Cotton-Clipping Technique to Repair Intraoperative Aneurysm Neck Tear: A Technical Note

BACKGROUND: Intraoperative rupture of an intracranial aneurysm is a potentially devastating but avoidable and manageable complication of aneurysm surgery. OBJECTIVE: To describe a surgical technique that the authors have used successfully to repair a tear at the neck of an intracranial aneurysm, as well as alternative options for managing this intraoperative complication. METHODS: The tear on the neck of the aneurysm is covered with a small piece of free cotton and held in place with a suction device to clear the field of blood. The cotton is then clipped onto the tear with an aneurysm clip, using the cotton as a bolster to obliterate the tear. The cotton increases the surface area, allowing the clip to be placed more distally on the neck to preserve patency of the parent artery. Case examples are used to illustrate the technique. RESULTS: Both authors independently have used this technique on several occasions to successfully repair tears at the neck of an aneurysm. CONCLUSION: Intraoperative rupture of an intracranial aneurysm is a potentially devastating complication, particularly if a tear occurs at the neck. This simple yet effective method has been very useful in repairing a partial avulsion or tear of the neck of an aneurysm. KEY WORDS: Aneurysm, Aneurysm clipping, Cerebrovascular surgery, Subarachnoid hemorrhage

The intraoperative rupture of an intracranial aneurysm is a potentially devastating but preventable and manageable complication of aneurysm surgery. Proximal arterial control, temporary clipping, and sharp dissection may reduce the risk of intraoperative aneurysm rupture. An intraoperative rupture that occurs after full exposure of the aneurysm usually can be managed without ill consequences to the patient. Intraoperative ruptures most often involve the dome of the aneurysm. In such cases, an appropriately applied clip will both halt the hemorrhage and repair the aneurysm. An intraoperative rupture or tear of the neck of the aneurysm, however, is a devastating misadventure. Use of an aneurysm clip to occlude the tear almost invariably narrows, and often occludes, the parent artery, potentially resulting in ischemic insult.

We report a technique for managing an intraoperative tear of an aneurysm neck by using cotton as a bolster applied with an aneurysm clip or clips to occlude otherwise irreparable aneurysm neck tears while maintaining patency of the parent artery. This technique has been used independently by both authors and was reported as a single case report by the senior author (RFS) in 2003. Over the years, this technique has been used successfully in a number of cases, and we believe that it is important to reintroduce the...
technique to the neurosurgical community. Illustrative cases are presented to demonstrate the technique and its utility.

TECHNIQUE

The surgeon should have available a selection of free cotton tufts of various sizes soaked in saline. In the event of an intraoperative rupture, free cotton applied to a bleeding site will tamponade the hemorrhage and provide a larger surface area to apply suction onto the cotton. Doing so clears the blood from the surgical field more rapidly and effectively. If possible, temporary clips also can be used to obtain proximal control or to trap the ruptured aneurysm and assist in obtaining hemostasis. The neck tear or bleeding site is completely covered by a small piece of free cotton and held in place with a suction device. The cotton is held in place and compressed against the tear on the aneurysm or its neck by the clip, which is only partially applied over the cotton. By placing the clip just above the tear, the cotton acts as a bolster held in place by the clip, which is located far enough distally on the neck to maintain patency of the arterial lumen. The surface area of the cotton allows the clip to be placed further distally on the neck than would be possible with the clip alone (Figure 1).

Intraoperative verification of aneurysm obliteration and patency of the parent vessel is recommended. Intraoperative digital subtraction angiography and microvascular Doppler ultrasonography are helpful for this purpose. The use of indocyanine green (ICG) video angiography is a recent adjunct that also can help verify patency of the parent artery.11

Illustrative Case Examples

Case 1.

A 51-year-old man presented with a Hunt and Hess Grade III subarachnoid hemorrhage (SAH) (see Video 1, Supplemental Digital Content 1, http://links.lww.com/NEU/A385). Angiography revealed a right middle cerebral artery (MCA) aneurysm that was considered the source of the hemorrhage. The patient also had anterior communicating artery (Figure 2A) and left internal carotid artery (ICA) aneurysms at the origin of the anterior choroidal artery. On the day after his SAH, the patient underwent a right frontotemporal craniotomy for clip ligation of all 3 aneurysms. The ruptured right MCA aneurysm was clipped initially, and ICG video angiography demonstrated complete obliteration of the aneurysm and normal filling of the surrounding vasculature. Attention was then directed to the anterior communicating artery aneurysm. After dissecting the aneurysm and identifying both A1 and A2 segments, a straight Sugita titanium mini-clip (Mizuho America, Inc, Beverly, Massachusetts) was placed across the neck of the aneurysm. As the clip closed, there was a slight tear on the left side in the crotch between the aneurysm neck and the left A2 segment just proximal to the aneurysm clip at the neck of the aneurysm (Figure 2B). This bleeding, blister-like area was wrapped with a small piece of cotton placed below the clip (Figure 2C). The clip was then opened and reapplied to include some of the cotton as a bolster (Figure 2D). The bleeding halted immediately. Dissection across the optic chiasm identified the distal left ICA, and the anterior choroidal artery aneurysm was clipped as well. ICG video angiography was repeated and demonstrated complete obliteration of the anterior communicating artery and left ICA aneurysms. Intraoperative digital subtraction angiography documented complete obliteration of all 3 aneurysms and excellent filling of the surrounding vasculature (Figure 2E).

Case 2.

A 62-year-old woman had presented in the past with an SAH from a posterior inferior cerebellar artery (PICA) aneurysm that had been treated by clip ligation and reimplantation of PICA to the proximal vertebral artery (See Video 2, Supplemental Digital Content 2, http://links.lww.com/NEU/A386). She had 2...
unruptured aneurysms on the left MCA that were being followed with serial imaging. Follow-up imaging demonstrated enlargement of the larger of the 2 aneurysms at the bifurcation of the left MCA (Figure 3A). The patient underwent a left frontotemporal craniotomy for clip ligation of both MCA aneurysms.

During clipping of the larger MCA bifurcation aneurysm, a temporary clip was placed on the M1 segment for the final stages of dissection. A side-angled fenestrated Yasargil clip was placed across the neck of the aneurysm with the fenestration encompassing 1 trunk of the bifurcation as well as the lateral

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**FIGURE 2.** Case 1. A, digital subtraction angiogram (DSA) demonstrating anterior communicating artery aneurysm. B, intraoperative photograph shows the aneurysm clip across the neck of the aneurysm and a thin area of bleeding (arrow) between the left side of the aneurysm neck and the left A2 segment. C, a small piece of cotton is placed above the clip. D, the clip is opened and reclosed over the cotton, using the cotton to tamponade the tear at the neck. E, intraoperative left ICA DSA documents obliteration of the anterior communicating artery aneurysm and normal filling of both A2 segments. Used with permission from Emory University School of Medicine.

**FIGURE 3.** Case 2. A, preoperative DSA and B, 3-dimensional angiogram of the largest left MCA aneurysm. C, the MCA bifurcation aneurysm has been clipped with a straight fenestrated clip that encompasses the medial portion of the neck with a straight tandem clip obliterating the portion that passes through the fenestration. A tear (arrow) is seen at the junction of the aneurysm neck and the medial M2 branch. D, intraoperative photograph showing the cotton now beneath the fenestrated clip to tamponade the tear. Used with permission from Emory University School of Medicine.
aspect of the neck of the aneurysm. The blades were then used to obliterative the medial portion of the neck of the aneurysm. The temporary clip was removed after approximately 30 seconds of temporary occlusion. The portion of the aneurysm passing through the fenestration was then clipped with a straight Yasargil clip. When the second clip was placed, a weak area of the neck at the junction of the M1 and the superior trunk of the MCA bifurcation bled from a tear at the neck (Figure 3B). The temporary clip was replaced, the fenestrated clip was opened, and a small piece of cotton was placed in the crotch between the distal neck of the aneurysm and the M2 segment. The clip was reclosed to hold the cotton in place over the tear (Figure 3C). After 15 seconds of temporary occlusion, the temporary clip was removed and the bleeding had stopped.

After the smaller distal MCA aneurysm was clipped, intraoperative angiography documented complete obliteration of both aneurysms and normal filling of the surrounding vasculature.

Case 3.
A 52-year-old woman was discovered to have multiple unruptured intracranial aneurysms, including a cavernous right ICA aneurysm, a right ICA aneurysm arising at the posterior communicating artery (Figure 4A), a left ophthalmic segment aneurysm, and a basilar trunk aneurysm arising at the origin of the superior cerebellar artery (see Video 3, Supplemental Digital Content 3, http://links.lww.com/NEU/A387).

She underwent a right frontotemporal craniotomy for clip ligation of the subarachnoid aneurysms. During management of the posterior communicating artery aneurysm, the aneurysm was dissected out carefully to identify the posterior communicating and anterior choroidal arteries (Figure 4B). A side-angled aneurysm clip was placed across the neck of the aneurysm, leaving a small dog-ear, which was then clipped with a small miniclip. Upon placement of the clip, the dog-ear bled at its neck (Figure 4C). A small piece of cotton was placed over the bleeding site, and the mini-clip was opened and reapplied over the cotton to immediately stop the bleeding (Figure 4D).

ICG video angiography documented complete obliteration of the aneurysm and normal filling of the posterior communicating and anterior choroidal arteries (Figure 4E). The remaining subarachnoid aneurysms were then clipped, and intraoperative angiography documented complete obliteration of those aneurysms and normal filling of the surrounding vasculature.

**FIGURE 4.** Case 3. A, preoperative DSA of the right ICA demonstrates a posterior communicating artery aneurysm. B, intraoperative photograph shows the aneurysm being dissected to expose the anterior choroidal artery (arrow) before clip placement. C, a side-angled clip has been placed across the neck of the aneurysm, leaving a small dog-ear that is being clipped with a slightly curved mini-clip. As the clip is placed, bleeding occurs from the neck of the dog-ear. D, a piece of cotton is being clipped to the tear with the mini-clip. E, intraoperative ICG video angiogram demonstrates complete obliteration of the aneurysm and normal filling of the ICA, its bifurcation, and the anterior choroidal artery (arrow). Used with permission from Emory University School of Medicine.
DISCUSSION

Although much has been written about intraoperative rupture of aneurysms, there is a relative paucity of literature on how to manage this complication. In the event of an untimely intraoperative rupture of an aneurysm, the surgeon faces 2 issues: (1) control of the bleeding and (2) definitive repair of the aneurysm and arterial defect. A number of techniques for control of unanticipated intraoperative hemorrhage have been described, including the use of a large-bore suction over the bleeding site (including a second suction handled by the surgeon or assistant), tamponade with a cottonoid, proximal temporary occlusion or trapping, carotid compression, coagulation of the aneurysm, and clip application to the distal sac, and induced hypotension.1-3,5-9,12

Methods for definitive repair include microsuturing the defect, placing a clip graft, or trapping of aneurysm with or without a bypass.

Microsuturing

Although repair of a vessel tear by microsuturing is intellectually appealing and maintains blood flow in the parent artery, it may not be a practical option. In the case of a tear at the neck of an aneurysm, the integrity of the vessel wall is poor. Suturing is often either impossible or may lead to further tearing.

Sundt-Clip Graft

The Sundt-clip graft is a vessel-encircling clip designed almost 40 years ago by Sundt, and Kees to repair defects in the walls of blood vessels.13-15 The clip graft is composed of a metallic spring encasing a Teflon or Dacron graft and is available in different lengths and widths. When applied over a torn vessel, the spring mechanism of the clip applies the synthetic graft over the defect with pressure and "reconstructs" the lumen of the parent vessel. In both authors' individual experiences, the Sundt-clip graft has been a life-saving device in a number of situations where other options were lacking. We keep a variety of these clips readily available for such circumstances.

However, the Sundt-clip graft has several disadvantages. Many surgeons do not have the clips readily available. The clip graft is difficult to maneuver and to apply precisely with preservation of adjacent branches or perforators. Although Sundt-clip grafts are available in various sizes, it is sometimes impossible to find the precise size that accommodates the damaged segment of vessel while preserving adjacent perforator-bearing segments (eg, anterior choroidal or posterior communicating arteries during repair of a carotid defect). If the vessel defect to be repaired is a tear at the neck of the aneurysm, the encircling clip graft would have to include the dome of the aneurysm. This additional tissue within the clip graft can occlude the lumen of the parent vessel.

Trapping With or Without Bypass

Permanent trapping of a damaged segment of an intracranial vessel has the advantage of providing prompt control of profuse bleeding and permanent exclusion of the injured segment of the vessel and aneurysm from the circulation. The obvious disadvantage of trap-ligation is the risk of ischemic complications. In the event of an urgent need to control unexpected bleeding, intraoperative assessment of collateral flow is difficult. Doing so is particularly dangerous if the segment of trapped artery bears perforators or branches.

The risk of ischemic complications can be reduced by performing either an extracranial-to-intracranial (EC-to-IC) or an intracranial-to-intracranial (IC-to-IC) bypass. In the event of an intraoperative hemorrhage from an irreparable defect in the vessel, the surgeon may not have prepared for an EC-to-IC bypass, however, and there may or may not be an anatomic option for an IC-to-IC bypass. Ischemic injury may occur during construction of the bypass. Furthermore, if the trapped segment harbors perforators, the bypass will not protect from ischemia in the territory of the perforators.

The relatively straightforward technique described in this report is quite effective in repairing a partial avulsion or tear of an aneurysm neck. When using this technique, the surgeon must ensure that the clip-cotton construct does not compromise the parent artery. Combinations of microvascular Doppler ultrasonography, intraoperative digital subtraction angiography, and ICG videoangiography can be used for this purpose. We have found this technique to be durable. In our collective experience, neither of us has seen delayed thrombosis or pseudoaneurysm formation. Recognizing that cotton, muslin or other fabric implants may cause opticociliary arachnoiditis, one must be careful not to place excessive cotton in the region of the optic nerves and chiasm.16,17 We have seen this complication of wrapping of carotid aneurysms, but not as a complication of the technique described in this publication, in which a small piece of cotton is clipped to a tear in the aneurysm neck.

Disclosure

The authors have no personal financial or institutional interest in any of the drugs, materials, or devices described in this article.

REFERENCES

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COMMENTS

In their article “Cotton-Clipping for Aneurysm Neck Tear” Drs Barrow and Spetzler describe a relatively simple technique to manage this potentially devastating complication. Previously published literature has shown that intraoperative rupture can be a common occurrence (3.8%-19%), and greatly affects postoperative outcomes.1,2 Although several studies have evaluated the risk factors associated with intraoperative rupture, there is a relative paucity of data describing measures to counter the complication.

This article shows a method using free cotton to bolster an aneurysm clip and repair the tear. Along with the technical description, the authors provide 3 case examples with associated figures and video to further clarify the use of this method. They also include a discussion of other techniques used in the case of intraoperative rupture, allowing the reader to compare and contrast the nuances of each method.

One problem with this technique is that arachnoiditis has been reported when fabric implants lie adjacent to the optic nerve and chiasm. In rare cases this may cause progressive loss of vision. This is probably a relatively small price to pay in the context of a life-threatening intraoperative rupture, but cerebrovascular surgeons should remain aware of this potential complication.3,4 The information in this article provides important insight from 2 senior vascular neurosurgeons on the management of a serious intraoperative complication. It is imperative that articles such as this, which build on years of experience, continue to be published, to provide the future generation of vascular neurosurgeons with the knowledge and skills to manage these complicated patients.

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The authors describe an elegant and effective technique for addressing intraoperative aneurysm neck tear during open surgical clipping of cerebral aneurysms. The technique is to use cotton as a bolster to provide expanded surface area for the placement of a clip across a torn aneurysm neck. The 3 cases described and the associated images and video demonstrate the effectiveness of this technique in what would otherwise be a difficult and challenging situation. For young neurosurgeons such as myself, the description of pearls such as this by senior experts is greatly appreciated and will certainly be incorporated into practice.

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