

Intentional partial coil occlusion followed by delayed clip application to wide-necked middle cerebral artery aneurysms in patients presenting with severe vasospasm

Report of two cases

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✓ The treatment of ruptured cerebral aneurysms in patients presenting with vasospasm remains a particular challenge. The authors treated two patients harboring Hunt and Hess Grade 1 subarachnoid hemorrhages from middle cerebral artery (MCA) aneurysms associated with severe local angiographically demonstrated yet asymptomatic vasospasm on presentation. Because both aneurysms had wide necks and were located at the MCA bifurcation, they were believed to be anatomically suitable for microsurgical clip application. Severe M₁ vasospasm was believed to be a relative contraindication to open surgery, however.

An intentionally staged endovascular and microsurgical treatment strategy was planned in each patient. Partial coil occlusion of the aneurysmal dome was performed to prevent the lesion from rebleeding and was followed by balloon angioplasty of the spastic vessel. Early treatment of the severe spasm appeared to prevent significant delayed neurological ischemic deficit. Following resolution of the vasospasm, definitive clipping of the aneurysms was performed on Day 13 post embolization. One patient had a good clinical recovery and was discharged without neurological deficit. The other patient's hospital course was complicated by the occurrence of a postoperative posterior temporal infarct requiring partial temporal lobectomy, although she eventually had a good recovery with only a small visual field deficit. Based on data obtained in these two patients, one can infer that ruptured wide-necked MCA aneurysms associated with severe local vasospasm may best be treated using a staged combined treatment plan. Delayed clip application might be performed more safely 4 to 6 weeks postocclusion, or later, than at 2 weeks.

KEY WORDS • coil occlusion • clip application • middle cerebral artery aneurysm • vasospasm • angioplasty

DESPITE the growing number of intracranial aneurysms amenable to endovascular repair, those of the MCA remain a particular challenge. Treatment with coil occlusion is often risky and incomplete because these dilations are often wide-necked and incorporate one of the M₂ branches. In contrast, the surgical exposure and technique required to clip an MCA aneurysm properly through a craniotomy are often straightforward factors for the experienced cerebrovascular surgeon.¹⁵ Middle cerebral artery aneurysms in patients who present with SAH and significant vasospasm represent a unique management dilemma. Although the lesion is often anatomically more suited to clip application, severe vasospasm, particularly if it is symptomatic, is considered a contraindication to the procedure.^{10,16} Endovascular repair that either jeopardizes the M₂ branches or allows for only partial occlusion is also not

ideal, especially in young patients in whom a partially open aneurysm may pose a long-term risk of repeated rupture.

The management of aneurysmal SAH in patients presenting with vasospasm is controversial. Many factors, including clinical grade, patient age, aneurysm location, and whether the vasospasm is symptomatic, play a role in decision making. Different treatment strategies have been reported, including conservative treatment, waiting for the vasospasm to resolve, microsurgical clip application immediately followed by endovascular vasospasm treatment (angioplasty and/or intraarterial vasodilating vessels),¹¹ or endovascular obliteration of the aneurysm combined with simultaneous vasospasm treatment.¹³ In this report, we describe two patients who presented with ruptured MCA aneurysms associated with severe local vasospasm and who were successfully treated using an intentionally staged endovascular and microsurgical treatment strategy. A combined dual modality approach was planned, which involved intentional partial coil occlusion of the aneurysmal dome, balloon angioplasty of the stenotic vessel segments, and

Abbreviations used in this paper: CT = computerized tomography; ICP = intracranial pressure; MCA = middle cerebral artery; SAH = subarachnoid hemorrhage.

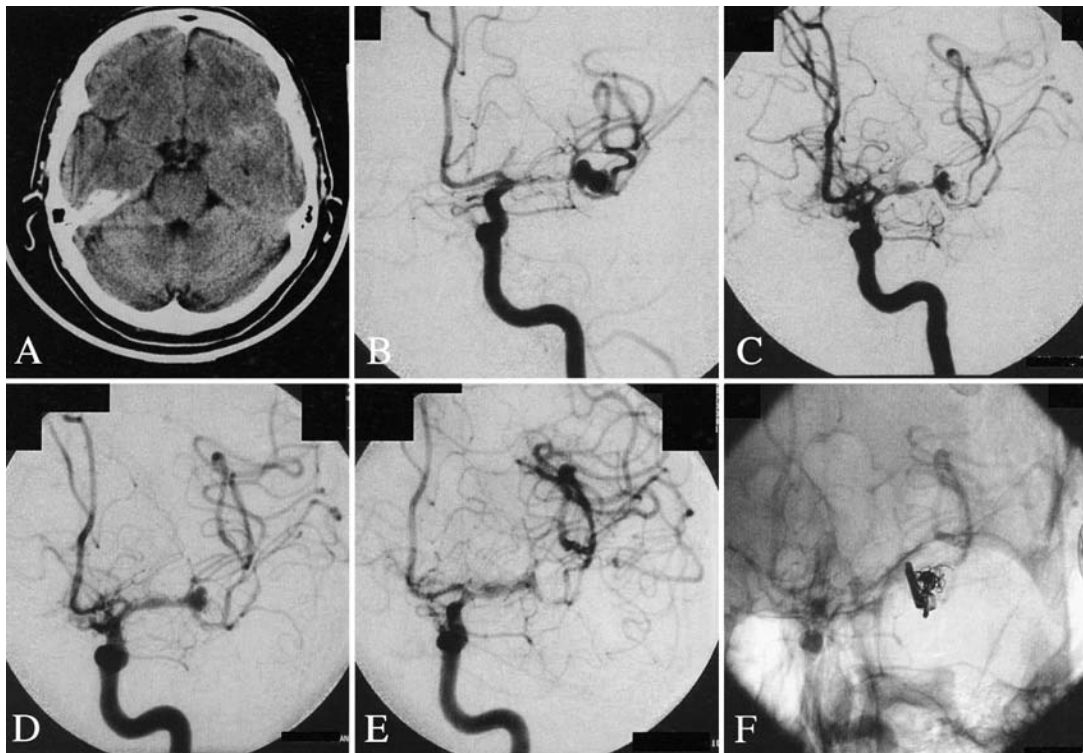


FIG. 1. Case 1. A: Axial noncontrast CT scan revealing a small SAH in the left sylvian fissure. B: Anteroposterior digital subtraction (DS) angiogram of the left internal carotid artery (ICA) demonstrating a left-sided, bilobed, irregularly shaped MCA bifurcation aneurysm with significant M₁ narrowing. C: Anteroposterior DS angiogram of the left ICA obtained immediately after coil occlusion and dilation angioplasty of the M₁ segment. D: Digital subtraction angiogram obtained 6 days later, exhibiting an M₁ that appears to have a normal lumen diameter. E: Postsurgical DS angiogram obtained 3 days after clip application, demonstrating successful obliteration of the aneurysm. F: Oblique digital non-subtracted angiogram revealing the relationship between the aneurysm clip and the coil mass.

then delayed definitive surgical clip application of the aneurysm after resolution of the vasospasm.

Illustrative Cases

Case 1

History. This 48-year-old woman with a history of heavy tobacco use presented 11 days prior to admission to an outside clinic with the sudden onset of acute left occipital headache, photophobia, and neck stiffness. She was treated conservatively and her symptoms resolved. The headaches returned 5 days later, and a CT scan of her head revealed a left sylvian SAH (Fig. 1A). Angiography studies were performed at an outside hospital, and results demonstrated an irregularly shaped MCA aneurysm. Significant vasospasm was revealed in the M₁ segment. The patient was transferred to our institution for further treatment.

Examination. On arrival, she was neurologically intact but suffering from severe headache. An angiography study demonstrated a complex left MCA bifurcation aneurysm pointing laterally. The lesion had an irregular, saccular shape with multiple lobules, measuring 8.5 × 4.3 mm. The neck measured 4.4 mm. Both superior and inferior trunks of the MCA M₂ segments were incorporated into the aneurysmal neck. Severe vasospasm was noted in the M₁ segment and moderate vasospasm in the M₂ segment (Fig. 1B). Given the morphology of the aneurysm, we determined that

adequate occlusion would be impossible. We decided to occlude the lesion enough to prevent rebleeding but not so much that definitive clip application at a later date would be cumbersome.

Aneurysm Occlusion. Successful advancement of the microcatheter into the aneurysm obviated the need for dilation before occlusion. Three coils (Matrix; Boston Scientific/Target Therapeutics, Boston, MA) were successfully placed in the aneurysmal dome. We attempted to insert a third coil, but this caused an obstruction of the inferior M₂ branch and thus was removed. Gentle balloon angioplasty of the midportion of the M₁ segment was then performed. On completion of the procedure, control angiography studies revealed successful dilation of the M₁ segment and partial occlusion of the aneurysm with a residual wide neck (Fig. 1C).

The patient tolerated the procedure well and awoke neurologically intact. As her previously elevated transcranial Doppler velocities normalized (initial postangioplasty mean values 188–213 cm/second), she was weaned from hypervolemia and hypertension therapy.

Clip Application. Angiography studies obtained 12 days postocclusion demonstrated continued patency of the aneurysm and resolution of the vasospasm (Fig. 1D). The next day, the patient was brought to the operating room to undergo clip application. A standard left pterional craniotomy was performed, and the sylvian fissure was carefully

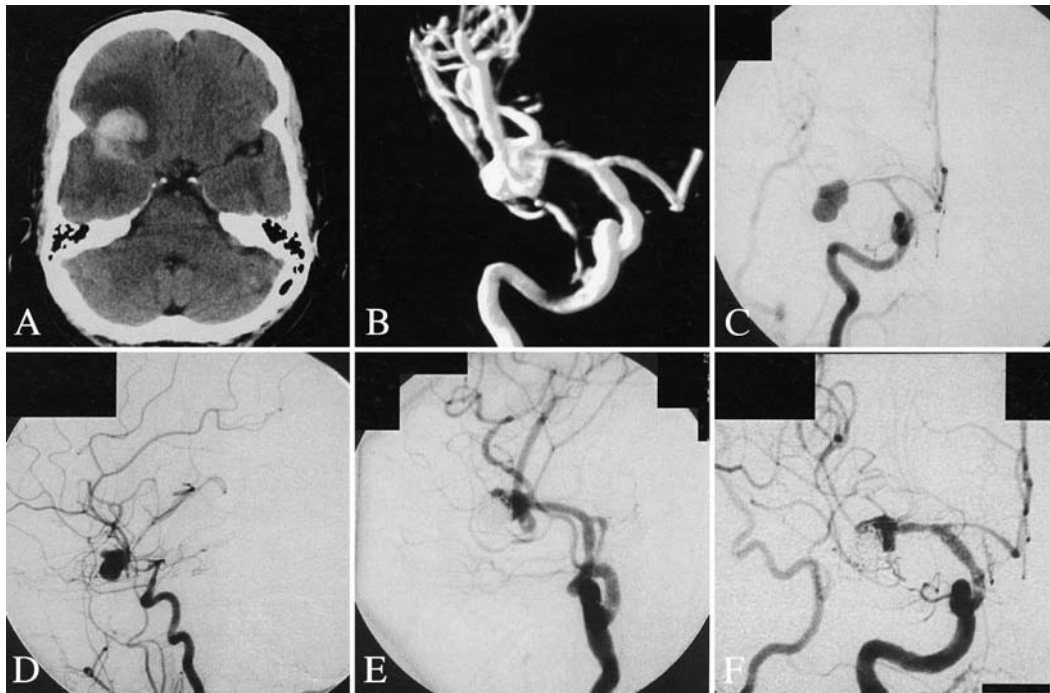


FIG. 2. Case 2. A: Axial noncontrast CT scan revealing SAH in the right sylvian fissure together with an associated frontotemporal hematoma. B: Three-dimensional rotational angiogram of the right ICA exhibiting a large irregularly shaped, multilobed MCA aneurysm. C: Anteroposterior view. D: Lateral DS angiography of the right ICA demonstrating the MCA aneurysm together with severe M₁ and A₁ vasospasm. Lateral (E) and anteroposterior (F) DS angiograms of the right ICA obtained after intentional partial occlusion and successful balloon angioplasty of the M₁ and A₁ segments.

opened until the M₁ segment was visualized. The dissection continued with exposure of the MCA bifurcation and a view of the broad-necked aneurysm. With the aid of temporary occlusion for approximately 2 minutes, the aneurysm was dissected, freeing the M₂ branches from the base. A single clip was placed across the aneurysmal neck. Good Doppler signals were recorded from the M₂ branches. The patient tolerated the surgery well and awoke neurologically intact. A follow-up angiogram obtained on postoperative Day 3 (Fig. 1E and F) revealed successful occlusion of the left MCA aneurysm and persistent, marked improvement of the M₁ vasospasm. She was discharged home neurologically intact 4 days after surgery.

Case 2

History and Examination. This 35-year-old woman with a history of cigarette smoking presented to another hospital with a syncopal episode after having suffered from severe headache. Initially, she was sent home with analgesic agents, but she returned to the emergency room 3 days later with a worsening headache. A head CT scan revealed a right frontal opercular hemorrhage with SAH (Fig. 2A). The patient was transferred to our institution 6 days after the first ictus for further care. On admission, she had a significant headache and was neurologically intact. An angiogram revealed left and right MCA bifurcation aneurysms. The left MCA aneurysm measured 5 × 2 mm. The right MCA aneurysm was a large, irregularly shaped lesion measuring 8 × 6.5 mm and was associated with severe right A₁, M₁, and M₂ vasospasm (Fig. 2B–D). The left MCA aneurysm was believed to be incidental, because the sylvian hema-

toma was situated on the right side. The right aneurysmal neck was dysplastic and wide (6.5 mm); the inferior and superior divisions of the MCA were incorporated into the base of the aneurysm.

Aneurysm Occlusion. Partial occlusion of the right MCA aneurysmal dome was undertaken. A total of 11 coils (one Microplex framing coil [Microvention, Aliso Viejo, CA] and 10 Guglielmi Detachable Coils [Boston Scientific/Target Therapeutics]) were placed in the aneurysm, with preservation of the M₂ branches and leaving the proximal neck and sac open. Angioplasty of the M₁ segment was then performed using a Sentry 15 (Boston Scientific/Target Therapeutics) microballoon, resulting in successful dilation of this segment. The patient tolerated the procedure well and awoke neurologically intact. During the next 12 days, her previously elevated transcranial Doppler measurements normalized with the administration of medical therapy. Follow-up angiography performed 12 days following coil embolization and angioplasty revealed a partially coiled aneurysm with near resolution of the vasospasm (Fig. 2E and F). Significant hyperemia with early venous drainage was noted in the frontal lobe adjacent to the hematoma. This was believed to represent luxury perfusion, but the true significance of this is unclear.

Clip Application. On the following day, the patient underwent a pterional craniotomy for clip application of the residual right MCA aneurysm. After opening the sylvian fissure, the lesion was identified. A small area of the aneurysmal dome appeared translucent and some of the coils appeared to extrude through this thinned-out area of the lesion into the subarachnoid space. Blood from the old hematoma was

Partial coil occlusion and delayed clip application for aneurysms

encountered and evacuated. A temporary clip was applied to the M_1 segment for approximately 6 minutes to facilitate dissection of the M_2 branches. Motor evoked potentials temporarily decreased during that time but returned to baseline after the clip had been removed for approximately 10 minutes of recirculation time. The coil mass made the dome rigid and difficult to manipulate. Final application of the clip was also more difficult than usual, because the clip would readily slide proximally, either obstructing the bifurcation or incompletely obliterating the aneurysmal neck. Eventually, a clip was satisfactorily placed across the base of the lesion, parallel to the bifurcation, and appeared to obliterate the aneurysm. Good Doppler signals were obtained from both M_2 branches thereafter.

Although the patient was slow to awaken, she did not have a focal deficit. Head CT scanning performed during the next 18-hour period demonstrated diffuse cerebral edema and an evolving right posterior temporal infarct. The patient required reintubation, and a left frontal ICP monitor was placed to assess ICP and maximize medical treatment of the swelling. Despite the administration of medical therapy including mannitol, her ICP continued to rise above 30 mm H₂O. We elected to perform a temporal lobectomy to prevent neurological deterioration. Afterward, we induced a barbiturate coma with electroencephalography confirmed burst suppression. Her ICP normalized, and the barbiturates were stopped after 4 days. Two days later the patient was extubated and began to verbalize. She continued to make a good recovery and was discharged home on postoperative Day 20, ambulating with a mild left hemiparesis and visual field deficit. At a 2-month follow up, her hemiparesis had resolved and she had a persistent partial homonymous field cut.

Discussion

Advances in microsurgical clip application and endovascular coil occlusion techniques have led to new disease management strategies to address problems inadequately treated using either modality alone.² In this report we present our experience with two female patients harboring ruptured wide-necked MCA aneurysms associated with severe vasospasm and in whom combined endovascular and microsurgical treatments made for a reasonable management strategy. Both patients presented with a good Hunt and Hess⁹ grade and underwent partial occlusion of the aneurysm dome, which prevented early rebleeding, followed by definitive surgical clip application. One patient fared very well and was discharged home neurologically intact 4 days post-clip application. The other patient suffered postoperative temporal lobe infarction requiring partial temporal lobectomy but has since made an excellent recovery with only mild residual deficits. Diffuse vascular blush demonstrated on angiography prior to clip application might have indicated diminished cerebrovascular reserve and thus signified that further delay in microsurgical clip application may have resulted in a better outcome.

The management of aneurysms in patients who present with SAH and vasospasm is controversial.^{11,13,17} Analysis of data from several reports has shown that intracranial aneurysm surgery in the face of vasospasm carries a significantly high risk, which is believed to be related to the ill effects of manipulating and retracting the brain and manipulating

and/or temporary clipping of the spastic vessels. Most of this literature is related to patients with symptomatic vasospasm and therefore is not necessarily applicable to our two patients in whom vasospasm was a radiographically demonstrated finding without clinical sequelae. Data from one recent study of patients with SAH and no vasospasm showed that patients treated with craniotomy and clip application later experienced increased incidence of vasospasm compared with patients who had undergone endovascular therapy.¹⁴ Researchers studying 12 patients with aneurysmal SAH and symptomatic vasospasm concluded that endovascular therapy should be attempted as a first line of therapy in such patients. The aneurysm and vasospasm could thus be treated during the same procedure.¹⁷ With our patients having wide dysplastic aneurysmal necks incorporating the upper and lower divisions of the MCA, we believed it to be unlikely that we would achieve a stable, adequate occlusion with coil embolization alone. For this reason, we determined that final surgical clip application would be necessary to complete aneurysm obliteration.

Combining microsurgical and endovascular therapy to treat intracranial aneurysms is not new.^{1-3,5-8,12,17-19} Most reports relate to treating recurrences or inadequately treated aneurysms after embolization followed by surgical clip application, or the opposite scenario. Combined therapy was undertaken in a series of 12 patients with complex aneurysms, two of whom were treated using partial aneurysmal dome packing and subsequent clip application. One of these patients presented with a poor grade SAH from a midbasilar artery aneurysm and severe vasospasm.⁶ Deliberate partial coil placement followed by clip application has also been reported in treating MCA aneurysms.^{2,6} Intentional partial coil occlusion has traditionally been performed in surgically poor candidates who have a poor clinical grade, an advanced age, or anatomically difficult aneurysms.

Literature on clip application following partial coil embolization indicates that the presence of the coil mass makes the technical aspects of surgery more difficult. Partially coiled aneurysms are relatively immobile, making dissection and visualization around the lesion more difficult. The presence of the coil mass may significantly impede application of the aneurysm clip, causing an increase in both the temporary occlusion time and the number of clip repositionings. All of these intraoperative manipulations may adversely affect patient outcome following aneurysm surgery.⁴ Most surgeons recommend leaving the coils in place and attending to the aneurysmal neck only; coil extraction has been described in cases in which adequate visualization of the neck and perforating vessels is impossible. Because clip application is still considered to be a good primary modality in treating MCA aneurysms, relatively few of the reports on clip application following coil embolization refer specifically to MCA aneurysms (Table 1).

Planning to treat an aneurysm with partial coil occlusion followed by clip application is important in that an aneurysm with 30 to 40% coils is easier to clip than one with 80 to 90% coils. Although there are no data from a large controlled trial showing that partial or dome coil embolization prevents early rebleeding, other data from several large series of aneurysms treated using coil placement did include ruptured aneurysms that had been partially occluded and were protected from rebleeding.¹³ Furthermore, we acknowledge that there is no evidence that 80% coil

TABLE 1

*Middle cerebral artery aneurysms treated surgically after nondefinitive endovascular coil embolization**

Authors & Year	Age (yrs), Sex	Admission H & H Grade	Aneurysm Size (mm)	No. of Coils Placed	Timing Btwn Occl & Clip Appl	Postop Result	Rationale for Combined Procedures
Civit, 1996	67, M	IV	25.0	24	3 mos	death	IC
	50, F	V	8.0	3	4 mos	baseline	IC
	57, F	IV	6.0	4	15 mos	baseline	recurrence
Thornton, et al., 2000	67, F	NA	5.0	NA	7 days	rt hemiparesis	mass effect/ stroke
Conrad, et al., 2002	58, F	III	<10.0	NA	3 mos	excellent	IC
	58, F	III	10.0–15.0	NA	48 hrs	excellent	IC
Zhang, et al., 2003	60, F	IV	15.0	NA	5 mos	excellent	recurrence
	present study	35, F	II	8.0	11	13 days	lt visual field cut
	48, F	II	8.5	3	13 days	excellent	vasospasm

* Appl = application; H & H = Hunt and Hess; IC = incomplete coil occlusion; NA = not available; occl = occlusion.

occlusion is more effective in preventing early rebleeding compared with 40% occlusion; obvious aneurysmal wall defects, such as tears, should be covered with coils if partial dome coil embolization is undertaken.

Our two cases highlight the new management strategies that are emerging given the technology currently available to the neurovascular team of surgeons and endovascular specialists. There are multiple treatment options with different risk profiles in patients with ruptured wide-necked MCA aneurysms and severe vasospasm, asymptomatic or not. We elected to treat our patients by performing immediate intentional partial coil placement and angioplasty followed by delayed clip application. This staged, combined modality was well tolerated and resulted in good clinical outcome in both of our patients and should be considered as an effective treatment option in such situations. Delaying definitive clip application 4 to 6 weeks or more after coil placement might allow the injured brain sufficient time to restore cerebral reserves to tolerate surgical manipulation after SAH and vasospasm.

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