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Endovascular Management of Wide-Necked Aneurysms

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Learning Objectives: *After reading this article, the participant should be able to:*
1. Recall the causes of difficulties that arise in endovascular treatment of wide-necked aneurysms.
2. Describe the indications, techniques, and potential complications of the endovascular treatment of wide-necked aneurysms.
3. Identify the currently available and potential future options to be used in the endovascular treatment of wide-necked aneurysms.

Endovascular management of intracranial aneurysms using detachable platinum coils (Guglielmi detachable coils, Target Therapeutics, Fremont, CA) was introduced in 1990 by Guido Guglielmi, an Italian neurosurgeon. Working in collaboration with Vinuela and others at the University of California at Los Angeles, along with Target Therapeutics, endovascular obliteration of aneurysms became a common practice. Many studies have shown equivalent or improved short- and medium-term outcomes when comparing matched groups of patients undergoing surgical and endovascular therapy. Despite advances, however, the treatment of wide-necked aneurysms (aneurysms with a fundus-to-neck ratio less than 2) remains problematic. Results from early studies using single-dimensional coils alone demonstrated 72% to 80% complete occlusion when the ratio was greater than 2, and 53% when it was lower. Inability to keep coils within these lesions, the posttreatment presence of residual aneurysm, and the occurrence of delayed aneurysm recanalization led investigators to seek new ways to embolize these lesions safely and effectively. This article focuses on techniques and devices aimed at treating wide-necked aneurysms.

What Is a Wide-Necked Aneurysm?

The term *wide-necked aneurysm* is relative. Rather than thinking of a wide neck as exceeding a particular size, one should primarily define a wide neck as the size of the neck compared to the maximal fundal width. One characteristic that makes an aneurysm ideal for endovascular therapy is a fundus-to-neck ratio greater than 2. The greater this ratio, the greater the disparity between the orifice and the body, thus making coil deposition easier and coil stability within the lesion greater. As the ratio drops, it is more difficult to prevent coils from herniating out of the fundus, through the neck, and into the parent vessel. In some cases, "wide-necked" can be considered a neck that exceeds the diameter of the widest diameter coil available. This diameter depends on the system used for embolization.

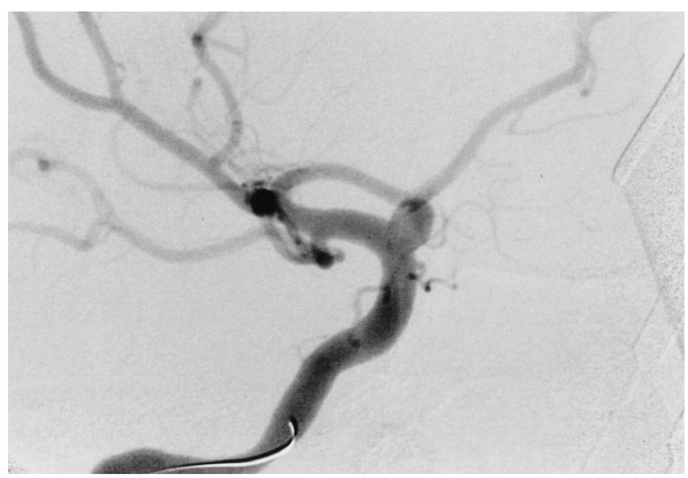

Figure 1. Ophthalmic artery aneurysm with a fundus-to-neck ratio greater than 2.

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Category: Surgical anatomy

Key Words: Aneurysm, Coiling, Endovascular, Wide neck

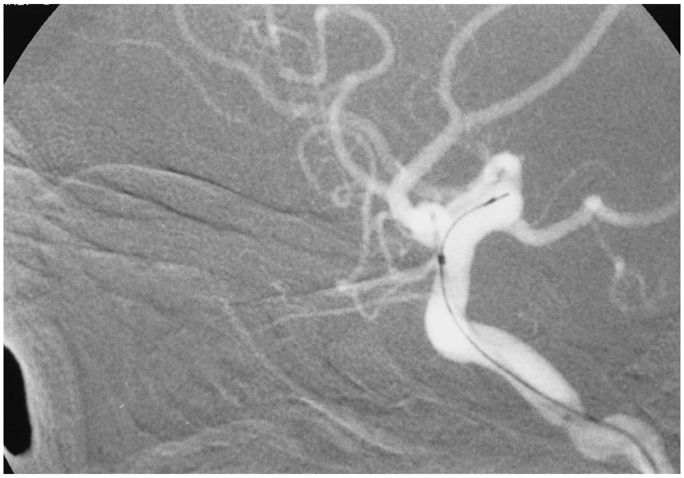

Figure 2. The catheter tip has been inserted in the aneurysm, and the deflated balloon is across aneurysm neck.

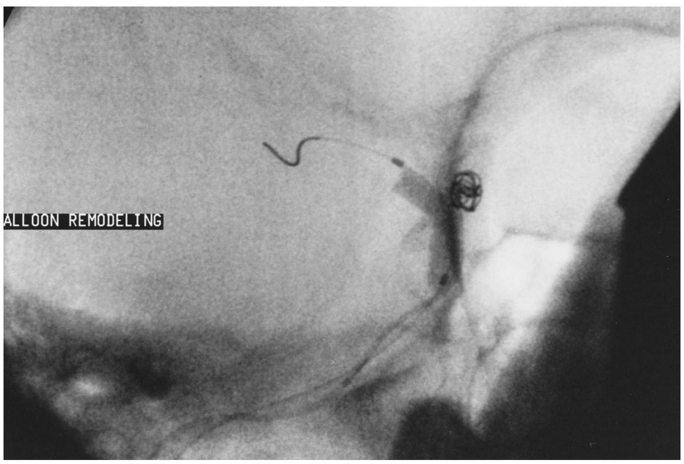

Figure 3. The wire is seen coming out of the middle cerebral artery, the balloon is inflated across the aneurysm neck, and the first coil is inserted in the aneurysm.

What Techniques or Devices Exist for Repairing Wide-Necked Aneurysms?

A number of techniques and devices can be used in the treatment of wide-necked aneurysms. These include balloon remodeling, use of three-dimensional (3D) coils, combined use of stents and coils, use of devices that span the neck, simultaneous deposition of more than one coil in an aneurysm, intentional partial aneurysm embolization, and combined exo- and endovascular treatment.

Balloon Remodeling

The balloon remodeling technique was first promoted by Moret, in France, who achieved total and near-total occlusion of wide-necked lesions in 94% of cases. This maneuver involves simultaneous catheterization using both a microcatheter and a nondetachable silicone balloon. The interventionalist may pass both catheter and balloon through a single, large guiding catheter (8- or 9-French), or may work through two smaller guiding catheters (6-French) placed in each femoral artery with a balloon in one catheter and a microcatheter in another. The technique is chosen based on the surgeon's preference as well as the size of the proximal vessels. Advantages of the single guiding catheter technique are that only one femoral artery is punctured, a single guide catheter is placed in a feeding artery, the surgeon can work from one side of the patient without having to reach across the patient's body, and fewer catheters

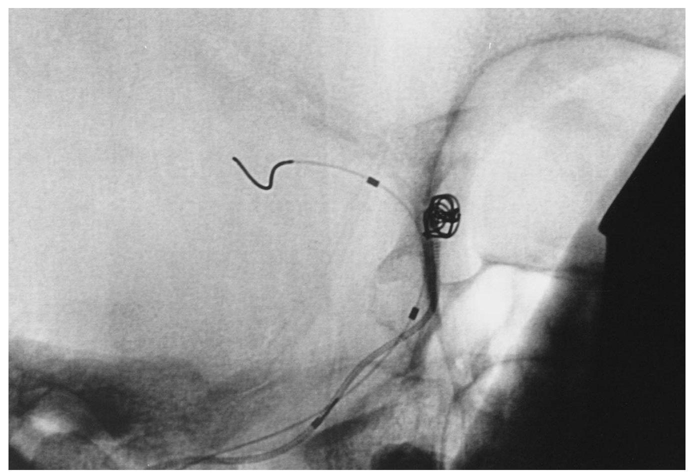

Figure 4. The balloon is deflated, and the first coil has been placed in the aneurysm.

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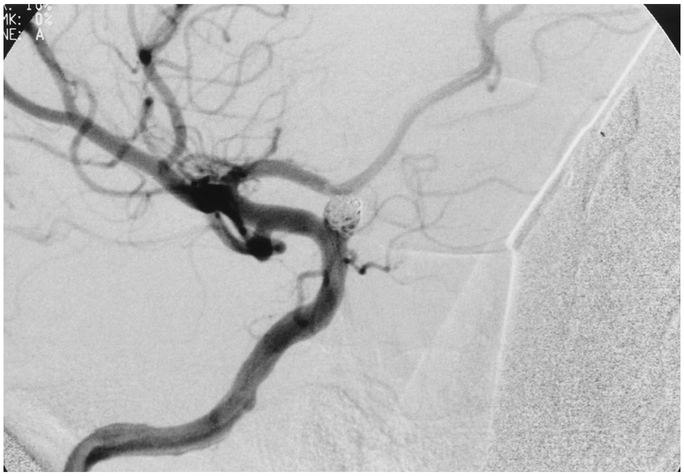

Figure 5. Embolization of the aneurysm has been completed. The filling still is seen through the coil interstices.

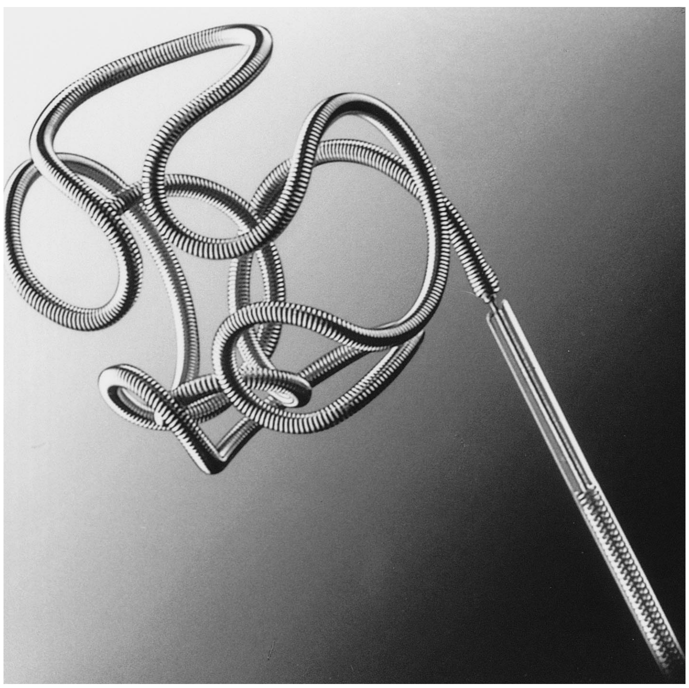

Figure 6. Three-dimensional coil (Target Therapeutics).

are used, thus making catheter maintenance during the procedure simpler, which, in turn, reduces risk to the patient. Disadvantages involve the increased size of the guiding catheter, which may increase the risk of vessel injury or occlusion. Advantages of the double-guide catheter system reside in the smaller individual catheter size. When working in the internal carotid artery (ICA), for instance, one 6-French catheter can be placed in the ICA while the other remains in the common carotid artery (CCA). When working in the vertebral artery (VA), one catheter can be placed in the VA while the other is positioned in the subclavian artery, or one catheter can be placed in each vertebral artery. In many cases, the ICA or VA diameter is too small to accommodate a single 8- or 9-French or two 6-French catheters.

Once a stable guiding catheter platform is established, a nondetachable silicone microballoon, an intracranial angio-

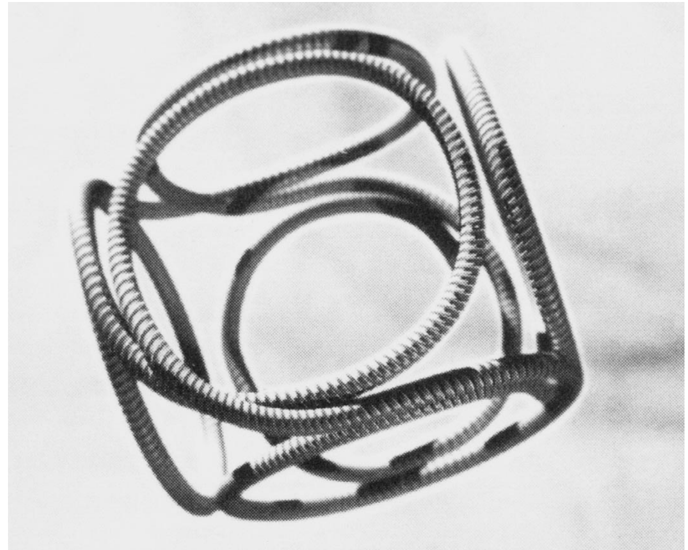

Figure 7. Micrus Microsphere coil.

Figure 8. Wide-necked aneurysm at the vertebral confluence.

plasty balloon, or a coronary angioplasty balloon is advanced to the level of the aneurysm neck. The microcatheter is then advanced into the aneurysm. Variable-sized coils are placed into the aneurysm. If the coils have a tendency to herniate out of the aneurysm, the balloon is gently inflated across the aneurysm neck while the coil is introduced. This keeps the coil in the fundus and out of the parent vessel and serves to shape the coil so that it assumes a convex configuration along the balloon interface. Once the coil is completely introduced, the balloon is deflated. The coil is observed for a minute to determine that it is stable and then is detached. Sequential coils are introduced into the aneurysm using the same technique until the lesion is maximally filled (Figs. 1 through 5).

Using balloon remodeling, it is now possible to occlude many wide-necked aneurysms that formerly were not amenable to endovascular therapy. Nevertheless, this technique is not without risks and drawbacks. It is possible for the procedure to be performed by a single operator, but it is easier for two endovascular surgeons to perform it, with one maneuvering the balloon while the other introduces the coils. This requires human resources that are not always readily available, however. Inflation of the balloon across an unsecured aneurysm can lead to neck deformation and aneurysm rupture. Inflation of a balloon in a 5-mm or smaller vessel, if not performed carefully, can lead to vessel rupture or thrombosis. Use of a large guiding catheter or two smaller guiding catheters can increase the risk of vessel injury. Finally, the procedure requires experience that can be achieved only in a busy endovascular practice. Many endovascular surgeons may not have enough opportunities to practice the technique to permit them to develop the necessary skills. In Moret et al. series, technique-related morbidity and mortality were 2% and 0%, respectively.

Three-Dimensional Coils

Three-dimensional coils assume a complex 3D configuration once they exit the catheter and enter the fundus of the aneurysm. The coils manufactured by Target Therapeutics take on an "omega" shape at each turn, eventually assuming a spherical configuration (Fig. 6). The goal of this device is to cover the neck of the aneurysm, making it less likely that 3D coils or regular coils introduced subsequently will herniate out into the parent vessel.

Three-dimensional coils have proved very useful in the management of wide-necked aneurysms, obviating the need for balloon remodeling in many cases. These coils, however, are not a panacea and, at times, may make successful aneurysm obliteration difficult. The difficulties arise from the stiffer, less compliant quality of the coil. Once the 3D coils are placed, compartments can develop in the aneurysm that are difficult to fill later with regular coils. In many cases, this is not a long-term problem, because the neck of the aneurysm ultimately is well covered, and thrombosis occurs within the small fundal compartments once the heparin wears off or is reversed. Three-dimensional coils also have a tendency to place increased forces on the aneurysm wall because of the rigidity of the omega turns. This rigidity can increase the risk of aneurysm rupture, especially in patients who have recently had subarachnoid hemorrhaging. Despite these qualities, 3D coils have made many aneurysms with fundus-to-neck ratios less than 2 amenable to endovascular therapy without the use of balloon remodeling. They also have been useful in cases in which balloon remodeling alone could not keep coils within the fundus. Used in combination with an angioplasty balloon, 3D coils can occlude many previously untreatable lesions.

Figure 9. Stent across aneurysm neck.

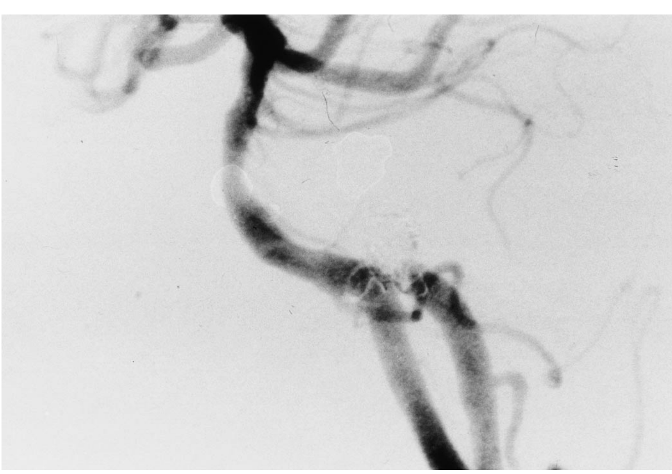

Figure 10. Stent with coils in the aneurysm. The coils that appear to be in the lumen actually are external to the stent and are simply superimposed on the vessel.

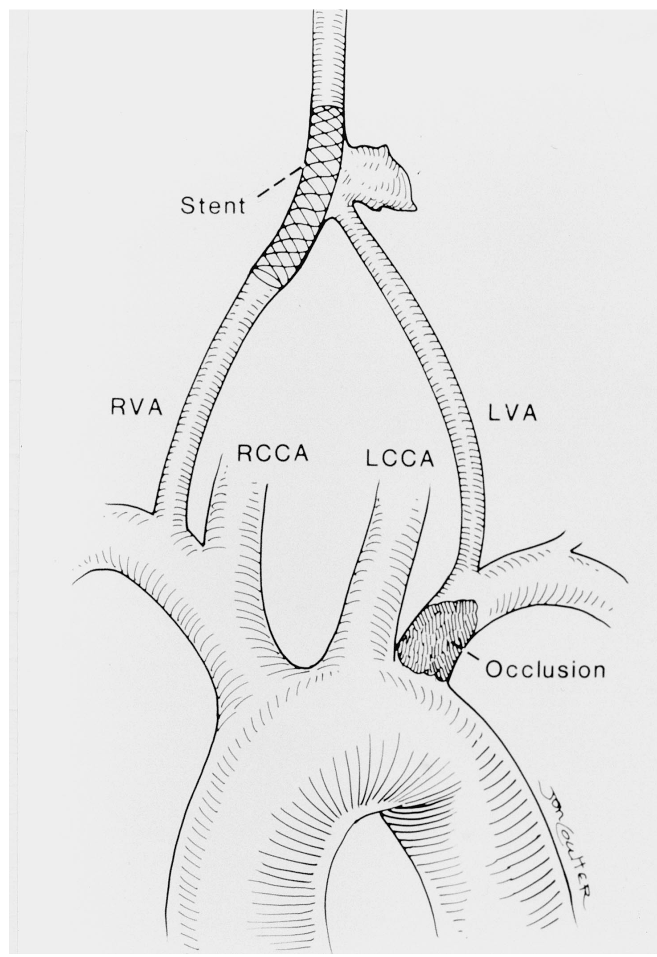

Figure 11. Stent position relative to the aneurysm prior to coiling.

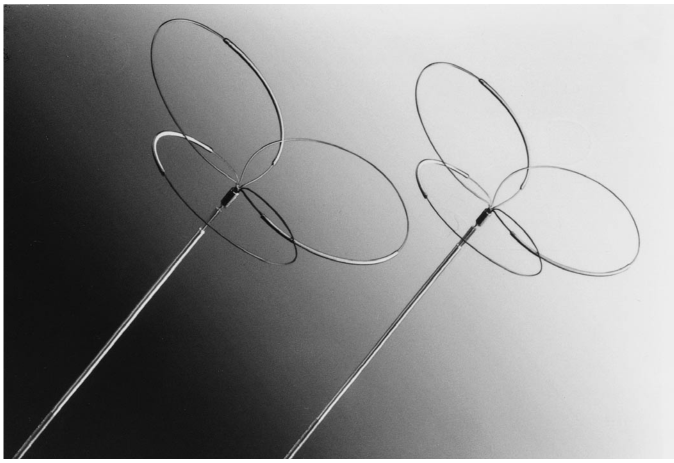

Figure 12. TriSpan neck occlusion device (Target Therapeutics).

Other three-dimensional coils, manufactured by Micrus (Mountain View, CA), also form a scaffolding within the aneurysm, thereby allowing for further deposition of coils without occluding the parent vessel (Fig. 7). These devices are mechanically rather than electrolytically detached. Experience with them is limited, and further work is needed to determine the long-term efficacy of this technology.

Stents and Coils

In certain situations, an aneurysm neck is so wide relative to its fundus that it is impossible to keep coils within the lesion. In these cases it often is possible to cover the neck of the aneurysm with a coronary stent and then use the stent to hold the coils within the fundus (Figs. 8 through 11). The patient is prepared with one or two guiding catheters, as described in the section on balloon remodeling. A coronary stent is then advanced across the aneurysm neck and deposited. A 300-cm .014-inch guidewire is left across the stent until the entire procedure has been completed, in case access to the stent lumen is required. Once the stent is in position, a microcatheter is advanced over a wire through a stent cell and into the aneurysm fundus. The aneurysm is then embolized with coils until it is completely filled. The stent wall acts as a scaffolding, holding the coils in the aneurysm and out of the parent vessel.

The combined use of stents and coils is not free of difficulties and risks. In some situations, for example, stents cannot expand to the degree needed. The largest coronary stent manufactured has a diameter of 4.5 mm and will open only to a diameter of 4.7 mm (when overinflated). When the parent vessel is larger than 4.7 mm, it may be impossible to open the stent and have it appose the vessel walls. If apposition fails to occur, the stent will move and become either a source of emboli or an embolus itself. In other situations, despite the flexibility of newer coronary devices, the stent cannot be advanced through the numerous turns inherent in the intracranial vasculature. This

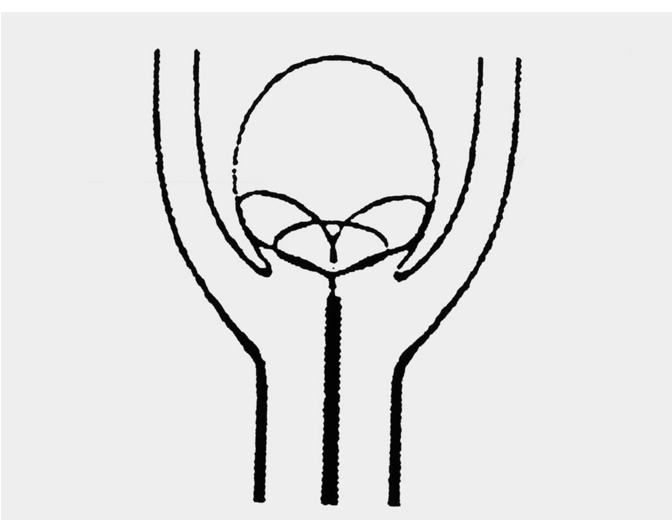

Figure 13. TriSpan device across an aneurysm neck prior to coil embolization of the lesion.

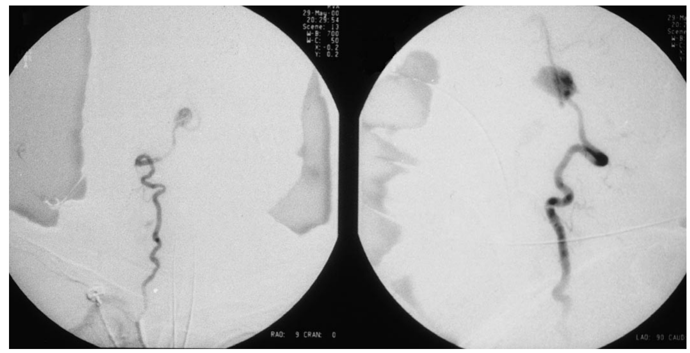

Figure 14. Right posteroinferior cerebellar artery aneurysm with large neck.

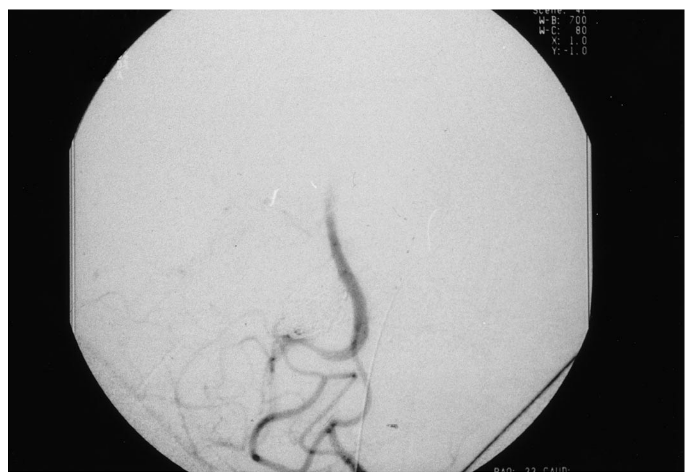

Figure 15. Coiled aneurysm. The posteroinferior cerebellar artery continues to opacify from the portion of the base intentionally left open.

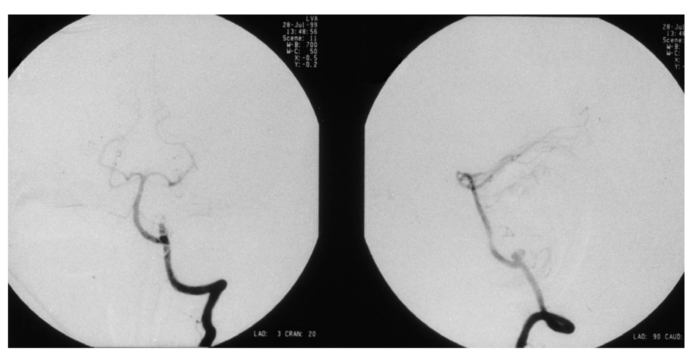

Figure 16. Large-necked posteroinferior cerebellar artery aneurysm following partial neck clipping.

Figure 17. Aneurysm obliteration following coil embolization of post-clipping residual.

Figure 18. Large-necked posterior carotid wall aneurysm in a poor-grade patient with a posterior communicating artery originating from the fundal base.

makes it impossible to advance the stent to the required location. Attempts to place it through these turns can lead to vessel injury, dissection, occlusion, and subsequent stroke. Finally, the long-term sequelae of placing stents into small intracranial ves-

Figure 19. Aneurysm following intentional incomplete embolization using 3D coils. The posterior communicating artery remains intact.

sels are unknown. Intimal hyperplasia, the bane of interventional cardiologists, can lead to vessel stenosis over time, thus predisposing patients to delayed cerebral ischemic symptoms.

Neck Occlusion Devices

In the quest to control the aperture of wide-necked aneurysms, devices have been developed to block coils from exiting the aneurysm once introduced. Target Therapeutics recently has introduced a device called TriSpan (Figs. 12 and 13). This coil, not yet available for general use in the United States, is placed into the aneurysm through one microcatheter. Coils are then placed into the aneurysm and blocked from herniating out of the lesion by the presence of the TriSpan device across the neck. Preliminary animal and human studies are promising, but more patients must be treated and followed over time to determine the utility of this technology.

Simultaneous Coil Deposition

Another technique that can be used to occlude wide-necked aneurysms is simultaneous deployment of two coils in the hope that a complex shape will form that covers the neck, while the intertwining of the two coils restrains them from herniating out into the parent vessel. This maneuver requires one large or two smaller guiding catheters, and has the drawbacks of each technique, as discussed earlier in this article. It also necessitates placing two catheters into the aneurysm, which may not be possible or safe in smaller wide-necked lesions. Finally, the deposition of simultaneous coils requires two interventionalists, an arrangement that may not be available at all institutions.

Intentional Incomplete Embolization

Although the issue of incomplete coiling is sensitive, especially when competing procedures such as exo- and endovascular therapy are being considered, it is important to realize that the goal of aneurysm therapy is to reduce or eliminate the incidence of hemorrhage while at the same time preserving patient function. It is not clear whether incomplete coiling of an aneurysm reduces the incidence of delayed hemorrhage. This information will be available only with increased patient follow-up. However, as with aneurysm clipping, there are some instances in which an aneurysm cannot be completely obliterated because of afferent and efferent vessel relationships to the fundus and neck. This is especially true for large aneurysms with large necks and aneurysms of the middle cerebral artery M1 bifurcation. In such instances, it may be desirable to plan on managing the wide-necked lesion by intentionally placing coils in the fundus and not trying to place material flush with the neck. This may strengthen the weaker fundus wall and reduce the incidence of future bleeding (Figs. 14 and 15).

Combined Therapies

It often is necessary to treat a wide-necked aneurysm in two stages. If the techniques already discussed fail, and clipping of the entire lesion is judged too risky, the surgeon may opt to clip the aneurysm neck partially, thus turning a wide-necked lesion into a narrow-necked lesion. The aneurysm can then be treated endovascularly, with reduced risk for coil herniation into the parent vessel. This technique should be reserved for those rare lesions that cannot be remedied using exo- or endovascular therapy alone. If it is performed, both procedures should be carried out on the same day to minimize the risk of aneurysm rupture following partial clipping. Surgical hemostasis must be impeccable, because the patient is heparinized during the endovascular stage and may need to remain anticoagulated following the coiling (Figs. 16 through 19).

Conclusion

Wide-necked aneurysms remain difficult to treat and occlude permanently. A variety of techniques and devices currently are available or in development to improve on the interventionalist's ability to embolize these lesions. Only time and well-organized studies will reveal whether endovascular approaches to these entities are safe and effective.

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1. Single-dimensional coils achieve complete obliteration of 72% to 80% of aneurysms with a fundus-to-neck ratio of greater than 2.

True or False?

2. Aneurysms considered ideal for endovascular therapy have a fundus-to-neck ratio of less than 2.

True or False?

3. Three-dimensional coils are advantageous in wide-necked aneurysms because they may obviate the need for balloon remodeling.

True or False?

4. Three-dimensional coils are stiffer and may interfere with complete coil obliteration of the aneurysm.

True or False?

5. Three-dimensional coils may increase the risk of aneurysm rupture during coiling.

True or False?

6. The long-term sequelae of placing stents into small intracranial vessels are unknown.

True or False?

7. Balloon remodeling to occlude wide-necked aneurysms is not without risks and throwbacks and is safer in the setting of a busy endovascular practice.

True or False?

8. Coil herniation into parent vessels is the main risk of wide-necked aneurysm repair.

True or False?

9. If a combined approach of endovascular and surgical clipping is chosen for treatment of an aneurysm, it is preferred that both not be done on the same day.

True or False?

10. Endovascular treatment for wide-necked aneurysms is the best and only treatment option.

True or False?