectomy (SWIFT)¹ and the Trevo versus Merci retrievers for Thrombectomy REvascularisation of large Vessel Occlusions in acute ischemic stroke (TREVO 2)² trials (69% and 78% recanalization, respectively), the Solitaire (ev3/Covidien, Irvine, California, USA) and Trevo (Stryker, Kalamazoo, Michigan, USA) stent retrieval devices (stentriever) were granted Food & Drug Administration approval for use in mechanical thrombectomy for acute ischemic stroke. Both trials showed superior revascularization rates (69% Thrombolysis in Myocardial Infarction flow ≥ 2 and 86% Thrombolysis in Cerebral Infarction (TICI) flow ≥ 2 for Solitaire and Trevo, respectively) and neurological outcomes (modified Rankin Scale score ≤ 2 in 37% and 40% of patients treated with Solitaire and Trevo, respectively) compared with the Merci device (Stryker).

Nevertheless, stentriever remain imperfect tools for thrombectomy. One problem frequently encountered is distal thromboembolism of the offending clot during thrombectomy (reported in 7% of patients treated with the Trevo,² not reported in the SWIFT trial). Additionally, multiple passes are frequently required prior to revascularization (mean 1.7 ± 0.9 and 2.4 ± 1.4 for Solitaire¹ and Trevo,² respectively).

In the SWIFT and TREVO 2 trials, aspiration thrombectomy was not able to be performed. Outside these studies, in post-market application, the interventionist can use aspiration thrombectomy in addition to stent device thrombectomy. This technique is described in detail in the present report. Combined aspiration/stentriever thrombectomy may improve recanalization efforts, simplify a second thrombectomy attempt if necessary and may limit distal embolization.

TECHNIQUE

Standard sedation, positioning and femoral artery access are obtained. A 6 Fr or larger guide catheter or sheath is placed within the cervical segment of the affected vessel (vertebral or carotid artery). A 0.21 inch or larger inner diameter microcatheter (for stentriever delivery) is placed within a large-caliber aspiration catheter (Penumbra 54 aspiration catheter or Penumbra 5 Max (a larger guide catheter is required for the Penumbra 5 Max); Penumbra, Alameda, California, USA) and advanced through the guide catheter under roadmap guidance to the vessel occlusion site. A typical set-up for combined aspiration/stentriever thrombectomy is displayed in figure 1. The aspiration catheter is advanced over the microcatheter to the most distal position possible in the affected vessel. For middle cerebral artery (MCA) thrombectomy, a position within the distal internal carotid artery (ICA) or proximal MCA is typically feasible. The microcatheter is advanced through the thrombus using fluoroscopic visualization over a microwire. The microwire is removed and the stent is advanced into position overlying the site of thrombus and then deployed. If a microcatheter larger than 0.021 inch inner diameter is used for stent delivery, the stent delivery sheath should be inserted as far as possible into the catheter prior to advancing the stent because the distal end of the stent may partially deploy within a larger microcatheter, making delivery difficult. Once the stent is deployed in an acceptable position, the microcatheter is completely removed using exchange technique, leaving the stentriever in place at the site of occlusion. Because the stent delivery system for the Solitaire and Trevo devices is shorter than standard exchange wires (push wire length 180 cm), the microcatheter must be removed without control of the wire. This is not typically problematic as the deployed stent device is anchored in position at the site of occlusion. Once the microcatheter is removed, the aspiration tubing is prepared for thrombectomy. Stentriever thrombectomy is then performed by removing the stent device into the distal access catheter with ongoing continuous aspiration (figure 2). Aspiration is continued typically for 1–2 min to clear any intraluminal debris created during the thrombectomy attempt. The stent device is inspected for thrombus and resheathed for additional thrombectomy attempts, if necessary. An angiogram is performed to inspect for revascularization, persistent occlusion or new distal emboli. Additional thrombectomy attempts

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Figure 1 Typical set-up for combination aspiration/stentriever mechanical thrombectomy. A microcatheter (0.021 inch inner diameter) for stent delivery is within an aspiration catheter (0.054 inch inner diameter) which is within a guide catheter (0.070 inch inner diameter) introduced through a sheath (6 Fr). Heparinized saline flush is used for all catheters.

with the stent device are performed by bringing the microcatheter back into position within the occluded vessel through the distal access catheter, which remains in position just proximal to the area of stenosis from the first thrombectomy attempt.

CASE PRESENTATION

A previously well left-handed octogenarian presented with acute onset of left hemiplegia and hemibody neglect. The initial National Institutes of Health Stroke Scale (NIHSS) score was 23. CT angiography and perfusion imaging suggested an MCA superior branch occlusion with favorable perfusion (figure 3). An incidental right frontal meningioma was also appreciated. The patient was initially evaluated 2 h after the onset of symptoms and was treated with intravenous tissue plasminogen activator. The examination remained unchanged despite the

Figure 2 Schematic representation of combined aspiration/stentriever thrombectomy for a middle cerebral artery (MCA) thrombus (in this schematic the stent delivery microcatheter has not been removed although it may be removed, as described in the text). The stent device has engaged the thrombus, which is retracted into the aspiration catheter with continuous suction. Embolization into new territory (such as the anterior cerebral artery) is minimized. Debris created with thrombectomy may also be aspirated rather than embolized distally to branches of the MCA. Distal access provided by the aspiration catheter simplifies subsequent thrombectomy attempts, if required. ACA, anterior cerebral artery.

intravenous thrombolysis. The patient was taken for thrombectomy after discussion of risks and benefits with the family.

TREATMENT

Angiography confirmed occlusion (TICI grade 0) of the superior trunk of the right MCA (figure 4). The diagnostic catheter was exchanged for a 6 Fr Cook shuttle which was placed within the proximal internal carotid artery. A Trevo Pro 18 microcatheter (0.021 inch inner diameter) was directed into position over a flow-directed 0.016 inch microwire through a Penumbra 054 catheter. Upon confirming the position distal to the site of occlusion, the Trevo device was deployed and the microcatheter subsequently removed. Thrombectomy was performed with continuous aspiration through the Penumbra 054 catheter, which was brought into position just proximal to the deployed Trevo stent at the site of occlusion. Two thrombectomy attempts were made, with return of thick thromboembolic material on both passes. After two thrombectomy attempts, TICI grade 2b flow was achieved (figure 5). There was an area of delayed flow in the distal frontal lobe that was thought to be clinically insignificant, and the procedure was completed with removal of the catheters and arteriotomy closure.

POSTOPERATIVE COURSE

Postoperative MRI displayed a small infarction (figure 6). The patient's neurological examination returned to near baseline level with subtle hemiparesis (NIHSS score 2).

DISCUSSION

Stentriever is the newest tool in the arsenal of the endovascular surgeon for the treatment of acute ischemic stroke. Although the results of the SWIFT¹ and TREVO 2² studies are promising, it is our hope that thromboaspiration at the site of the occlusion in addition to thrombectomy will further improve outcomes with more efficient and complete thrombectomy. Thrombectomy with aspiration (playfully coined 'Sol-numbra' and 'Tre-numbra' based on the thrombectomy and aspiration systems typically used; see table 1 for commonly employed catheters and compatibility) may improve recanalization and outcomes. Recanalization time is limited in the event of multiple thrombectomy attempts, as the position of the distal access catheter simplifies repositioning of the stent delivery microcatheter if multiple thrombectomy attempts are required for recanalization. Thromboaspiration just

Figure 3 Case example. Axial cut of CT perfusion image displays areas of increased time-to-peak contrast material opacification (small arrows) with preserved volume (large arrow), consistent with ischemic penumbra.

proximal to the occlusion site may limit distal embolization of endoluminal thrombus debris mobilized but not removed during thrombectomy attempts. The importance of maximizing recanalization and minimizing recanalization time should not be underestimated in acute ischemic stroke.

The application of manual aspiration thrombectomy in acute stroke interventions is not well described in the literature. Jankowitz *et al*³ recently described their experience with manual aspiration thrombectomy in 191 patients with acute ischemic stroke. They found that a larger aspiration catheter

Figure 4 Same case as figure 3. Angiography, right internal carotid artery injection with anteroposterior (left) and lateral (right) views showing occlusion of the superior trunk of the middle cerebral artery (arrows).

Figure 5 Same case as figure 3. Angiography, right internal carotid artery injection with anteroposterior (left) and lateral (right) views showing Thrombolysis in Cerebral Infarction grade 2b flow of the middle cerebral artery after thrombectomy.

diameter (≥ 0.054 inch), which they used in most of their cases, was associated with higher recanalization rates compared with cases in which a small aspiration catheter was used. In most cases, mechanical thrombectomy (primarily with the Merci device) was performed before initiation of aspiration. The use of stentrievers in conjunction with aspiration thrombectomy, however, was not described in this article. Manual aspiration through an occlusive balloon guide catheter has been described previously⁴ and was encouraged in the TREVO 2² and SWIFT¹ trials.

In contrast, adjunctive manual thrombectomy performed during acute coronary intervention has been studied more extensively. In a meta-analysis of randomized trials conducted with adjunctive manual thrombectomy devices to prevent distal embolization in acute myocardial infarction, significantly lower mortality, decreased distal embolization and an improved myocardial perfusion pattern were observed with adjunctive

thrombectomy compared with percutaneous coronary intervention alone.^{4,5}

One major limitation of performing aspiration thrombectomy in acute stroke as a sole technique is a significantly longer time from initiation of the procedure to achieving successful recanalization.^{6–8} Stentrievers are capable of providing almost instant recanalization (the concept called temporary endovascular bypass), but they carry the risk of distal embolization of clot debris during performance of the retrieval maneuver. The clinical relevance of distal thromboembolism in the setting of mechanical thrombectomy for acute ischemic stroke remains unclear. Theoretically, combining the two fundamentally different approaches to recanalization (distal aspiration together with stent thrombectomy) provides a technique that offers both rapid recanalization and low risk for distal embolic complications. The distal location of the aspiration catheter enables rapid replacement of a stent-retriever device if a second thrombectomy attempt is required. This must be weighed against the increased cost of using a distal access catheter and the increased time required to set up a three-tiered catheter system. Another theoretical limitation to this technique is the potential for disrupting the thrombus when pulling it within the distal access catheter. The diameter of most distal access catheters we employ for this technique is between 0.054 and 0.058 inch or 1.4 and 1.5 mm (table 1). This has been sufficiently capacious to allow effective thrombectomy, although the aspiration catheter diameter is considerably smaller than the diameter of a 9 Fr balloon guide catheter (0.085 inch or 2.2 mm). The clinical significance of this theoretical risk is difficult to quantify, but is worth considering when employing aspiration through a distal access catheter in concert with stent thrombectomy. We have not experienced significant distal thromboembolism with this technique, although the delayed filling in the frontal lobe seen in the case described may represent a distal thromboembolism from such a shearing event. Of additional note, we have not experienced clogging of the aspiration catheter, which may be secondary to the stent device clearing the aspiration catheter as it is withdrawn and removed.

Further study of this technique will be required to demonstrate efficacy and safety compared with conventional thromboaspiration and stent device thrombectomy.

Figure 6 Same case as figure 3. Axial sections of diffusion-weighted imaging 24 h postoperatively showing punctuate areas of restricted diffusion within the middle cerebral artery distribution (arrow) consistent with areas of infarction. The majority of ischemic penumbra has been preserved.

Table 1 Commonly used catheters and compatibility for combination aspiration/stentriever thrombectomy

Guide	Max OD	Min ID	Compatible
Neuron Max 088 (Penumbra)	8 Fr 2.7 mm 0.10 inch	6.71 Fr 2.24 mm 0.088 inch	All listed intermediate catheters
Cook shuttle 6 Fr (Cook Medical)	7.93 Fr 2.64 mm 0.104 inch	6.63 Fr 2.21 mm 0.087 inch	All listed intermediate catheters
Concentric 9 Fr (Stryker Neurovascular)	8.99 Fr 3.00 mm 0.118 inch	6.4 Fr 2.16 mm 0.085 inch	All listed intermediate catheters
Cello 8 Fr (ev3/Covidien)	7.8 Fr 2.6 mm 0.10 inch	5.7 Fr 1.90 mm 0.075 inch	Navien 058 DAC 057
Intermediate/distal access/aspiration	Max OD	Min ID	Compatible
5 Max (Penumbra)	6.10 Fr 2.03 mm 0.080 inch	4.12 Fr 1.37 mm 0.054 inch	All listed microcatheters
Navien 058 (ev3/Covidien)	5.33 Fr 1.78 mm 0.070 inch	4.42 Fr 1.5 mm 0.058 inch	All listed microcatheters
DAC 057 (Stryker Neurovascular)	5.2 Fr 1.7 mm 0.068 inch	4.34 Fr 1.45 mm 0.057 inch	All listed microcatheters
Stent delivery	Max OD	Min ID	
Velocity (Penumbra)	2.90 Fr 0.965 mm 0.038 inch	1.91 Fr 0.635 mm 0.025 inch	
Prowler SP (Codman & Shurtleff)	2.85 Fr 0.95 mm 0.037 inch	1.6 Fr 0.533 mm 0.021 inch	
Trevo Pro 18 (Stryker Neurovascular)	2.7 Fr 0.90 mm 0.035 inch	1.6 Fr 0.533 mm 0.021 inch	
Orion (Cordis)	2.6 Fr 0.88 mm 0.034 inch	1.6 Fr 0.533 mm 0.021 inch	

Numbers in bold type are published values; other values are extrapolated.
Fr, French; ID, inner diameter; OD, outer diameter.

Learning points

- ▶ A mechanical thrombectomy technique using an aspiration catheter with a stent thrombectomy device is described.
- ▶ Limitations of stent thrombectomy (distal embolization) and aspiration thrombectomy (prolonged revascularization) are minimized with the combination technique.
- ▶ Use of the aspiration catheter as a distal access catheter may hasten subsequent stentriever passes for revascularization, if required.

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Medical Ltd and Mynx/Access Closure; serves as a consultant on the board of scientific advisors to Codman & Shurtleff, Inc; serves as a consultant per project and/or per hour for Codman & Shurtleff, Inc, ev3/Covidien Vascular Therapies, and TheraSyn Sensors, Inc; and receives fees for carotid stent training from Abbott Vascular and ev3/Covidien Vascular Therapies. Dr Levy receives no consulting salary arrangements. All consulting is per project and/or per hour. Dr Mokin has received an educational grant from Toshiba. Dr Siddiqui has received research grants from the National Institutes of Health (co-investigator: NINDS 1R01NS064592-01A1, Hemodynamic induction of pathologic remodeling leading to intracranial aneurysms) and the University at Buffalo (Research Development Award); holds financial interests in Hotspur, Intratech Medical, StimSox, Valor Medical and Blockade Medical; serves as a consultant to Codman & Shurtleff, Inc, Concentric Medical, Covidien Vascular Therapies, GuidePoint Global Consulting, Penumbra, Inc, Stryker Neurovascular and Pulsar Vascular; belongs to the speakers' bureaus of Codman & Shurtleff, Inc and Genentech; serves on National Steering Committees for Penumbra, Inc 3D Separator Trial and Covidien SWIFT PRIME Trial; serves on an advisory board for Codman & Shurtleff and Covidien Vascular Therapies; and has received honoraria from American Association of Neurological Surgeons' courses, Annual Peripheral Angioplasty and All That Jazz Course, Penumbra, Inc, and from Abbott Vascular and Codman & Shurtleff, Inc for training other neurointerventionists in carotid stenting and for training physicians in endovascular stenting for aneurysms. Dr Siddiqui receives no consulting salary arrangements. All consulting is per project and/or per hour. (*Boston Scientific's neurovascular business has been acquired by Stryker.)

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