Mechanical Thrombectomy Use in Acute Stroke Treatment

A method of recanalization for intracranial vessels that utilizes stent retrievers.

BY LEE R. GUTERMAN, PHD, MD

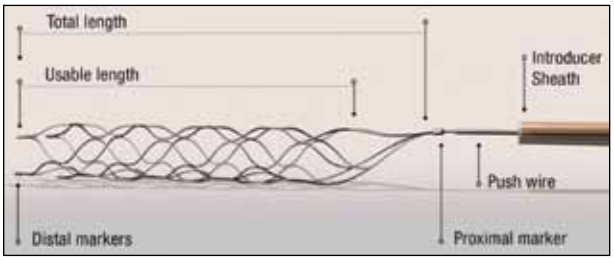
Mechanical thrombolysis for acute cerebral vessel occlusion has been used for many years. Numerous devices have been introduced during the past 10 years to improve recanalization rates when compared to clot disruption with a wire and microcatheter alone. More recently, a device made from a self-expanding nitinol stent permanently affixed to a delivery wire was introduced to the European and American markets (Solitaire, Covidien, Mansfield, MA, or Trevo, Concentric, acquired by Stryker Medical, Kalamazoo, MI). Over the past 3 years, stent retrievers have been incorporated into clinical practice for revascularization of cerebral vessels in acute stroke.

This article reviews the history of catheter-based treatment for acute stroke and the recently published studies on stent retrievers, as well as two case reports from a recent series of 12 patients with acute stroke who were treated using stent retrievers. It also illustrates the role that CT imaging plays in the treatment algorithm for acute stroke.[1]

CATHETER-BASED TREATMENT FOR ACUTE STROKE

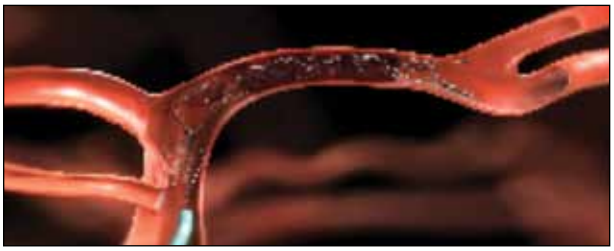
Catheter-based treatment for acute cerebral vessel occlusion began with microcatheter infusion of lytics into the clot.[2] The PROACT trial was designed to omit mechanical thrombectomy. The intention was to perform an intra-arterial (IA) infusion of prourokinase, not mechanical thrombectomy. This prospective trial demonstrated that IA lytic therapy for revascularization in acute stroke patients was safe and effective within a 6-hour time window. During this trial, numerous interventionists noted that manipulation of the thrombus with the wire might enhance the lytic process (personal communication, Prourokinase Investigators Meeting, 1996).

Microcatheter- and wire-based mechanical thrombectomy was used during the period that followed with some success. The first device to gain US Food and Drug Administration approval for mechanical clot retrieval was the Merci retrieval system (Concentric Medical). The original iteration of the Merci retriever was a corkscrew-like device on a wire delivered via a microcatheter into the intracranial circulation. A portion of the device was placed distal to the thrombus into normal vessel. The remainder was deployed into the thrombus as the microcatheter was withdrawn. As the device was unsheathed, it assumed a corkscrew



(Courtesy of Covidien.)

Figure 1. The Solitaire stent retriever.



(Courtesy of Covidien.)

Figure 2. An artist's rendition of a stent retriever in the left middle cerebral artery (MCA) extending into the distal internal carotid artery (ICA). The delivery microcatheter is positioned at a point where the stent is attached to the delivery wire.

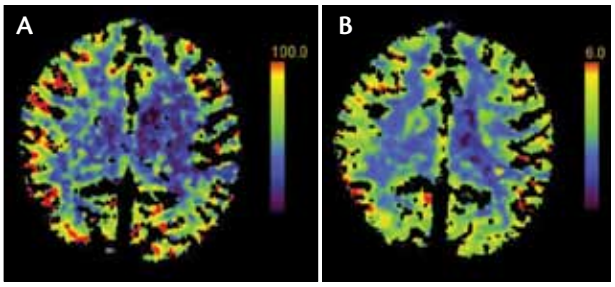


Figure 3. Axial CT scans. Note the cerebral blood flow image demonstrating decreased density in the left hemisphere (A). The cerebral blood volume in that same area does not show this density reduction, suggesting preservation of brain tissue (B).

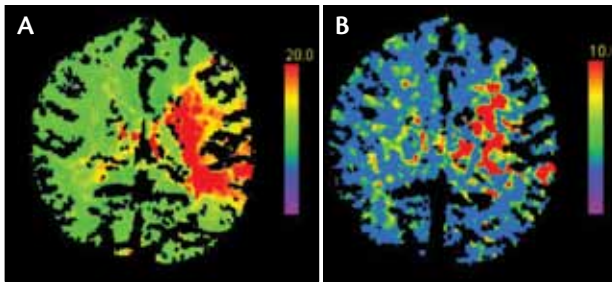


Figure 4. CT axial perfusion images showing the brain at risk from the acute stroke. Time to peak (A) and mean time to peak (B).

shape, penetrating its way into the clot. This bare-metal corkscrew had some early success in removing intracranial thrombus.

With the second iteration of the device, the company modified the bare-metal wire corkscrew by attaching multiple Prolene sutures onto the bare metal. These sutures were intended to anchor the clot to the bare-metal corkscrew and prevent clot release as the device was withdrawn. Slow retraction of the thrombus/retriever complex resulted in clot retrieval. Occlusion of the proximal carotid or vertebral artery with a balloon guide appeared to increase the likelihood of thrombus retrieval by preventing the antegrade blood flow from removing the clot from the device.

The MULTIMERCI trial for acute stroke reported recanalization rates of 48% for the bare-metal device and 60% when IA lytic was used as an adjunct. When the Merci device with the Prolene sutures was used, the recanalization rate was 57% and increased to 69% when IA lytic was used as an adjunct. The investigators reported favorable outcome rates of 36% (modified Rankin [mRankin], 0–2) (Table 1).[3]

The next device to receive US Food and Drug Administration approval with an acute stroke indication was the Penumbra clot aspiration system (Penumbra, Inc., Alameda, CA). A series of Penumbra aspiration microcatheters (inner diameter [ID], 0.21–0.54) was developed to be delivered into the MCA and basilar arteries. The smaller suction aspiration catheters facilitate access to clots in the distal intracranial circulation; larger catheters were used in the more proximal intracranial circulation. Catheters with large IDs remove clots faster and more thoroughly and clog less often. When using the larger ID Penumbra catheters, such as the 0.54, 0.27, or 0.21, a microcatheter could be used as an obterator to aid in distal access for the Penumbra aspiration catheter. A wire with a ball tip is used for clearing thrombus during aspiration should the aspira-

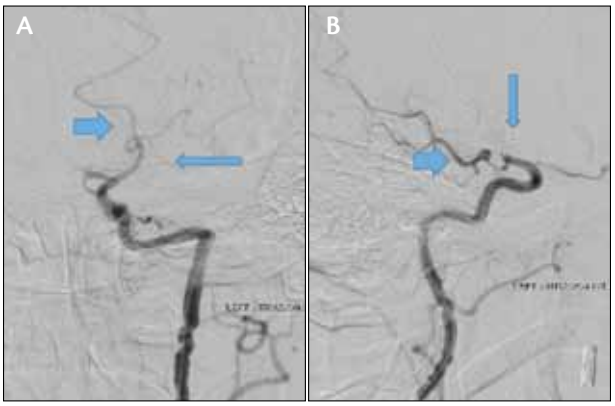


Figure 5. Left ICA angiography: left ICA injection, anteroposterior (A) and lateral (B). On the left, the thin arrow indicates the tip of the microcatheter in the occluded MCA. The thick arrow shows the posterior cerebral artery that fills via the posterior communicating artery.

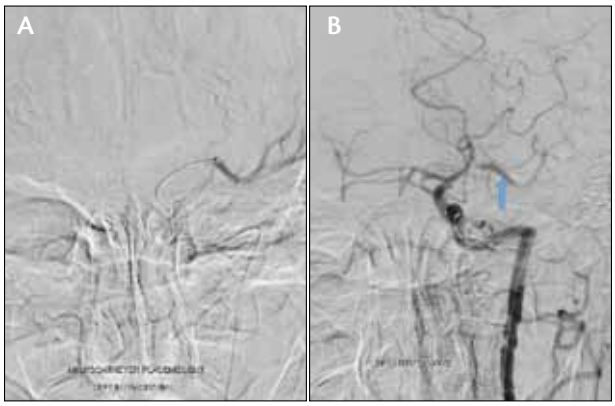


Figure 6. Microcatheter injection, left MCA (A). The left ICA injection with a stent retriever in the MCA is open (B). The distal end of the stent is indicated with an arrowhead. Note that the main trunk of the MCA is open.

TABLE 1. MODIFIED RANKIN SCALE

Score	Impairments
0	No symptoms at all
1	No disability despite symptoms
2	Slight disability
3	Moderate disability
4	Moderately severe disability
5	Severe disability
6	Dead

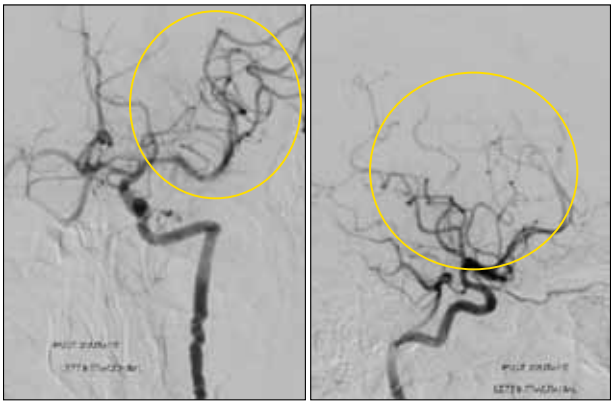


Figure 7. Left ICA injection after stent retrieval. Note that the left MCA is fully recanalized. The right MCA can be seen filling from the left ICA injection. Both anterior cerebral arteries fill with this injection. Encircled left MCA blood vessels.

tion tube become occluded. The Penumbra pivotal trial reported on 125 patients who were treated within 8 hours of stroke symptom onset. They achieved an 82% recanalization rate (TIMI 2 or 3 flow.) One-quarter (25%) of these patients experienced a good outcome (mRankin ≤ 2).[4]

STENT RETRIEVERS

More recently, a new class of mechanical thrombectomy retrievers has been clinically utilized, first in Europe and then in the United States. In Figure 1, a stent retriever is shown with the microcatheter proximal to the stent. Figure 2 shows an artist's rendition of a stent retriever in the MCA with the stent extending into the supraclinoidal segment of the ICA. The microcatheter can be seen proximal to the stent.

An early report by Castano et al in 2010 included 20 patients with acute ischemic stroke who were treated using the Solitaire stent retriever within 8 hours of stroke symptom onset.[5] The National Institutes of Health Stroke Scale (NIHSS) ranged from 15 to 23, 12 occlusions were located in the MCA, five patients had carotid T lesions (occlusion of the distal ICA, anterior cerebral artery [ACA], and MCA), and two had combined ACA/MCA occlusions. In this series, 18 of 20 patients (90%) had TIMI 2 or 3 flow after treatment with the stent retriever. At 3 months, 45% showed good functional outcomes.

In another 2010 report, 22 patients with acute stroke were treated with the stent retriever.[6] This group included eight patients with basilar artery occlusion. Use of the stent retriever resulted in 20 of 22 patients with TIMI 2 or 3 flow. Two-thirds of these patients improved 10 points or more from the NIHSS on presentation.

A retrospective multicenter study using the Solitaire stent retriever for revascularization in acute stroke report-

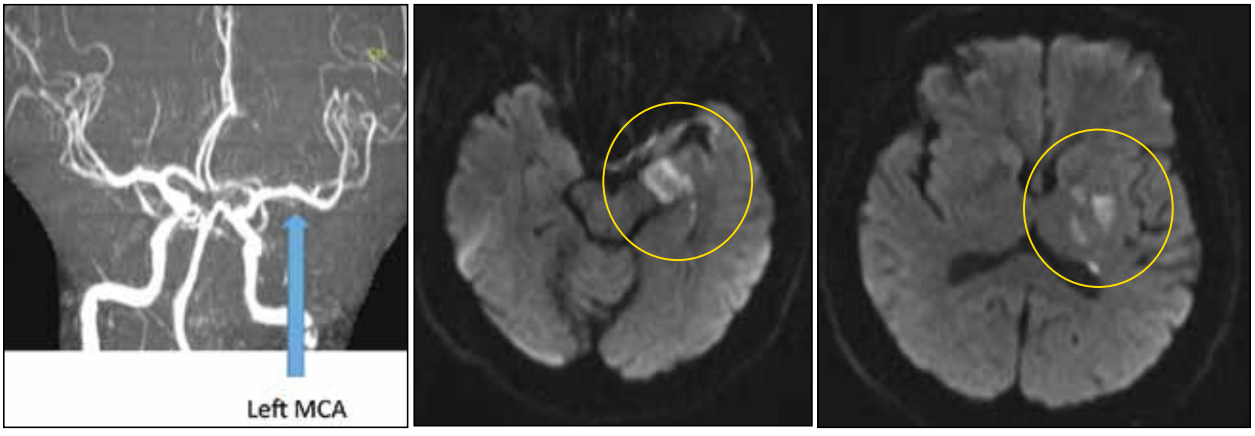


Figure 8. MRA of the intracranial circulation posttreatment day 1 after recanalization showing complete recanalization of the left MCA. Diffusion MRI images: areas of increased signal intensity are seen in the left temporal lobe and the left deep nuclei. Encircled stroke in the left MCA distribution.

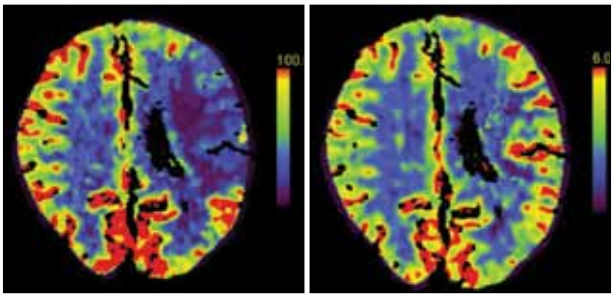


Figure 9. CT axial perfusion images. Color blood flow is reduced in the right hemisphere; color blood volume is maintained, suggesting viable brain tissue. The black area is the right ventricle containing cerebrospinal fluid.

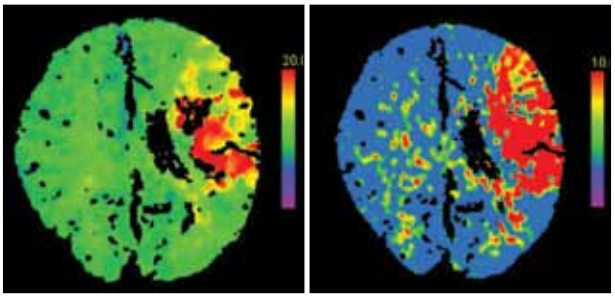


Figure 10. CT axial perfusion images showing the brain at risk using time to peak and mean time to peak.

ed on the treatment of 141 patients, 74 of whom received intravenous tissue plasminogen activator (IV tPA) before stent retriever use.[7] One hundred twenty patients out of 144 experienced complete revascularization. In 55% of patients, there was a good outcome (mRankin < 2). Favorable outcomes were achieved in 66% of patients who received IV tPA before stent retriever use and in 42% of patients who received the stent retriever therapy alone, indicating that use of IV tPA before clot retrieval improved patient outcomes.

In a United States multicenter retrospective trial, 10 centers contributed data for review.[8] In total, 101 patients with acute stroke were treated with the Solitaire stent retriever. The mean NIHSS was 17.6 in the study population. IV tPA was used in 39% of the patients. Successful recanalization was achieved in 88% of patients. Fifteen percent of patients experienced intracranial hemorrhage within the first 24 hours after treatment. At 30 days, 38% had a favorable outcome. In this population, 53 of 101 patients were treated with the Penumbra revascularization system in addition to the stent retriever.

IMS III TRIAL RESULTS

IMS III trial data were presented at the 2013 American Heart Association Stroke meeting in New Orleans. The presentation did not support the use of catheter-based mechanical thrombectomy after administration of IV tPA.[9] Patient outcomes did not improve in the mechanical thrombectomy group when compared to IV tPA alone. Unfortunately, of the 200 patients who were treated using IV tPA and mechanical thrombectomy, only four were treated with a stent retriever. When mechanical thrombectomy was used, Merci and Penumbra were overwhelmingly the devices of choice. Stent retrievers were not available when IMS III was initiated and were incorporated later in the IMS III enrollment cycle. Although the IMS III rules encouraged new technologies to be adopted into the trial over time, only four stent retriever cases were included in this trial. Had the stent retrievers been available at the beginning of IMS III, the results may have favored the use of mechanical thrombectomy with IV tPA for the treatment of acute stroke, as aforementioned studies have indicated.

METHODS

Since September 2012, I have performed 12 intracranial revascularization procedures for acute stroke using stent retrievers for mechanical thrombectomy. In each case, patients were acutely imaged using CT and CT perfusion.[1] Patients who were selected for catheter-based thrombectomy were sent to the catheterization lab. A Siemens Artis Zee biplane flat-panel detector angiography unit (Siemens Healthcare, Malvern, PA) was used in all cases. We try not to intubate patients unless absolutely necessary.

Mechanical thrombectomy with a stent retriever was preferred in patients who were awake. Diagnostic

Figure 11. Left ICA injection. Arrowhead indicates a complete occlusion of the MCA on the left.

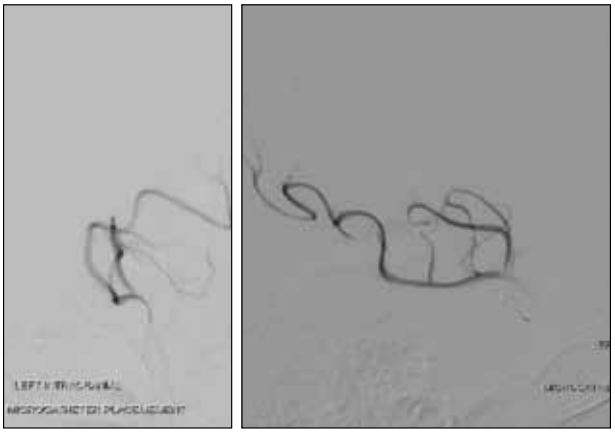


Figure 12. Microcatheter injection in the MCA temporal branch distal to the occlusion. The patient is not sedated or intubated.

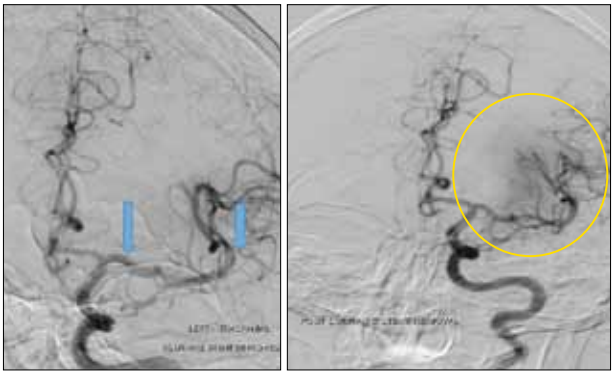


Figure 13. Recanalization of the left MCA after stent retriever deployment. The location of the stent is indicated by arrowheads. The right image after clot retrieval shows TIMI 3 flow in the MCA and its branches. Note that hyperemia of the deep nuclear tissue depicted as a cloud (encircled area).

angiography was performed using a 5-F Sim2 Glide catheter (Terumo Interventional Systems, Somerset, NJ). A 6-F Envoy guide catheter (DePuy Synthes, Johnson & Johnson, New Brunswick, NJ) was then placed into the ICA or vertebral artery. All catheters were perfused with heparinized saline using a rotating hemostatic adapter. No heparin bolus was used. A Prowler Select Plus microcatheter (DePuy Synthes) and Target Transcend floppy-tip wire (Covidien) were used to cross the occlusion. Microcatheter angiography was performed to ensure that the distal end of the microcatheter was distal to the vessel occlusion. The stent retriever was then delivered through the microcatheter into the target vessel using biplane fluoroscopy. The stent retriever was subsequently unsheathed by pulling back the microcatheter while securing the push wire of the stent retriever.

In most cases, stent deployment resulted in partial reperfusion of the target vessel (Figures 6 and 13). If the stent is deployed distal to the thrombus and is long enough to cover the entire lesion, immediate recanalization is achieved before clot removal. This fact distinguishes stent retrievers from other mechanical thrombectomy devices. The stent retriever was left in position for 5 minutes. A 60-mL syringe was attached to the guide catheter. Gentle suction was applied, and the stent retriever was gently withdrawn. Retrievers can be used for up to three retrievals with each device; however, care must be taken not to damage the device and to thoroughly inspect the device before reuse. In all cases, clot was retrieved and could be seen on the stent (Figure 15). Patients undergo CT of the head after treatment to rule out reperfusion hemorrhage. In many cases, this study was performed using the cone-beam CT feature of the Siemens Artis Zee.

Patients were cared for by our stroke neurology and neurocritical care teams during the perioperative period. MRI of the head and MRA of the head and neck were performed the following day if there was no contraindication to being placed into the magnet. An MRI-compatible ventilator was used when needed.

CASE REVIEWS

Case 1

An 81-year-old woman with a severe stroke (NIHSS = 22) presented to a hospital 25 miles from our endovascular stroke center. She received 0.9 mg/kg of IV tPA. She was urgently transferred to our facility. Upon

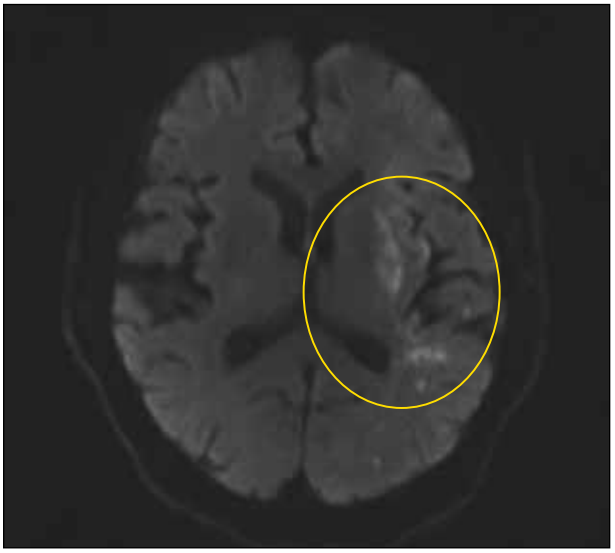


Figure 14. MRI axial diffusion image. Areas of increased signal intensity indicate acute stroke. The encircled area indicates the area of embolic stroke.

Figure 15. A clot retrieved using the Solitaire stent retriever.

arrival, she had improved to an NIHSS of 12, still with significant disability. CT perfusion images indicated an occlusion of the left MCA (Figures 3 and 4). Left internal carotid angiography demonstrated complete occlusion of the left MCA. The posterior cerebral artery filled on left ICA injection secondary to a patent posterior communicating artery (Figure 5). A microcatheter was positioned distal to the occlusion in the left MCA. After stent retriever deployment, the left MCA was open (Figure 6). After clot removal, the left MCA was widely patent with TIMI 3 flow in the MCA and ACA (Figure 7). MRI and MRA the next day showed that the MCA was still open (Figure 8). Stroke can be seen in the medical temporal lobe and the deep brain parenchyma on the left. The infarcted area was considerably smaller than it would have been if the MCA remained occluded (Figure 8). The patient was discharged home and was able to care for herself at the 3-month neuro exam.

Case 2

The patient was a 70-year-old man who presented to our institution with severe stroke (NIHSS = 18). The patient had aphasia as well as dense right upper and lower extremity weakness. He received 0.9 mg/kg IV tPA. He initially improved to an NIHSS of 6 but then deteriorated back to an NIHSS of 18. He was taken for endovascular stroke therapy. His CT perfusion study indicated a left MCA occlusion. The color blood flow was reduced, and the color blood volume was maintained (Figures 9 and 10). Left internal carotid angiography indicated a complete MCA occlusion (Figure 11). A microcatheter was placed into the MCA distal to the occlusion (Figure 12). The stent retriever was deployed in the MCA, and immediate recanalization of the MCA was achieved. This was done while the patient was awake. After clot removal, TIMI 3 flow was reestablished in the MCA (Figure 13). The diffusion MRI performed the next morning indicated embolic stroke in the left MCA distribution (Figure 14). A portion of the clot retrieved can be seen in Figure 15. The patient is free from neurologic deficit and is working at his previous job.

CONCLUSION

Mechanical thrombolysis techniques for recanalization of cerebral vessels in acute stroke have been studied in multicenter retrospective trials. It appears that 80% to 90% recanalization rates can be expected with application of careful technique. Adjunctive therapy with IA or IV lytics and the Penumbra aspiration system may help improve recanalization rates and therefore improve outcomes. Had stent retrievers been included earlier in the IMS III trial, mechanical thrombectomy may have demonstrated improved outcomes after 90 days when compared to IV tPA alone. This is the most promising technology I have seen for vessel recanalization in acute stroke in 20 years. The features that make it a standout are its ease of use, high recanalization rate, and immediate recanalization upon stent deployment before clot removal. I look forward to improved stroke outcomes as stent retrievers gain wide international acceptance. ■

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