

Treating Wide-Neck Intracranial Aneurysms

Although progress has been made using several endovascular options, we remain without a gold standard treatment.

BY LEE R. GUTERMAN, MD, PhD

Treating wide-neck intracranial aneurysms is a difficult endeavor. From a surgical standpoint, they are technically demanding to dissect, especially when they reside in the posterior circulation or near the cranial skull base. Although initially considered by endovascular surgeons to be “poor open-surgery candidates,” patients with wide-neck aneurysms have posed problems for catheter-based therapy as well.

In cases in which the aneurysm neck diameter approaches the aneurysm body diameter (aspect ratio = 1), detachable platinum coils may not remain stable within the aneurysm.¹ The initial one-dimensional coil configuration (Figure 1A) can herniate out of the aneurysm into the parent vessel. Coil designs in which the first loop is of a smaller diameter than successive loops (Figure 1B) help

seat the coil within the aneurysm. Unfortunately, as coil delivery progresses, loops of coils may not be contained within the aneurysm, resulting in narrowing of the parent vessel. Use of a supporting balloon adjacent to the aneurysm neck to help remodel the coils during delivery was pioneered by Moret et al.² This technique facilitated treatment of numerous aneurysms that would have been untreatable with coils alone.

The Moret balloon-assist technique helped drive use of liquid embolic agents for the treatment of wide-neck intracranial aneurysms. The use of coronary stents to cover the necks of cerebral aneurysms gained popularity in the mid-1990s, but delivery problems limited wide acceptance of this technique. Coils with three-dimensional spherical shapes (Figure 1C) help maintain the coils

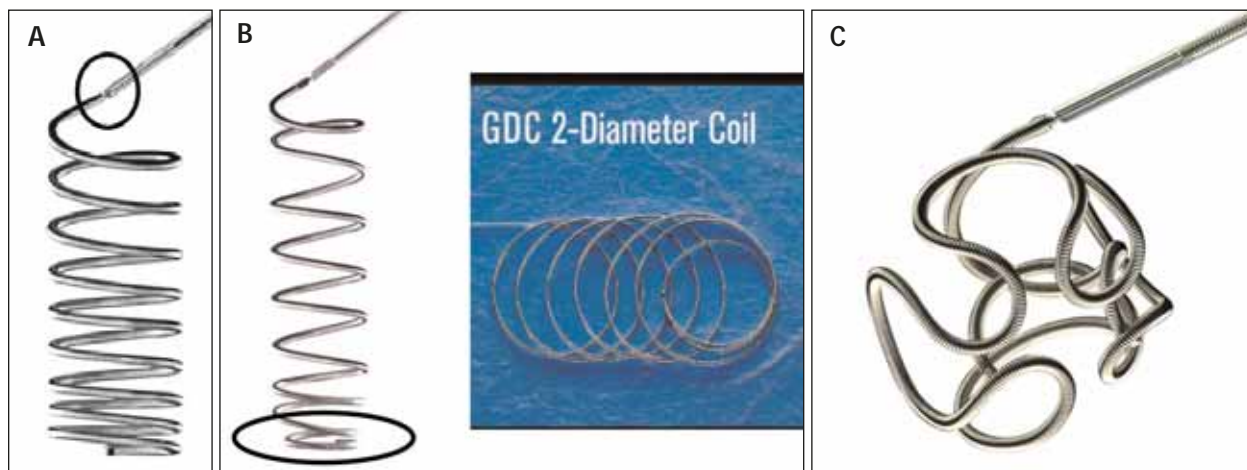


Figure 1. Standard one-dimensional platinum coil in which all loops are the same diameter (A). The coil has an appearance resembling a stack of coins. Two-dimensional platinum coil (B). The first 1.5 loops are smaller in diameter than the remaining loops. Three-dimensional coil (C). The spherical structure becomes apparent as the coil is delivered into the aneurysm. This coil acts as a frame while one- or two-dimensional coils are delivered.

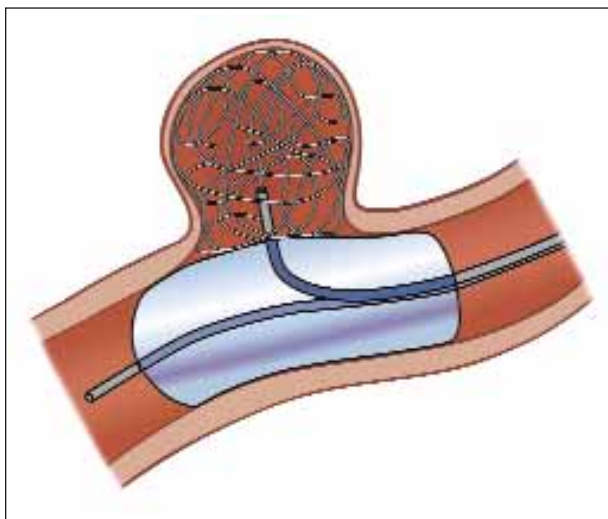


Figure 2. Artist's rendition of Moret's balloon-assist technique. The balloon is inflated adjacent to the aneurysm neck. Coils are introduced into the aneurysm through a separate microcatheter.

within aneurysms, even those with wide necks.³ Recent developments using a nitinol self-expanding stent platform have enabled the wide application of this technology for aneurysms of the intracranial circulation. Unfortunately, wide-neck bifurcation intracranial aneurysms are still very difficult to manage and represent an obstacle to safe and effective endovascular treatment that has not yet been solved.

THE DEVELOPMENT OF NOVEL ENDOVASCULAR OPTIONS

In 1997, Moret et al reported on a coil remodeling technique that substantially changed the way many centers treated wide-neck intracranial aneurysms.⁴ They developed a two-catheter technique in which a microcatheter and a balloon catheter were used simultaneously. The microcatheter was placed within the aneurysm and, during coil delivery, a silicone balloon was inflated in the parent vessel adjacent to the aneurysm orifice. The balloon remained inflated during the coil delivery, remodeling the coil to fit within the aneurysm and forcing the coil into a stable three-dimensional configuration (Figure 2). Prior to coil detachment, the balloon was deflated, and the coil mass was inspected for stability and signs of herniation into the parent vessel. The balloon would then be reinflated and another coil was placed into the aneurysm. This process would be repeated until the aneurysm had been completely occluded. This technique sparked the off-label use of compliant silicone balloons for this application.

In 2001, Nelson and Levy reported on 22 saccular

aneurysms of the internal carotid artery treated with detachable platinum coils and balloon remodeling.⁵ All aneurysms were characterized as wide-neck. Angiographic follow-up after a mean of 19 months revealed occlusion in 17 of 20 patients. Two patients died during the follow-up period. Twenty of the 22 patients had good clinical outcomes. Also in 2001, Cottier et al reported on balloon-assisted coiling in patients with wide-necked cerebral aneurysms.⁶ In this series, a nondetachable balloon was used during 49 procedures in 44 patients to remodel detachable platinum coils. In four procedures, the balloon technique failed. Total occlusion was achieved in 30 cases, subtotal occlusion in 11, and incomplete occlusion in four. Two minor thromboembolic complications occurred. Although this technique proved very useful in wide-neck sidewall aneurysms, it was not as useful with aneurysms arising from vessel bifurcations.

Around this time, development of an implant began that would span the orifice of wide-neck bifurcation aneurysms when placed within the aneurysm. The Trispan device (Boston Scientific/Target, Fremont, CA) (Figure 3) was never marketed in the US but is widely available in Europe, Asia, and Canada. The Trispan device is composed of three loops of nitinol wire in the shape of a three-leaf clover. The device is delivered through a microcatheter into the aneurysm and deployed. It is held in place by its pushwire. Once the Trispan device is positioned to cover the neck without compromising the parent vessels that comprise the bifurcation, a microcatheter is placed through the device into the aneurysm, and the coils are delivered. After the aneurysm is adequately filled with coils, the Trispan device is detached by dissolving a solder junction between the pushwire and the device.

The largest experience using the Trispan for treating intracranial aneurysms has been in Montreal. In 2001,

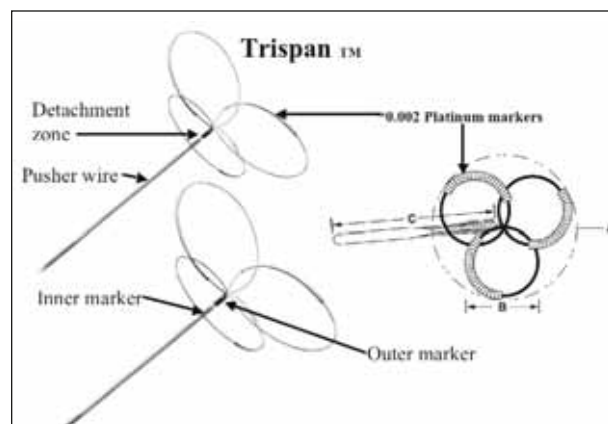


Figure 3. The Trispan device is deployed inside the aneurysm and is positioned in the neck. It spans the neck, providing a stage to keep the coils within the aneurysm.

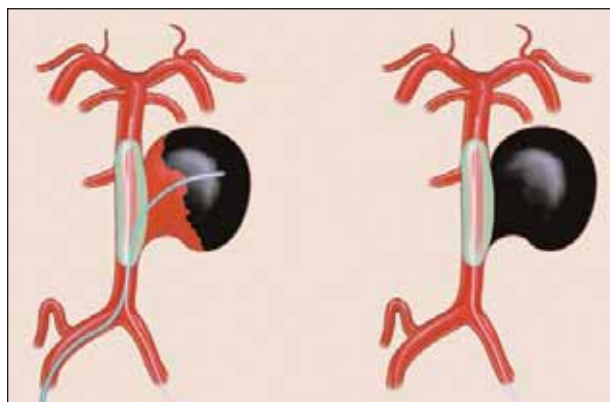


Figure 4. Artist's rendition of the balloon-assist technique for delivery of liquid embolic agent into a sidewall basilar artery aneurysm.

Raymond et al reported on 25 patients with 19 basilar bifurcation and six anterior circulation aneurysms.⁷ Nine aneurysms were treated acutely after subarachnoid hemorrhage. All aneurysms had a wide neck except one. Follow-up angiography was performed on 16 patients. The procedure was successfully performed in all patients with complete obliteration in three patients, residual necks in 13, and a minimal sac in seven. Follow-up angiography in 16 patients revealed complete obliteration in four patients, a residual neck in one, a persistent residual sac in four, and recurrent aneurysm in seven.

LIQUID EMBOLIC AGENTS

The use of liquid embolic agents for treating wide-neck intracranial aneurysms has had a long history. Numerous publications throughout the late 1980s and early 1990s described various techniques using polymers and precipitates to treat abnormal blood vessels in the brain. Yet, control of the liquid during delivery and preventing embolization of the material to unwanted locations remained of concern to the neuroendovascular community. MicroTherapeutics, Inc. (Irvine, CA) developed and marketed Onyx, an ethylene vinyl copolymer that was dissolved in dimethyl sulfoxide (DMSO), the only polar organic solvent. When the solution of polymer dissolved in DMSO is mixed with another polar solvent, such as water or blood, the DMSO solvent disperses and polymer material precipitates. The polymer is not soluble in an aqueous polar solvent like water or blood.

Eventually, a technique was developed incorporating Moret's balloon-remodeling method to protect the cerebral circulation from embolization during delivery of polymer into aneurysms (Figure 4). After the microcatheter is placed into the aneurysm, a balloon is placed into the parent artery adjacent to the aneurysm. The balloon is inflated;

an aliquot of polymer is then delivered into the aneurysm, and the balloon is deflated. Angiography is performed to confirm the polymer's location relative to the aneurysm, and this process is continued until the aneurysm is occluded. The microcatheter is then removed from the aneurysm with the balloon inflated.

The CAMEO Trial

MicroTherapeutics sponsored the Cerebral Aneurysm Multicenter European Onyx (CAMEO) trial in 20 centers.⁸ CAMEO was a prospective, observational trial that enrolled 119 consecutive patients with 123 aneurysms. Follow-up results were reported for 100 of these patients. CAMEO reported complete occlusion in 79% of aneurysms, subtotal occlusion in 13%, and incomplete occlusion in 8%. Delayed occlusion of the parent vessel occurred in nine patients, five of whom were asymptomatic. A large proportion of patients in this trial had large or giant wide-neck aneurysms known to be the most challenging to treat by either open surgery or endovascular techniques. It appeared in some cases that Onyx would "pave" the parent vessel adjacent to the neck of the aneurysm, especially in patients with wide-necked aneurysms.

Although this endovascular paving was not initially expected using the balloon-assist technique, it does bring an interesting issue into question. In patients with cerebral sidewall aneurysms in which the parent vessel from which the aneurysm grew is itself aneurysmal or degenerated, will filling the aneurysm primarily without treating the parent vessel result in lasting angiographic cures? MicroTherapeutics, Inc. initiated a subsequent trial in the US in which patients with cerebral aneurysms were randomized to open surgery or treatment with Onyx. Unfortunately, enrollment was slow, and the trial was eventually halted; a humanitarian device exemption strategy was approved. Although it is relatively unsupported in the US, Onyx is widely available in Europe, Asia, and South America for the treatment of intracranial aneurysms.

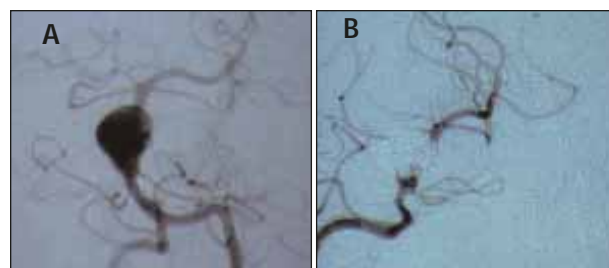


Figure 5. Ectatic basilar artery aneurysm in a 34-year-old woman. Before treatment (A). After treatment with a coronary balloon-mounted stent and detachable platinum coils (B).



Figure 6. Artist's rendition of a carotid-ophthalmic artery aneurysm with a self-expanding stent covering the neck of the aneurysm (A). A microcatheter traverses the stent into the aneurysm and a coil is being delivered into the aneurysm (B). Internal carotid artery angiogram of a bilobed aneurysm before (left) and after (right) treatment with a Neuroform stent (Smart Therapeutics/Boston Scientific, San Leandro, CA) and platinum coils.

The expanded use of Onyx and the balloon-assist coil technique drove the need for a bifurcation balloon product to help treat wide-neck bifurcation aneurysms. Compliant balloons at the tips of microcatheters have been used off-label for balloon remodeling while coiling wide-neck bifurcation aneurysms. Lubicz et al reported on the use of the HyperForm balloon (MicroTherapeutics, Inc.) for treating wide-neck aneurysms in 16 patients.⁹ They reported excellent clinical outcomes in 15 of 16 patients treated using the HyperForm balloon-assisted coiling technique.

INTRACRANIAL STENTING

The use of intracranial stents for the treatment of intracranial aneurysms was popularized in the mid-1990s using coronary balloon-mounted stent systems.¹⁰ The flexibility of the AVE coronary stent platform (Arterial Vascular Engineering, Santa Rosa, CA) enabled delivery of these stents into the intracranial circulation.¹¹ Placement of these devices was challenging but possible. Use of balloon-expanding coronary stents to treat acutely ruptured wide-neck intracranial aneurysms resulted in a high degree of procedure-related morbidity and mortality. In arteries in which extensive disease existed in the parent vessel adjacent to the aneurysm, fibrous remodeling of the vessel induced by the stent placement was believed to be beneficial (Figure 5). Delivery of the balloon-mounted stents required delivery guide purchase at or past the skull base in the internal carotid or vertebral artery. In addition, stiffer coronary wires were employed, which had a higher propensity to damage intracranial vessels than wires designed for the cerebral circulation.

The development of a nitinol self-expanding stent designed specifically for intracranial aneurysms was successfully achieved by Arani Bose, MD, and Kim Nelson,

MD, from Smart Therapeutics/Boston Scientific. They produced a nitinol self-expanding stent that could be delivered through a standard neuromicrocatheter (Neuroform stent) (Figure 6). Once the stent is placed into the correct location in the parent vessel adjacent to the aneurysm neck, a pushwire is used to immobilize the stent. The stent is unsheathed by withdrawing the microcatheter while stabilizing the pushwire. The Neuroform stent is delicate and has markers on the proximal and distal end. It holds coils in place for the majority of the time. Aspirin and clopidogrel therapy must be administered for 3 days before the procedure, and then for at least 1 month after the procedure. Prolonged antiplatelet therapy can be problematic in the face of intracranial hemorrhage.

The Neuroform stent is available in a maximum diameter of 4.5 mm. As a result, patients with aneurysms of the horizontal petrous carotid or extracranial carotid artery are unlikely candidates for this stent, secondary to size. Use of this product for other complex intracranial aneurysms has gained widespread acceptance.

In 2005, Lylyk et al reported on 46 patients with 48 intracranial aneurysms treated with a stent-coil procedure using the Neuroform stent.¹² There was a 92% technical success rate, although the majority of aneurysms treated were in the anterior circulation. Almost half the patients treated had experienced recent or remote subarachnoid hemorrhage. Approximately 20% of the stents were placed in a suboptimal location, according to these investigators. In 31% of cases, the stent was difficult to deliver or place. Procedure-related morbidity and mortality were 8.6% and 2.1%, respectively. In-stent restenosis in patients with aneurysms treated with the Neuroform stent was reported in 2004 by Fiorella et al.¹³ In this case report, severe in-stent stenosis resulted in the proximal segment

of the middle cerebral artery adjacent to the aneurysm. The vessel was treated with balloon angioplasty. Subsequent follow-up evaluation displayed restenosis after angioplasty, and an extracranial-to-intracranial arterial bypass procedure was performed.

CONCERNS REGARDING MEDICAL THERAPY

The use of prolonged antiplatelet therapy in patients with hemorrhagic stroke from cerebral aneurysm is concerning. Pretreatment with aspirin and clopidogrel in addition to heparin for acutely ruptured intracranial aneurysms is problematic. Vessel trauma caused by wire perforation of a small vessel in the cerebral circulation during stent placement can be fatal in the presence of platelet inhibition with clopidogrel and aspirin. If the aneurysm rebleeds in the perioperative period, the hemorrhage is often fatal. Patients who require ventricular drainage of their cerebrospinal fluid space secondary to hydrocephalus can develop hemorrhage along the catheter track in the brain. For these reasons, a temporary neck bridge device that would function like a balloon but not limit flow in the parent vessel during deployment would be desirable. This device would need to be configured for use with sidewall or bifurcation wide-neck aneurysms, allowing flow to continue in the parent vessel throughout the procedure. After the aneurysm has been coiled, the device would be removed, negating the need for prolonged antiplatelet therapy.

CONCLUSION

Much progress has been made in the endovascular treatment of wide-neck intracranial aneurysms since the introduction of detachable platinum coils in 1991. Complex coil shapes helped effectively occlude a higher percentage of aneurysms. Stent technology has increased the permanent occlusion rate of many wide-neck aneurysms. Yet, the use of perioperative antiplatelet therapy can result in increased bleeding complications, especially in patients with subarachnoid hemorrhage. A device to adequately treat wide-neck bifurcation aneurysms is desperately needed. Hopefully, future device development will provide technology that will permanently eradicate wide-neck aneurysms using endovascular techniques. ■

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