

The Brain Aneurysm Institute

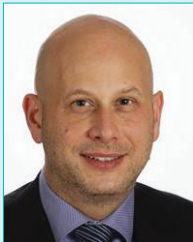
Multidisciplinary Care of Patients with Hemorrhagic and Ischemic Stroke

FALL/WINTER
2026

Neurovascular News



Christopher S. Ogilvy, MD
Attending,
Brain Aneurysm Institute



Phil Taussky, MD
Attending,
Brain Aneurysm Institute



Justin Granstein, MD
Attending,
Brain Aneurysm Institute

Endoscopic Evacuation of Intraparenchymal Hemorrhage: The MINUTE Trial at BIDMC

Kimberly Han, B.S., Annalydia Siegenthaler, B.S., Philipp Taussky M.D., Magdy Selim, M.D., Justin Granstein M.D., Christopher S. Ogilvy, M.D.

Background

Intraparenchymal hemorrhage (IPH) is a subtype of stroke characterized by bleeding into the brain parenchyma and represents 10-15% of all strokes.¹ Although less common than ischemic stroke, IPH carries high morbidity and mortality, with one-year mortality rates around 40% and only 12-39% of survivors regaining functional independence.^{1,2} While the role of medical management and open surgical evacuation of IPH has been well-established, the utility of minimally invasive endoscopic evacuation of IPH is a growing field of study. This update summarizes the evidence for endoscopic evacuation of IPH and highlights BIDMC's participation in the Minimally Invasive Neuroendoscopic Ultra-Early Targeted ICH Evacuation (MINUTE) trial, a multicenter randomized trial led by the Icahn School of Medicine at Mount Sinai.³

of hematoma removal by combining dry-field debulking with a fluid-filled phase that permits direct visualization and cauterization of the bleeding source and assessment of residual clot. The initial series of patients treated with the SCUBA technique demonstrated high rates of hematoma removal, with a mean evacuation of 88.2%. Intra-operative and post-operative rebleeding rates were low, occurring at 6.4% and 2.1% of cases, respectively.⁴ Subsequent endoscopic cohorts have demonstrated similarly high evacuation rates.^{5,6} These studies have also demonstrated that shorter time to evacuation is associated with improved functional independence at 6 months, with evacuation within 24 hours being independently associated with long-term independence.^{5,7}

Randomized Trial Evidence and Rationale for MINUTE

Recently, a number of randomized trials have investigated whether minimally invasive endoscopic hematoma evacuation can improve outcomes beyond medical management alone. The Trial of Early Minimally Invasive Removal of Intracerebral

We are available to accept referrals of patients on an emergent or non-urgent basis.

Direct Transfer Line:

617-667-7000;

Page **"9COIL"**

Direct Emergency

Department Access:

617-754-2494

Physician Referral for

Non-Urgent Cases

brainaneurysm@

bidmc.harvard.edu

or call

617-632-9940

Hemorrhage (ENRICH) investigated whether early endoscopic evacuation plus medical management improves functional outcome compared with medical management alone in patients with lobar or anterior basal ganglia hemorrhage. The study demonstrated that endoscopic evacuation in patients with lobar hemorrhage specifically improved 180-day functional outcomes and 30-day mortality. However, in the anterior basal ganglia subgroup, the effect was null.⁸ Following this trial, the Prospective, Multicenter Study of Artemis a Minimally Invasive Neuro Evacuation Device, in the Removal of Intracerebral Hemorrhage (MIND) tested whether endoscopic evacuation with the Artemis device plus medical management, performed within 72 hours of onset, improves functional outcome compared with medical management alone in patients with supratentorial hemorrhage. The trial found no improved 180-day disability and no difference in mortality between groups.⁹ Because the MIND trial initiated evacuation later and enrolled a higher proportion of deep bleeds compared to the ENRICH trial, its null findings

implicated timing and location as the likely determinants of benefit.

Ongoing randomized trials are now evaluating the benefit of ultra-early endoscopic evacuation. Both the Dutch Intracerebral Hemorrhage Surgery Trial (DIST) and the Ultra-Early, Minimally Invasive Intracerebral Hemorrhage Evacuation Versus Standard Treatment (EVACUTE) trials are investigating whether minimally invasive endoscopic surgery within 8-hours of symptom onset improves functional outcomes in patients with supratentorial hemorrhage.^{10,11}

MINUTE Trial at BIDMC

The MINUTE trial evaluates the benefit of ultra-early endoscopic evacuation in patients with spontaneous basal ganglia hemorrhage.³ Patients with basal ganglia ICH ≥ 20 mL are randomized to minimally invasive endoscopic SCUBA evacuation plus standard medical management or standard medical management alone. Surgery is initiated within 120 minutes of randomization, and all randomization occurs within 16 hours of last-known-well. The primary endpoint of the study is

mRS at 180 days, with secondary endpoints including successful clot removal to ≤ 10 mL residual, residual volume on 24-hour CT, symptomatic rebleeding, CNS infection at 30 days, and all-cause mortality at 30 days.

As part of BIDMC's lead-in phase for the MINUTE trial, nine patients have undergone minimally invasive endoscopic hematoma evacuation. These non-randomized cases establish site and operator proficiency with the SCUBA technique in preparation for randomized enrollment. Figure 1 shows the pre-operative (Panels A-C) and post-operative (Panels D-F) imaging of one such patient, treated for a left-sided basal ganglia hemorrhage.

In Summary;

- Endoscopic hematoma evacuation is emerging as an important treatment option for spontaneous intraparenchymal hemorrhage.
- While many ongoing clinical trials are investigating the role of endoscopic hematoma evacuation, current literature suggests that early endoscopic evacuation may be beneficial in appropriately selected patients.
- The MINUTE Trial is evaluating whether ultra-early endoscopic evacuation improves functional outcomes in patients with basal ganglia hemorrhage.

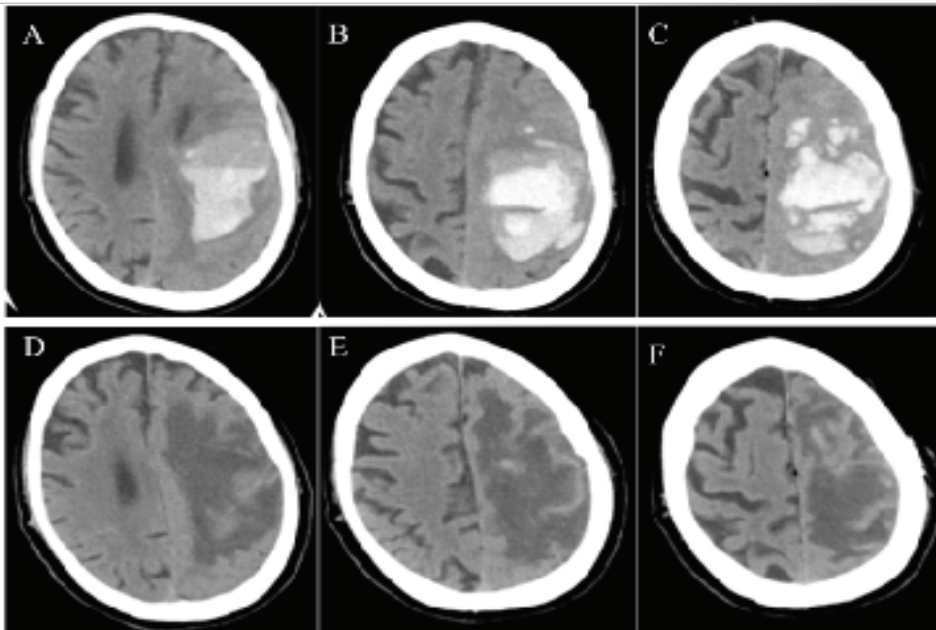


Fig 1: A left-sided basal ganglia hemorrhage with midline shift (A-C). Surgical management involved a minimally invasive endoscopic approach utilizing a single burr hole with significant volume reduction of the IPH and decreased mass effect (D-F)

REFERENCES

1. Gross, B. A., Jankowitz, B. T., & Friedlander, R. M. (2019). Cerebral Intraparenchymal Hemorrhage: A Review. *Jama*, 321(13), 1295-1303. <https://doi.org/10.1001/jama.2019.2413>
2. van Asch, C. J., Luitse, M. J., Rinkel, G. J., van der Tweel, I., Algra, A., & Klijn, C. J. (2010). Incidence, case fatality, and functional outcome of intracerebral haemorrhage over time, according to age, sex, and ethnic origin: a systematic review and meta-analysis. *Lancet Neurol*, 9(2), 167-176. [https://doi.org/10.1016/s1474-4422\(09\)70340-0](https://doi.org/10.1016/s1474-4422(09)70340-0)
3. Minimally Invasive Neuroendoscopic Ultra-Early Targeted ICH Evacuation (MINUTE) Trial. (2025). <https://clinicaltrials.gov/study/NCT07260916>
4. Kellner, C. P., Chartrain, A. G., Nistal, D. A., Scaggiante, J., Hom, D., Ghatan, S., Bederson, J. B., & Mocco, J. (2018). The Stereotactic Intracerebral Hemorrhage Underwater Blood Aspiration (SCUBA) technique for minimally invasive endoscopic intracerebral hemorrhage evacuation. *J Neurointerv Surg*, 10(8), 771-776. <https://doi.org/10.1136/neurintsurg-2017-013719>
5. Kellner, C. P., Ali, M., Kalagara, R., Rao, A., Smith, C., Finesilver, J., Hardigan, T., Shigematsu, T., Liang, J., Poyraz, F. C., Waters, M. F., Selim, M., & Mocco, J. (2025). SCUBA evacuation within 24 hours of basal ganglia hemorrhage results in promising functional outcomes. *J Neurointerv Surg*, 18(1), 74-78. <https://doi.org/10.1136/jnis-2024-022591>
6. Liu, S., Long, J., Cao, S., Su, S., Li, F., Wang, S., Niu, H., Gao, Z., Chen, Y., Wang, D., & Zhang, X. (2023). Endoport Assisted Endoscopic Surgery for Hypertensive Basal Ganglia Hemorrhage by Transsylvian Approach: Technical Nuances and Preliminary Clinical Results. *World Neurosurg*, 179, e593-e600. <https://doi.org/10.1016/j.wneu.2023.09.013>
7. Ali, M., Zhang, X., Ascanio, L. C., Troiani, Z., Smith, C., Dangayach, N. S., Liang, J. W., Selim, M., Mocco, J., & Kellner, C. P. (2023). Long-term functional independence after minimally invasive endoscopic intracerebral hemorrhage evacuation. *J Neurosurg*, 138(1), 154-164. <https://doi.org/10.3171/2022.3.Jns22286>
8. Pradilla, G., Ratcliff, J. J., Hall, A. J., Saville, B. R., Allen, J. W., Paulon, G., McGlothlin, A., Lewis, R. J., Fitzgerald, M., Caveney, A. F., Li, X. T., Bain, M., Gomes, J., Jankowitz, B., Zenonos, G., Molyneaux, B. J., Davies, J., Siddiqui, A., Chicoine, M. R., . . . Barrow, D. L. (2024). Trial of Early Minimally Invasive Removal of Intracerebral Hemorrhage. *New England Journal of Medicine*, 390(14), 1277-1289. <https://doi.org/doi:10.1056/NEJMoa2308440>
9. Arthur, A. S., Jahromi, B. S., Saphier, P. S., Nickele, C. M., Ryan, R. W., Vajkoczy, P., Schirmer, C. M., Kellner, C. P., Matouk, C. C., Arias, E. J., Ullman, J. S., Levitt, M. R., Hage, Z. A., Fiorella, D. J., Investigators, M. S., & Collaborators. (2025). Minimally Invasive Surgery vs Medical Management Alone for Intracerebral Hemorrhage: The MIND Randomized Clinical Trial. *JAMA Neurology*, 82(11), 1113-1121. <https://doi.org/10.1001/jamaneurol.2025.3151>
10. Dutch ICH Surgery Trial; Minimally Invasive Endoscopy-guided Surgery for Spontaneous Supratentorial Intracerebral Hemorrhage. (2022). <https://clinicaltrials.gov/study/NCT05460793>
11. Ultra-Early, Minimally inVasive intraCerebral Haemorrhage evacUAtion Versus Standard trEatment (EVACUATE). (2020). <https://clinicaltrials.gov/study/NCT04434807>

Revascularization Surgeries for Adult Moyamoya Disease

Omar Alwakaa, MD, Tatiana Abou-Mrad, MD MS, Laura Reed, MD, Felipe Ramirez-Velandia, MD, Pratham B. Bhatt, BA, Abdulrhman Alsalama, MD, Gursant Atwal, MD, Justin H. Granstein, MD MPH, Philipp Taussky, MD, Fady T. Charbel, MD, Christopher S. Ogilvy, MD

Moyamoya disease is a progressive cerebrovascular arteriopathy characterized by stenosis or occlusion of the terminal internal carotid arteries and their proximal branches, accompanied by the development of fragile compensatory collateral vessels. In adults, the disease may present with transient ischemic attacks, ischemic stroke, intracranial hemorrhage, headache, or seizures. Surgical revascularization is well established as the principal treatment

and reduces the risk of recurrent ischemic events relative to medical management alone. One of three broad surgical approaches is usually used. The choice of technique, however, remains unsettled. Direct bypass, most commonly a superficial temporal artery-to-middle cerebral artery anastomosis, provides an immediate source of blood flow. Indirect bypass, including encephaloduro-arterio-synangiosis (EDAS), places vascularized, mostly the

superficial temporal artery (STA) in contact with the brain surface and depends on gradual collateral ingrowth over subsequent months. A combined operation incorporates both mechanisms. Despite these options, the optimal treatment paradigm remains undefined, with preferred techniques and patient selection criteria varying across regions, institutions, and individual surgeon preferences.¹ At the BIDMC Adult Moyamoya Center, we utilize all these of these techniques to treat affected patients.

Each approach has potential advantages, yet the literature has not produced a universally applicable selection rule. Meta-analyses have often reported favorable pooled angiographic or clinical outcomes

with direct or combined procedures, whereas large multicenter data suggest that direct and indirect strategies can yield comparable stroke outcomes in selected populations.^{2,3} Comparisons of this kind estimate the average effect of one technique across heterogeneous populations. They do not address the question a surgeon actually faces in clinic. It is not which procedure performs better on average, but which procedure will perform better in an individual hemisphere with a defined angiographic architecture. Our group set out to address this question directly.

What We Did to Optimize Patients' Selection for Revascularization Surgery

We performed a retrospective study using prospectively maintained databases from two United States academic centers (Beth Israel Deaconess Medical Center "BIDMC" and University of Illinois Chicago "UIC"). Adults with angiographically confirmed MMD who underwent revascularization between 2005 and 2024 were included in the study. The analysis included 103 patients and 134 treated hemispheres: 60 underwent indirect bypasses, 47 direct bypasses, and 27 combined revascularizations. Most EDAS procedures incorporated frontal and parietal burr holes, an important technical feature because these holes may facilitate dural collateral formation.

The primary endpoint was angiographic success at follow-up, defined as grade 2 or 3 on the Orbital Grading System (OGS). The OGS uses reproducible angiographic landmarks to characterize the depth of postoperative collateral penetration and has demonstrated greater interrater reliability and objectivity than the traditional Matsushima scale.⁴ Median clinical follow-up was 23.49 months, and median angiographic follow-up was 13.83 months. We first examined predictors of success separately within each bypass type. We then screened for treatment-effect modification and performed exploratory inverse probability of treatment weighting (IPTW) analyses to compare outcomes among patients with similar measured baseline characteristics. This design allowed us to ask whether the relative performance of direct and indirect bypass changed across clinically relevant subgroups.

What We Found?

Overall, 98 of 134 hemispheres (73.1%) achieved OGS-defined angiographic success. Success was observed in 66.7% of indirect, 76.6% of direct, and 81.5% of combined bypasses. Interaction testing identified significant bypass type by modifier interactions for middle meningeal artery (MMA) diameter ($p < 0.001$), Suzuki stage 4–6 versus 1–3 ($p < 0.001$), contralateral hemispheric collateralization ($p < 0.001$), MCA occlusion ($p < 0.001$), ICA occlusion ($p = 0.0015$), ACA occlusion ($p = 0.007$), and ever-smoker status ($p = 0.0113$).

Figure 1. No significant interaction was demonstrated for age, sex, hypertension, hyperlipidemia, diabetes mellitus, or lenticulostriate and transdural collateralization.

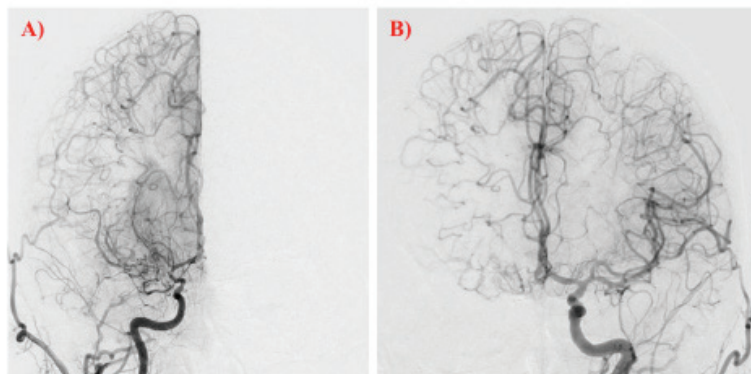


Figure 1. (A) Preoperative angiogram of a 27-year-old female patient with moyamoya disease on the right side who later underwent EDAS. (B) The patient had abundant interhemispheric collateralization from the contralateral left hemisphere.

In the IPTW-weighted direct-versus-indirect comparison, direct bypass was favored in hemispheres with an MMA diameter below 1.4 mm (OR 11.58; 95% CI 1.60–118.18), with contralateral collaterals present (OR 14.78; 2.53–86.35), at Suzuki stage 1–3 (OR 6.12; 1.48–25.72), without ACA occlusion (OR 7.42; 1.30–42.33), and in non-smokers (OR 5.35; 1.36–21.04).

Figure 2. Indirect revascularization was favored in the reciprocal strata: MMA diameter of 1.4 mm or greater (OR 0.17; 0.04–0.69), absence of contralateral collaterals (OR 0.20; 0.05–0.91), Suzuki stage 4–6 (OR 0.15; 0.03–0.85), and ICA occlusion (OR 0.19; 0.03–0.65).

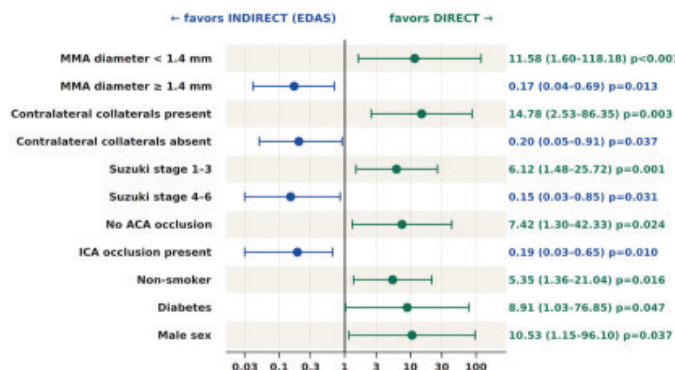


Figure 2. Significant variables of the "IPTW" subgroup analyses of bypass success: Indirect vs Direct. Forest plot of subgroup-stratified IPTW-weighted ORs for bypass success comparing direct vs indirect bypass.

The Middle Meningeal Artery, an Overlooked Vessel

To our knowledge, no prior studies have specifically examined the role of the MMA in revascularization outcomes in MMD. In our cohort, MMA diameter emerged as a significant modifier in angiographic response across revascularization types. Beyond the regression analyses, the IPTW-analysis clearly showed that direct bypass was favored when MMA diameter was < 1.4 mm, whereas indirect bypass was favored when MMA diameter was ≥ 1.4 mm. This suggests that preoperative large MMA caliber may function as a practical marker of indirect revascularization potential, likely reflecting the capacity of the dural and external carotid arterial system to support postoperative collateral ingrowth. Notably, this might not be a generic prognostic marker but a treatment-selection factor, because the direction of benefit changes according to bypass type. Nearly all the indirect bypass procedures in our cohort included adjunctive frontal and parietal burr holes, which are intended to facilitate collateral formation from the dural arterial system. Accordingly, a larger MMA diameter may improve this collateral pathway and thereby support indirect revascularization.

Why The Presence of Contralateral Collaterals May Matter

The presence of contralateral collaterals on preoperative angiograms could play an important role in surgical decision-making. MMD hemispheres with contralateral collaterals were more likely to benefit from direct bypass, whereas absence of these collaterals favored a successful indirect bypass. The consistency of this pattern indicates that contralateral collateralization behaves as a true effect modifier in the revascularization. Consequently, this relationship could directly improve patient-specific surgical decision-making and flow adaptability that modifies the relative performance of revascularization type. In our previously published study, quantitative angiogram-pixel-density analysis showed that the presence of contralateral interhemispheric collaterals was associated with poorer postoperative collateral vessel ingrowth after EDAS.⁵ The present findings are consistent with this relationship and align with the concept that cross-filling from contralateral circulation may reduce the local ischemic signal needed to drive indirect angiogenesis which typically promotes robust neovascularization following indirect bypass.

Other Findings

Disease stage and occlusion pattern reinforce the above-mentioned hemodynamic interpretation. Advanced disease stage (Suzuki stage) and internal carotid artery occlusion favored indirect bypass, perhaps because chronic ischemic drive provides a strong stimulus for new vessel formation. Earlier-stage disease and preserved anterior circulation anatomy favored direct bypass, which requires a suitable recipient artery and a receptive vascular bed. Together, these findings suggest that selection should consider stenosis severity, existing perfusion pathways, and each hemisphere's capacity to remodel after surgery.

The diabetes-associated finding favoring direct bypass could be biologically plausible given already known associations

between diabetes, microvascular dysfunction, and impaired endothelial-mediated remodeling. Indirect revascularization relies on effective microvascular proliferation and maturation of new collaterals. Pathophysiological conditions, such as diabetes, that change angiogenic responsiveness could reduce the likelihood of robust indirect neovascularization and thereby shift the relative advantage toward immediate conduit-based flow augmentation.

From “One-Bypass-Fits-All” to Patient-Specific Bypass Selection

The main contribution of this study is not simply that one bypass strategy “outperformed” another in the overall cohort, but the demonstration that angiographic success of the bypass in adult MMD appears to be dependent on preoperative angiographic characteristics, with clinically meaningful heterogeneity in the relative performance between direct and indirect revascularization. In other words, the data argue against a “one-technique-fits-all” approach and instead support a more stratified, patient and angiographic-informed decision strategy for selecting bypass type in individual hemispheres. This distinction is important. In the overall cohort, direct and combined bypass showed numerically more favorable follow-up angiographic outcomes than indirect bypass, whereas pairwise weighted comparisons did not show a uniform statistically significant advantage for one approach across all patients. At the same time, the treatment-effect heterogeneity analyses (direct vs indirect) identified clinically meaningful subgroups in whom the direction and magnitude of benefit clearly diverged. This is the most clinically relevant interpretation of the study and the one with the greatest potential to influence practice and move the field from “technique preference” toward “patient-specific bypass selection” in adult MMD. This distinction is highly relevant to contemporary moyamoya surgical decision-making and we utilize this at the BIDMC Adult Moyamoya Center.

REFERENCES

1. Gonzalez NR, Amin-Hanjani S, Bang OY, et al. Adult moyamoya disease and syndrome: current perspectives and future directions: a scientific statement from the American Heart Association/ American Stroke Association. *Stroke*. 2023;54(10):e465-e479.
2. Nguyen VN, Motiwala M, Elarjani T, et al. Direct, indirect, and combined extracranial-to-intracranial bypass for adult moyamoya disease: an updated systematic review and meta-analysis. *Stroke*. 2022;53(12):3572-3582.
3. El Naamani K, Chen CJ, Jabre R, et al. Direct versus indirect revascularization for moyamoya: a large multicenter study. *J Neurol Neurosurg Psychiatry*. 2024;95(3):256-263.
4. Alwakaa O, Purohit S, Lau TS, et al. Presence of collaterals from the contralateral hemisphere on preoperative angiogram predicts failure of encephalo-duro-arterio-synangiosis (EDAS) in adult moyamoya patients. *AJNR Am J Neuroradiol*. Published online February 7, 2026. doi:10.3174/ajnr.A9197
5. Alwakaa O, Purohit S, Lau TS, et al. Presence of collaterals from the contralateral hemisphere on preoperative angiogram predicts failure of encephalo-duro-arterio-synangiosis (EDAS) in adult moyamoya patients. *AJNR Am J Neuroradiol*. Published online February 7, 2026. doi:10.3174/ajnr.A9197

Steering Toward New Endovascular Strategies: Overcoming Complex Anatomy with Steerable Microcatheter Technology for Flow Diverter Deployment in a Large Cavernous Carotid Aneurysm

Swas Shiv, B.S., Evan P. McNeil, MD, Alejandro Berenstein, MD, Naam Pisante, Bsc, Simona Beilin-Nissan, M.Sc., Philipp Tausky, MD, Christopher S. Ogilvy, MD, Justin H. Granstein, MD

Background

Cavernous carotid aneurysms develop on the internal carotid artery within the cavernous sinus, a venous confluence at the base of the skull that houses several cranial nerves. Unlike aneurysms in the subarachnoid space, they are typically benign lesions with a low risk of rupture and life-threatening complications.¹ They are often discovered incidentally on imaging or when they grow large enough to compress adjacent cranial nerves, causing symptoms such as diplopia, facial pain, or visual disturbance.^{1,2}

Two approaches to treating these aneurysms

Surgical: Surgical approaches include direct clipping of the aneurysm and parent artery occlusion (trapping) with or without bypass. These procedures require exposure of the cavernous sinus, which is inherently difficult and carries a higher risk of morbidity than standard craniotomy for aneurysms in other locations, including risk of injury to the cranial nerves and the internal carotid artery.² Parent-vessel sacrifice also requires adequate collateral circulation to maintain blood flow to the brain.³ While surgical treatment can be durable in experienced hands, the invasiveness of these procedures has driven the search for less invasive alternatives.

Endovascular: Endovascular approaches avoid open surgery by accessing the aneurysm through catheters threaded through the arterial system. Coil embolization, in which the aneurysm sac is packed with detachable coils to promote thrombosis, was long the endovascular standard for these lesions. However, coiling of large or giant aneurysms is limited by significant rates of recurrence and the frequent need for retreatment.^{4,5} Over the past decade, flow diversion has emerged as a more effective endovascular strategy. Rather than

filling the aneurysm directly, a flow-diverting stent is placed across the aneurysm neck within the parent artery, redirecting blood flow and promoting progressive thrombosis and exclusion of the aneurysm from the circulation. Studies have demonstrated high rates of complete aneurysm occlusion with favorable clinical outcomes, establishing flow diversion as the preferred treatment for large or complex unruptured cavernous carotid lesions.^{1,3}

New steerable microcatheter technology to aid stent deployment

Successful flow-diverter deployment, however, depends on one fundamental step: safely navigating a catheter system beyond the aneurysm. In cases of severe vessel tortuosity or distortion of the parent artery, this can become difficult or even impossible with conventional catheter and guidewire systems. Newly developed steerable microcatheters offer a different approach by allowing the operator to actively control the direction of the catheter tip rather than relying solely on guidewire manipulation and passive catheter shaping. The Bendit steerable microcatheter, designed by Bendit Technologies, was developed to provide active directional control during endovascular navigation, offering an alternative to conventional passive catheter and guidewire techniques.⁶

Our Patient

We present a 60-year-old male with a medical history notable for Apert syndrome, colon cancer, longstanding hypertension, and a former 66 pack-year smoker. He was originally evaluated by the Otolaryngology service for hearing loss, during which imaging incidentally revealed an unruptured intracranial aneurysm. Subsequent cerebral angiography demonstrated a large saccular aneurysm arising from the cavernous segment of the right internal carotid artery, measuring approximately 16.3

x 15.5 x 13.7 mm. Following weekly multidisciplinary neurovascular conference, flow diversion was selected as the preferred treatment strategy.

What happened during the procedure

During the initial treatment attempt, the sharp and tortuous geometry of the parent carotid artery prevented conventional microcatheter and microwire systems from safely achieving distal access to the artery beyond the aneurysm. Without stable access, the flow diverter could not be deployed, and the procedure was aborted.

The Bendit 17 is a newly developed steerable microcatheter that allows the surgeon to actively direct the catheter tip by rotating a control knob built into the device. Through close working relationships with industry partners to provide “cutting edge” treatment, the BIDMC Brain Aneurysm Institute had the catheter available for use. A second procedure was therefore planned using the Bendit 17, which allows active control of the catheter tip to help navigate complex vascular anatomy and establish distal access. This procedure was one of the first uses of the device in the United States.

A guide catheter was positioned in the right internal carotid artery, and the Bendit 17 steerable microcatheter was advanced through an intermediate catheter to the segment just before the aneurysm. At the aneurysm neck, the catheter tip was actively curved to follow the sharp turn of the parent artery. Its tip, capable of deflecting up to 180 degrees, allowed the surgeon to direct the guidewire beyond the aneurysm and secure it within a distal middle cerebral artery branch despite the complex vascular tortuosity. With this maneuver, safe distal access of the artery beyond the aneurysm was established, achieving the critical step that the conventional systems had been unable to accomplish during the first procedure. Next, we advanced the intermediate catheter across the aneurysm neck. Then, the Bendit 17 was exchanged for a standard microcatheter, and a Pipeline

Shield flow-diverting stent was advanced and successfully deployed across the aneurysm. A small area of narrowing near the distal end of the device was noted and corrected with catheter manipulation, resulting in full expansion of the flow diverter and excellent contact with the vessel wall.

What we found

Final angiography demonstrated excellent wall apposition (contact with the vessel wall), appropriate coverage across the aneurysm neck, preserved patency of the ophthalmic artery, and significant contrast stasis (delayed washout of contrast) within the aneurysm dome. No procedural complications were identified. The patient recovered uneventfully and remained neurologically intact following the procedure.

What this means for clinical practice

This case highlights an important technical limitation of flow diversion: even when the treatment strategy is appropriate, complex vascular anatomy can prevent successful delivery of the device. The Bendit 17 helped overcome this barrier through controlled active deflection of the catheter tip, allowing the surgeon to conform the system to the anatomy rather than relying solely on passive wire-shaping techniques. Its ability to steer up to 180 degrees while maintaining support for distal wire passage enabled the access necessary for successful flow-diverter deployment.

Steerable microcatheter platforms like the Bendit 17 represent a significant addition to a surgeon's endovascular toolkit. These platforms can facilitate navigation through otherwise difficult-to-traverse anatomy and have the potential to expand flow-diversion candidacy in selected patients, broadening the scope of what can be achieved through minimally invasive neurovascular intervention.

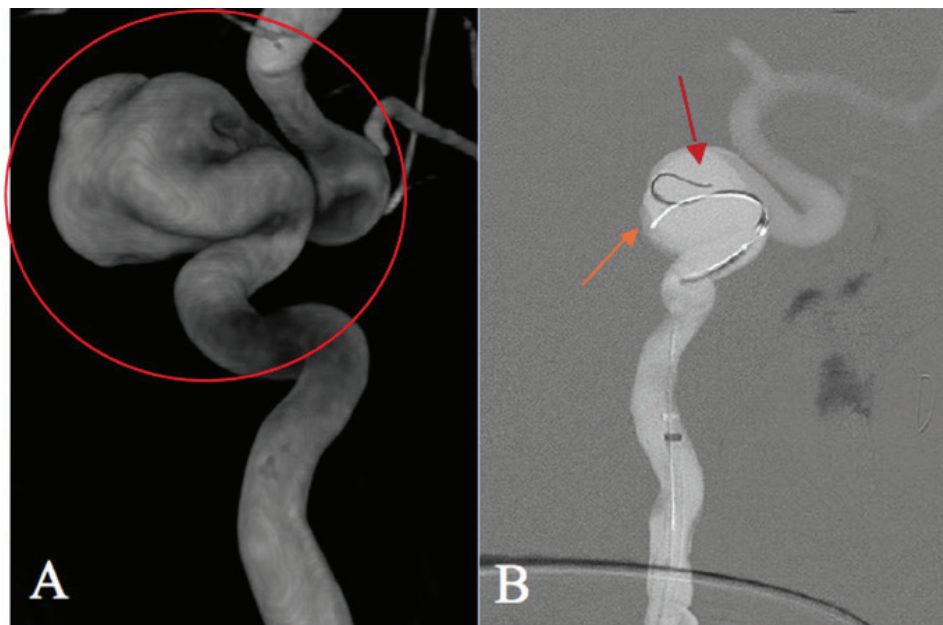


Figure 1.

A: Three-dimensional angiographic reconstruction demonstrating the aneurysm and the sharp turn of the carotid artery at its neck (red circle).

B: Roadmap angiography during the procedure. The faint "ghost" image shows the guidewire's natural tendency to fall into the aneurysm dome (orange arrow). Superimposed is the Bendit 17 steerable microcatheter redirecting the wire past the aneurysm and into the parent artery (red arrow), demonstrating the advantage of active tip steerability in achieving the distal access needed for flow-diverter delivery.

REFERENCES

1. Shahbandi A, Halpin BS, Turcotte EL, Krishna C, Di Nome MA, Bendok BR. Natural History of Cavernous Carotid Artery Aneurysms: A Systematic Review and Meta-Analysis. *World Neurosurg.* 2024;190:362-370.e1. doi:10.1016/j.wneu.2024.07.062
2. Eddleman CS, Hurley MC, Bendok BR, Batjer HH. Cavernous carotid aneurysms: to treat or not to treat? *Neurosurg Focus.* 2009;26(5):E4. doi:10.3171/2009.2.FOCUS0920
3. Tanweer O, Raz E, Brunswick A, et al. Cavernous carotid aneurysms in the era of flow diversion: a need to revisit treatment paradigms. *AJNR Am J Neuroradiol.* 2014;35(12):2334-2340. doi:10.3174/ajnr.A4081
4. Turfe ZA, Brinjikji W, Murad MH, Lanzino G, Cloft HJ, Kallmes DF. Endovascular coiling versus parent artery occlusion for treatment of cavernous carotid aneurysms: a meta-analysis. *J Neurointerv Surg.* 2014;7(4):250-255. doi:10.1136/neurintsurg-2014-011102
5. Ferns SP, Sprengers MES, van Rooij WJ, et al. Coiling of Intracranial Aneurysms. *Stroke.* 2009;40(8). doi:10.1161/strokeaha.109.553099
6. Berenstein A, Cabiri O, Broussalis E, Hufnagl C, Killer-Oberpfalzer M. New concept in neurovascular navigation: technical description and preclinical experience with the Bendit 17 and Bendit 21 microcatheters in a rabbit aneurysm model. *J Neurointerv Surg.* 2022;15(2):172-175. doi:10.1136/neurintsurg-2022-018644

Brain Aneurysm Institute
110 Francis Street, Suite 3B
Boston, MA 02215
bidmc.org/brainaneurysm

SAVE THE DATE

Ischemic and Hemorrhagic Update: Current Practices and Future Directions

May 10 2027

LOCATION: Omni Parker House Hotel, Boston, MA 02108

This is a unique course focused on recent advances in the field of neurovascular disease including up-to-date theories of carotid disease, cerebral hemorrhage, and brain aneurysms. Topics covered will include assessment, management, and specific issues of carotid disease, cerebral hemorrhage, and brain aneurysms.

CME credit awarded.

EMERGENT STROKE TRANSFERS
AT BIDMC BOSTON CALL: 617-278-7777
ASK FOR THE STROKE FELLOW ON CALL