Endovascular treatment of cerebral aneurysms following incomplete clipping

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The authors report their experience using electrolytically detachable coils for the treatment of residual cerebral aneurysms following incomplete surgical clipping. Eight patients were treated for six anterior and two posterior circulation aneurysm remnants. All patients were referred for endovascular treatment by experienced cerebrovascular neurosurgeons at the authors’ institution. Patients underwent follow-up angiography immediately after endovascular treatment. In seven of the eight patients, additional follow-up angiographic studies were obtained at periods ranging from 7 weeks to 2 years posttreatment. The latest follow-up angiograms demonstrated that six of the eight aneurysm remnants were 100% occluded, with near-complete occlusion of the other two aneurysm remnants. There was no permanent neurological or non-neurological morbidity or mortality associated with the treatment. There was no incidence of aneurysm hemorrhage during or after treatment.

Endovascular treatment of cerebral aneurysm remnants following prior surgical clipping can be accomplished with acceptable morbidity and mortality rates. Endovascular coil occlusion can play an important adjunctive role in the treatment of those aneurysms that have been incompletely obliterated by surgical clipping.

KEY WORDS • cerebral aneurysm • endovascular therapy • detachable coil • surgery • complications

The goal of cerebral aneurysm clipping is complete obliteration and exclusion of the entire aneurysm from the arterial circulation. Previous reports have documented that postoperative aneurysm remnants may be the result of technical or anatomical difficulties associated with initial clip placement, slippage of a placed clip, or regrowth of an aneurysm sac from an incompletely excluded aneurysm neck. The danger of hemorrhage persists if the aneurysm is not completely excluded from the circulation. Previous reports have advocated repeated open surgery to exclude aneurysm remnants of significant size identified following clipping. Such procedures are often technically difficult and may carry an increased risk of complications. These factors, in conjunction with the recent technological advances using electrolytically detachable coils, have prompted the exploration of endovascular strategies to treat major residual aneurysm rests that persist after clipping. Recent reports have documented promising initial outcomes using electrolytically detachable platinum coils for the treatment of cerebral aneurysms. We report our experience using electrolytically detachable platinum coils for the treatment of residual aneurysms in a small series of surgically treated patients at a single institution.

Clinical Material and Methods

Between October 1991 and November 1996, eight patients with residual aneurysm rests following surgical clipping were treated endovascularly with electrolytically detachable platinum coils (Table 1). The patients included four men and four women ranging in age from 25 to 65 years. All patients were referred for endovascular treatment by experienced cerebrovascular neurosurgeons at our institution. Five of the eight patients (Cases 3–7) were referred for further treatment because of a history of subarachnoid hemorrhage (SAH) related to the aneurysm. Each of the five patients in this group bore a significant risk for recurrent SAH. Two patients (Cases 1 and 8) demonstrated progressive enlargement of their aneurysm remnant. In the remaining patient (Case 2) a large remnant was identified on the postoperative angiogram, which prompted further treatment. Two patients (Cases 7 and 8) underwent clipping at another hospital and were subsequently referred to our institution for treatment.

There were six anterior and two posterior circulation cerebral aneurysm remnants. One patient was treated 3 weeks after surgical clipping; three were treated 6 to 10 months after the initial surgery; and four were treated to 15 years after the aneurysm surgery. Five of the patients originally presented to the neurosurgical service with SAH. Of the three patients without SAH, one (Case 1) presented with a right eye visual field defect secondary to mass effect from a distal right internal carotid artery (ICA) giant aneurysm. One patient (Case 2) had four aneurysms and presented with visual complaints related to a giant distal right ICA aneurysm while the aneurysm originating...
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### Results

#### Angiographic Occlusion

Five of the eight patients underwent follow-up cerebral angiography at least 1 year after their initial treatment. One patient (Case 6) underwent immediate as well as 3-week and 6-month posttreatment angiographic studies. A second patient (Case 7) underwent only immediate posttreatment angiography. The third patient (Case 8) underwent immediate as well as 1- and 7-week posttreatment angiographic studies. The most recent follow-up angiogram was used to determine the percentage of occlusion of the aneurysm remnant. An aneurysm remnant was determined to be 100% occluded if there was no opacification of the fundus, body, and neck on any angiographic projection. An aneurysm remnant was described as having “near-complete occlusion” if there was opacification of a tiny neck remnant on one or more projections and if the neck remnant was not amenable to further endovascular treatment. On the most recent angiograms, six of the eight aneurysm remnants were 100% occluded, and two rem-

### Summary of clinical characteristics in eight patients with residual aneurysms treated with detachable coil embolization*

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Aneurysm Location</th>
<th>Initial Aneurysm Size (mm)</th>
<th>Final Size of Residual Aneurysm (mm)</th>
<th>Initial Presentation†</th>
<th>Second Presentation</th>
<th>Interval to Endovascular Treatment</th>
<th>No. of Treatment Sessions</th>
<th>% Occlusion on Last Angio</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25, F</td>
<td>paracanoid ICA</td>
<td>35</td>
<td>10</td>
<td>mass effect, cranial nerve palsy, HA (0)</td>
<td>remnant growth on sequential postop angio</td>
<td>7 mos</td>
<td>1</td>
<td>100</td>
<td>good</td>
</tr>
<tr>
<td>2</td>
<td>52, M</td>
<td>ICA, AChA origin</td>
<td>6</td>
<td>5</td>
<td>mass effect from a different aneurysm (0)</td>
<td>postop angio</td>
<td>10 mos</td>
<td>3</td>
<td>100</td>
<td>good</td>
</tr>
<tr>
<td>3</td>
<td>46, M</td>
<td>PCA, vertebrobasilar junction</td>
<td>7</td>
<td>5</td>
<td>SAH (IV)</td>
<td>postop angio</td>
<td>10 mos</td>
<td>3</td>
<td>100</td>
<td>good</td>
</tr>
<tr>
<td>4</td>
<td>39, F</td>
<td>PCA</td>
<td>7</td>
<td>8</td>
<td>SAH (I)</td>
<td>remnant growth on sequential postop angio</td>
<td>8 yrs</td>
<td>2</td>
<td>NC</td>
<td>good</td>
</tr>
<tr>
<td>5</td>
<td>46, F</td>
<td>basilar apex</td>
<td>10</td>
<td>7</td>
<td>SAH (I)</td>
<td>transient ischemic attack</td>
<td>11.5 yrs</td>
<td>1</td>
<td>100</td>
<td>good</td>
</tr>
<tr>
<td>6</td>
<td>65, M</td>
<td>ACoA</td>
<td>10</td>
<td>8</td>
<td>SAH (II)</td>
<td>CT scan for HAs</td>
<td>10 yrs</td>
<td>1</td>
<td>100</td>
<td>good</td>
</tr>
<tr>
<td>7</td>
<td>43, F</td>
<td>ACoA</td>
<td>unknown</td>
<td>7</td>
<td>SAH (unknown)</td>
<td>neurological evaluation for deficits from prior SAH</td>
<td>14.5 yrs</td>
<td>1</td>
<td>100</td>
<td>good</td>
</tr>
<tr>
<td>8</td>
<td>30, M</td>
<td>ICA bifurcation</td>
<td>14</td>
<td>14</td>
<td>mass effect (0)</td>
<td>postop angio w/ remnant growth on later CT scan</td>
<td>7 mos</td>
<td>2</td>
<td>NC</td>
<td>good</td>
</tr>
</tbody>
</table>

*Angio = angiogram; HA = headache; NC = near-complete occlusion.
†Numbers in parentheses indicate the grade according to the Hunt and Hess scale.

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from the left anterior choroidal artery (AChA) and included in this study was asymptomatic. The third patient in the non-SAH group (Case 8) presented with left facial pain secondary to mass effect from a left ICA bifurcation aneurysm. No patient experienced hemorrhaging in the interval between surgical clipping and endovascular treatment.

The aneurysm rests ranged from 5 to 14 mm in maximum diameter at the time of endovascular treatment. Postoperative angiographic studies were obtained in four patients in the period immediately following surgical clipping. All four of these studies demonstrated residual unobliterated portions of the clipped aneurysm. One of these aneurysm remnants was immediately treated with endovascular coils. The remaining three aneurysm remnants, along with a fourth remnant that was discovered on angiograms obtained 6 weeks after clipping, were followed over time with serial cerebral angiography. All four aneurysm remnants slowly enlarged, prompting endovascular treatment. Each of our eight cases was determined to represent a residual sac as opposed to recanalization of a completely obliterated aneurysm.

We defined an aneurysm neck remnant as wide if it measured more than 4 mm in diameter or if the ratio of the diameter of the residual aneurysm sac to the diameter of the residual aneurysm neck was less than 3:1. An aneurysm remnant was also considered to have a wide neck if the origin of one of the adjacent vessels was incorporated into the neck of the aneurysm. By these criteria, five of the eight aneurysm remnants were considered to have narrow necks. One patient (Case 4) had a wide-necked vertebrobasilar junction aneurysm remnant associated with a basilar artery (BA) fenestration. A second patient (Case 5) had a wide-necked BA caput aneurysm remnant that partially incorporated the origin of the left posterior cerebral artery. The third patient (Case 8) had a wide-necked left ICA bifurcation aneurysm that incorporated the origins of the left anterior cerebral artery (ACA) and an anomalous left inferior temporal artery. The left middle cerebral artery (MCA) was occluded during the initial clipping.

All procedures were performed in a dedicated interventional angiographic suite with biplane fluoroscopy, digital subtraction angiography, and roadmaping capabilities. Procedures were performed while patients were undergoing systemic anticoagulation and receiving either general or neuroleptic analgesia. Catheterization of the aneurysms was achieved using either Tracker-10 or Tracker-18 microcatheters (Target Therapeutics, Inc., Fremont, CA). The residual aneurysm remnants were occluded with either 0.010- or 0.015-in diameter Guglielmi detachable coils (GDCs) (Target Therapeutics) of various lengths and helical diameters.

Angiographic follow-up studies were obtained immediately after endovascular treatment in all eight patients. Seven of the eight patients underwent additional follow-up angiography at times ranging from 7 weeks to 2 years posttreatment (mean follow-up period 11.8 months).
nants were described as having near-complete occlusion. The two aneurysms that achieved near-complete occlusion each had a wide neck.

Number of Treatments

Five of the eight aneurysm remnants were treated in one session. Of those requiring more than one session, one of the aneurysm remnants (Case 4) had a wide neck and required a second treatment session when coil compaction was noted on follow-up angiography. The aneurysm remnant in Case 2 could not be treated with coils during the initial endovascular treatment session, but was successfully treated 10 months later during a second attempt at coil placement. The patient then required a third treatment session in which an attempt was made to occlude a small neck remnant. An additional coil could not be placed in the residual remnant, but later follow-up angiography demonstrated 100% occlusion with spontaneous thrombosis of the neck remnant. The third aneurysm remnant (Case 8) could not be treated with coils during the initial endovascular treatment session because of transient aphasia and right upper-extremity paresis. The aneurysm remnant was successfully treated the following day during a second attempt at coil placement.

Aneurysm Hemorrhage During or After Endovascular Treatment

There were no instances of aneurysm rerupture during or after endovascular treatment (range 1 week–63 months, mean 28 months).

Clinical Follow-Up Review

Six of the eight patients were neurologically asymptomatic at the time of endovascular treatment. One patient (Case 3) had persistent aphasia and right hemiparesis as a result of the original SAH. One patient (Case 1) had a persistent visual field deficit secondary to mass effect caused by the aneurysm; this deficit improved after endovascular treatment. The neurological status of seven patients was unchanged on their latest clinical follow-up examination after endovascular treatment (range 1 week–24 months, mean 12 months).

Treatment-Related Morbidity and Mortality Rates

There were no serious treatment-related complications. One patient (Case 2) had a transient aphasia that completely resolved during an initial endovascular treatment session in which the left AChA origin aneurysm remnant could not be treated. This aneurysm remnant was successfully treated with GDCs 10 months later. A second patient (Case 5) had three 10-minute episodes of left-sided face and body numbness in the 1st month following endovascular treatment of a BA caput aneurysm remnant that were consistent with transient ischemic attacks. This patient had had no additional episodes as of her 10-month clinical follow-up examination. A third patient (Case 6) had a 45-

Fig. 1. Case 3. A: Lateral left ICA cerebral angiogram demonstrating a 7-mm aneurysm at the left PCoA origin (arrow). B and C: Lateral and oblique left common carotid cerebral angiogram demonstrating a 5 × 3-mm aneurysm remnant at the PCoA origin (arrows) located medial to the previously placed clip. In addition, the proximal MCA and ACA are narrowed secondary to vasospasm. D: Immediate follow-up lateral left ICA cerebral angiogram after endovascular occlusion demonstrating near-complete occlusion of the aneurysm remnant (arrow) with only a small amount of stagnant contrast within the neck. E and F: One year after endovascular treatment, follow-up lateral and oblique ICA cerebral angiograms demonstrate persistent complete occlusion of the aneurysm remnant (arrow).
minute episode of left-sided face and body numbness 6 weeks after endovascular treatment of an anterior communicating artery (ACoA) aneurysm remnant. The relationship of this single episode to the endovascular treatment was undetermined. A fourth patient (Case 8) had a transient aphasia and right upper-extremity paresis that completely resolved during an initial endovascular treatment session in which the left ICA bifurcation aneurysm remnant could not be treated. The aneurysm was successfully treated on the following day during a second attempt at coil placement. There were no deaths or poor functional outcomes. Therefore, in this group of eight patients, there was a 0% incidence of treatment-related permanent serious neurological morbidity and a 0% incidence of treatment-related mortality.

Illustrative Cases

Case 3

This 46-year-old man presented with an acute SAH that measured Grade IV on the Hunt and Hess scale and was secondary to a ruptured left ICA aneurysm arising near the left posterior communicating artery (PCoA) origin. Left carotid cerebral angiography performed at another institution demonstrated a 7-mm diameter left ICA aneurysm projecting posterolaterally and arising near the left PCoA origin (Fig. 1A). The patient was immediately transferred to our institution, where he underwent clipping of the aneurysm 48 hours after the initial SAH. Emergency cerebral angiography (Fig. 1B and C) performed because of declining neurological status 10 days after clipping demonstrated a 5-mm residual aneurysm remnant located medial to the aneurysm clip along with changes of vasospasm involving the proximal left MCA and ACA. The patient was then referred for possible endovascular treatment because of the size and location of the aneurysm remnant as well as the patient’s clinical status, which included suspected delayed ischemia of vasospasm. The aneurysm was treated with two GDCs measuring a total length of 12 cm. Immediate follow-up angiography (Fig. 1D) demonstrated near-complete occlusion of the aneurysm remnant with only a small amount of stagnant contrast within its neck. Follow-up angiographic studies obtained 3 months and 1 year later (Fig. 1E and F) confirmed complete occlusion of the aneurysm remnant. Fifteen months after endovascular treatment the patient displayed a residual aphasia as a sequela of the initial hemorrhage.

Case 6

This 55-year-old man first presented with an acute SAH of Hunt and Hess Grade II secondary to a ruptured multilobulated saccular ACoA aneurysm. The aneurysm was directed anteriorly and to the right and was identified on angiograms obtained 7 days after the initial hemorrhage. The lesion was clipped 8 days after the initial hemorrhage. The patient’s postoperative course was uneventful and he made a complete recovery. Postoperative angiographic studies were not obtained. The patient did well for 10 years; however, he then developed severe headaches that persisted for 1 month before he sought medical attention. The head discomfort was thought to be nonspecific and not indicative of SAH. A computerized tomography (CT) scan of the head was obtained and indicated a recurrent aneurysm of the ACoA. Angiography demonstrated an 8-mm diameter recurrent saccular aneurysm of the ACoA that was adjacent to the previously placed clip (Fig. 2A and B). The aneurysm was treated with four GDCs measuring a total length of 40 cm. Immediate follow-up angiography demonstrated only a small amount of stagnant contrast within the interstices of the coil mass (Fig. 2C). Follow-up angiograms obtained 3 weeks later demonstrated complete occlusion of the aneurysm (Fig. 2D).

Discussion

Surgical clipping of the neck of an aneurysm is currently the treatment of choice for symptomatic cerebral aneurysms. The goal of clipping is to obliterate the aneurysm completely and isolate the entire lesion from the arterial circulation. Previous reports have documented that aneurysm remnants may persist following clipping at a rate estimated at approximately 4%. In certain cases, these aneurysm remnants may be unavoidable
because of the aneurysm’s configuration or location. In other cases aneurysm remnants may be identified unexpectedly on immediate postoperative angiography or even many years postsurgery. Although a partially clipped aneurysm may carry a decreased risk of a subsequent SAH, the risk is not eliminated. Previous reports have described the significant risk of recurrent SAH associated with residual or recurrent aneurysm remnants following clipping.14–16 In a series of 329 patients, Drake and colleagues17 identified 43 residual aneurysms of which 12 were responsible for rebleeding. They advocated that repeated surgery be performed to obliterate the aneurysm remnant completely. Giannotta and Litofsky18 reported on 19 patients with aneurysm remnants requiring reoperation. Five of those with aneurysm remnants presented with recurrent SAH, whereas six of them presented with symptoms of mass effect. Furthermore, the average time interval from initial clipping to recurrent SAH was 10.5 years and 9.75 years for symptoms caused by mass effect. Feuerberg and colleagues6 reported that the incidence of rebleeding from an aneurysm rest was 3.7%, with up to a 0.79% per year risk of rupture. Sato and Suzuki25 reported that small aneurysm remnants may spontaneously thrombose, but progressive enlargement of the aneurysm remnant is an indication for reoperation. Reports from the endovascular literature have similarly documented the potential for aneurysm remnants to enlarge or hemorrhage following incomplete endovascular treatment.8,9,18,26

The results of these prior reports must be weighed against the hazards associated with reoperation. Technical difficulties inherent in reoperation include dealing with the previously placed clip as well as scarring around the aneurysm.11 Drake and colleagues1 reported a surgical morbidity rate of 7% associated with reoperation. The potentially extensive lag time between initial treatment and manifestation of the consequences of an individual aneurysm remnant must be considered during the development of a treatment strategy. Each patient’s clinical scenario must be evaluated in conjunction with the specific anatomical details of the aneurysm remnant.

Since 1991 GDCs have been available for the treatment of intracranial aneurysms. The technical aspects of the GDC device have been previously described.14–16 Briefly, the GDC system allows controlled placement and detachment of soft platinum coils within the aneurysm sac. Numerous reports have documented the short-term efficacy and safety of the technique.12,13,15,22–24

We report our experience using electrolytically detachable coils for the treatment of eight patients with aneurysm remnants identified following previous clipping. On the latest follow-up angiogram, six of the eight aneurysm remnants were 100% occluded and two remnants were described as having near-complete occlusion; both of these had a wide neck. There were no serious treatment-related complications. Five of the eight aneurysm remnants were treated in a single session, one remnant required placement of a single additional coil during a second treatment session, and in one patient the aneurysm remnant did not accept an additional coil during a second treatment session but eventually completely thrombosed, as identified on follow-up angiography. The last aneurysm remnant was not treated with GDCs during the initial endovascular treatment session because of a transient neurological deficit, but GDCs were successfully placed in the remnant the following day. There has been no incidence of aneurysm rerupture during or following endovascular treatment (range 1 week–63 months, mean 28 months).

To our knowledge, there have been only three case reports addressing the endovascular coil treatment of residual aneurysms following clipping.7,10,21 These reports contained a total of five patients successfully treated with coil embolization of aneurysm remnants, and only three of these patients were treated with GDCs.7,10 The ability to treat cerebral aneurysms surgically following unsuccessful or incomplete endovascular treatment has been previously documented.17 We have demonstrated that prior clipping does not preclude subsequent endovascular treatment of an aneurysm remnant. Minor technical challenges may be encountered during the course of endovascular treatment of previously clipped aneurysms that are not encountered with previously untreated aneurysms. First, the configuration of the aneurysm remnant usually is not saccular and is more likely to have a straight or truncated side because of the previously placed clip. This configuration requires a judicious selection of coils. Second, previously placed metal aneurysm clips can make delineation of the neck of the aneurysm remnant more challenging. Nevertheless, every attempt must be made to identify the neck of the aneurysm remnant prior to placement and detachment of any electrolytically detachable coils to avoid inadvertent coil detachment in the parent artery.

Conclusions

Our experience using electrolytically detachable coils for the treatment of aneurysm remnants following clipping has been excellent. Procedural permanent morbidity and mortality rates with endovascular treatment of aneurysm remnants appear to be extremely low and were zero in this series. Inasmuch as the treatment of aneurysms with electrolytically detachable coils is a relatively recent development, long-term data are not yet available on the rate of rehemorrhage. If long-term effectiveness of endovascular coil occlusion is established, this therapy will play an important adjunctive role in the treatment of those aneurysms that have been surgically clipped but are incompletely obliterated.

References

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