Randomized Comparison of Guglielmi Detachable Coils and Cellulose Acetate Polymer for Treatment of Aneurysms in Dogs

R. Loch Macdonald, MD, PhD; Saied Mojtahedi, MD; Lydia Johns; Andrew Kowalczuk, BA

Background and Purpose—Endovascular treatments for aneurysms are being used more frequently in patients in the absence of a large body of information on their histopathological effects. This study determined the efficacy and histopathological effects of treatment of experimental aneurysms with Guglielmi detachable coils (GDC) or cellulose acetate polymer (CAP).

Methods—Fourteen dogs had 13 terminal and 30 sidewall aneurysms created with venous pouches sutured to the cervical carotid arteries. Two weeks later, dogs had angiography followed by randomization to no treatment (n=2) or to aneurysm occlusion with GDC (n=4) or CAP (n=6). Two months later, angiography was repeated, animals were killed, and aneurysms were excised, fixed, photographed, and examined by light and electron microscopy.

Results—Two dogs were excluded because of common carotid artery occlusion at 2-week angiography. There were 11 terminal and 16 sidewall aneurysms available for treatment. The rate of spontaneous thrombosis of untreated aneurysms was 0% (0/5). Treatment with GDC showed complete terminal and sidewall aneurysm obliteration rates of 33% (1/3) and 80% (4/5), respectively. Greater than 90% occlusion occurred in the remaining cases. There were no parent or branch artery occlusions. Treatment with CAP showed complete terminal and sidewall aneurysm obliteration rates of 20% (1/5) and 0% (0/5), respectively, and incomplete sidewall aneurysm obliteration in 1 of 5 cases. Aneurysms reformed at 2 months in 2 of 5 terminal and 1 of 5 sidewall cases. There were parent or branch artery occlusions with CAP in 2 and 4 cases, respectively. The rate of aneurysm occlusion was significantly lower and the rate of arterial occlusion significantly higher with CAP than with GDC (P<.05). Histopathology showed complete endothelialization across the orifice of the aneurysm successfully treated with CAP, whereas aneurysms treated with GDC were significantly more likely to show fresh or organizing thrombus without complete endothelialization (P<.05).

Conclusions—It is concluded that both treatments have limitations. Complete packing of aneurysms with GDC obliterates the aneurysm, but endothelialization does not always occur within 2 months. There are substantial problems with CAP. It is thrombogenic and carries a higher risk of causing arterial thrombosis. Even if an aneurysm is successfully obliterated initially with CAP, the CAP may disappear, leaving the aneurysm completely untreated. (Stroke. 1998;29:478-486.)

Key Words: aneurysm ■ animal models ■ embolization, therapeutic ■ endovascular therapy ■ subarachnoid hemorrhage ■ vasospasm

The conventional treatment for most cerebral aneurysms is surgical clipping. Another treatment is to fill the aneurysm from the inside with balloons, Guglielmi detachable coils (GDC), or other agents such as cellulose acetate polymer (CAP).1-6 These “endovascular” therapies have been associated with aneurysm recurrence rates that in some situations may be in excess of those noted after surgical clipping.1-8 Recurrence of an aneurysm may be due to lack of reconstitution of normal arterial wall by clipping or of an endothelial cell–covered surface supported by organized fibrous tissue plus the packing agent in the case of endovascular therapy. This implies the need for complete thrombosis and endothelialization after treatment with GDC or CAP. There are, however, few studies documenting the histopathological changes after endovascular treatment of aneurysms.3-9-17

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The goal of this study was to determine angiographic occlusion rates and histopathological changes after treatment of aneurysms with GDC or CAP. A model of aneurysms in dogs was used because these aneurysms approximate the sizes seen in humans, and aneurysms with different types of hemodynamic stresses can be created.17-19

Materials and Methods

Protocol

All procedures on animals were performed with approval from the Institutional Animal Care and Use Committee. Fourteen mongrel dogs weighing between 11 and 18 kg had 13 terminal and 30 sidewall aneurysms created on the cervical carotid arteries with the use of venous...
pouches obtained from the external jugular vein.18 Two weeks after aneurysm creation, angiography was performed, and dogs were randomly allocated to a control group or to undergo endovascular treatment with either CAP (n=6) or GDC (n=4). Two months after endovascular treatment, animals underwent angiography, euthanasia, and examination of the aneurysms by light and electron microscopy.

Creation of Aneurysms
Dogs were anesthetized with intravenous thiopental sodium (10 to 20 mg/kg) and intubated and ventilated on O2 with isoflurane (0.5% to 3%). Atropine (0.04 mg/kg) was given intravenously. End-tidal CO2, heart rate, and respiratory rate were monitored continuously (Criticon Dinamap Research Monitor, Criticon). The anterior neck was prepared and draped in sterile fashion, and bilateral longitudinal incisions were made along the anterior borders of the sternomastoid muscles. Both carotid arteries and the right external jugular vein were exposed. A 6-cm length of jugular vein was removed and used to create the aneurysms. Aneurysm construction then proceeded under temporary carotid occlusion with atrumatic vascular clamps without systemic heparinization. The aneurysm orifices all approximated 5 mm in diameter because the orifices were made with 5-mm vascular punches. Sidewall aneurysms were created by sewing the venous sac to the carotid artery at a right angle, making an aneurysm similar to an internal carotid–posterior communicating artery aneurysm. In one dog, four sidewall-type aneurysms were created by making 5-mm round openings in the carotid arteries and sewing segments of jugular vein to the openings with 6-0 monofilament nylon suture with standard vascular anastomosis techniques. In the remaining 15 dogs, the left carotid artery was ligated caudally in the neck. The right carotid artery was divided in the midportion of the neck. The distal left carotid artery was mobilized and routed under the trachea and esophagus and anastomosed to the rostral right carotid artery.19 The caudal right carotid artery was then anastomosed to the caudal side of the loop created between the rostral carotid arteres. A terminal aneurysm was created by sewing a venous sac onto an orifice on the rostral side created immediately opposite the anastomosis of the right carotid artery with the loop (Fig 1). The terminal aneurysm had a configuration similar to a basilar apex or carotid termination aneurysm. Each side arm of the loop, consisting of the rostral right and left carotid arteries, was then used for a sidewall-type aneurysm. All anastomoses were made under magnification with the use of running 6-0 or 7-0 monofilament nylon sutures and standard vascular surgical techniques. Wounds were closed in multiple layers with interrupted absorbable sutures to prevent seroma formation. The skin was closed with interrupted monofilament nylon sutures.

Treatment of Aneurysms
Two weeks after aneurysm creation, an angiogram was performed by a transfemoral route with the animals under general anesthesia as described above. First, the left femoral artery was cannulated with the use of sterile technique, and a 5F catheter was advanced into the proximal right carotid artery. An angiogram of the carotid system and the aneurysms was obtained by manual injection of 5 to 10 mL iohexol meglumine. Magnification and exposure factors were constant throughout the experiment, and a magnification standard was included in each radiograph. Radiography was performed with the use of a digital subtraction angiography machine for aneurysm treatment and with a fluoroscopic system for other angiograms. Once aneurysms were identified, dogs were randomly allocated to remain untreated or to undergo treatment with either CAP or GDC. The GDC system was the Tracker-18-based system (Target Therapeutics, Inc) that is used clinically.17 As indicated above, an angiogram was first obtained through a nontapered 5F catheter inserted transfemorally into the common carotid artery proximal to the aneurysms. A Tracker-18 microcatheter was introduced through the guiding catheter and advanced under fluoroscopic control with road mapping until the tip was within the aneurysm to be treated. Continuous flushing of both the 5F guiding and the microcatheter was performed with heparinized physiological saline (0.9% NaCl with 1000 U heparin per liter). The size of the aneurysm was estimated along three orthogonal axes with the use of a radiopaque standard of known size. Coils of an appropriate size were selected and introduced into the microcatheter and advanced into the aneurysm. The first coil was selected to be equal to the diameter of the aneurysm so that it would fill the outermost portions of the aneurysm and span completely across the neck of the aneurysm. Coil placement was performed under fluoroscopic control. After achievement of proper positioning of a coil, the radiopaque marker was aligned with the marker on the microcatheter, and the coil was electrically detached. Additional coils were placed as necessary until there was > 90% obliteration of the aneurysm, as assessed by multiple angiographic views.

For treatment with CAP, a 7F guiding catheter was placed in the common carotid artery proximal to the aneurysms. A pretreatment angiogram was obtained. Next, a Tracker-18 catheter was advanced through the guiding catheter into the aneurysm that was selected for treatment, as described by Mandai and colleagues.15 Continuous flushing of both the guiding and the microcatheter was performed with heparinized physiological saline as described above. The size of the aneurysm was estimated along three orthogonal axes with the use of a radiopaque standard of known size. The contralateral femoral artery was exposed under sterile conditions and a balloon catheter (Interventional Therapeutics Corp) was advanced into the common carotid artery until it was positioned across the neck of the aneurysm to be treated. The balloon catheter was inflated, and the aneurysm was injected with contrast to estimate its volume and to confirm reduced flow into the aneurysm. A mixture of 250 mg cellulose acetate polymer, 3 mL dimethyl sulfoxide, and 900 mg bismuth trioxide (radiopaque marker) of a volume equivalent to the aneurysm was injected into the aneurysm and allowed to set for 5 to 10 minutes. The occluding balloon was deflated, and the balloon and microcatheters were removed. CAP is not adhesive, and the catheters do not become glued in place, although the dimethyl sulfoxide dissolved the hub of the microcatheter so that injection of the CAP had to be done rapidly. After all aneurysm treatments, repeated angiograms were obtained to assess the results. All catheters were removed, the femoral artery was ligated, and the dogs were allowed to recover.

2-Month Angiography and Histopathology
Two months later, dogs were anesthetized, and an angiogram was performed by the transfemoral route as described above. The right carotid artery was then exposed, cannulated, and perfused at physiological blood pressure with 0.9% NaCl followed by 10% buffered formalin. Animals were killed by exsanguination under general anesthesia. The aneurysm complex was carefully dissected, placed in 10% buffered formalin until adequately fixed, and then opened and photographed extensively to document the gross appearance of the aneurysms. The brain was removed, fixed in 10% buffered formalin,
and sectioned in the coronal plane. Aneurysm specimens were processed for light and scanning electron microscopy. For aneurysms treated with coils, specimens were transferred to 2% paraformaldehyde/2% glutaraldehyde fixative solution until processing. They were postfixed for 1 hour in 1% OsO4 in phosphate buffer, dehydrated in a graded series of ethanol solutions, embedded in Epon 812, and sectioned to 10-μm thickness with a carbide knife. They were stained with toluidine blue and viewed under a light microscope. Some aneurysms treated with coils were processed for scanning electron microscopy by dehydration in ethanol and hexamethyldisilazane, drying, mounting on aluminum stubs, and sputter coating with platinum. They were examined under a scanning electron microscope. All other specimens were embedded in paraffin, sectioned, and stained with hematoxylin and eosin.

### Data Analysis

For assessing treatment effects, we calculated rates of aneurysm thrombosis or occlusion and of parent or branch artery thrombosis using the number from the 2-week angiogram and not from the actual number of aneurysms created. Successful aneurysm treatment was considered to be 90% aneurysm obliteration at 2 months. Comparisons between treatment groups were made by \( \chi^2 \) or Fisher exact test. \( P, .05 \) was taken as significant.

### Results

#### Initial Thrombosis Rates

Angiography 2 weeks after aneurysm creation showed terminal aneurysms in 11 of 13 cases (85% patency) (Table 1). In the other 2 cases, the right carotid artery was occluded with no distal filling. This accounted for 4 sidewall aneurysms that were not visible. Of the 30 sidewall aneurysms created, an additional 10 were partially or completely thrombosed at 2 weeks (overall 16/30 patent or 53% patency). The number of patent aneurysms at 2 weeks was used as the baseline from which to calculate treatment effects described below.

#### Angiography

If an aneurysm was filling on angiography 2 weeks after creation, then it was always present 2 months later (Tables 1 and 2). Five terminal aneurysms were treated with CAP. After 2 months, 1 remained obliterated, 2 had completely reformed, and 2 carotid arteries were occluded completely. In the 2 aneurysms from which CAP disappeared and the aneurysm reformed (Fig 2), a thin rim of contrast dye was visible around the CAP within the aneurysm. Further CAP was not administered for fear of inducing the second problem that was observed, which was arterial thrombosis (Fig 3). Overfilling of the aneurysm with formation of CAP in the branch arteries was associated with the 2 carotid artery occlusions. For the 6 sidewall aneurysms treated with CAP, 2 had reformed after 2 months. The remaining 4 were associated with parent artery thromboses, 1 case being where the terminal aneurysm treated with CAP thrombosed the parent artery.

Treatment of 3 terminal aneurysms with GDC resulted in 100% occlusion in 1 and 90% occlusion in the remaining 2 (Fig 4). The 5 sidewall aneurysms treated with GDC were 100% occluded in 4 cases and 90% occluded in 1. There were no parent or branch artery occlusions.

Statistical analysis confirmed the observations that there was significantly more likely to be failure of successful aneurysm treatment and significantly more likely to be a parent or branch artery occlusion with CAP than with GDC (\( P, .05 \)).

#### Histopathology

In untreated control aneurysms, an endothelial cell–lined sac was observed that had features of normal jugular vein and that was considerably thicker than the wall of an intracranial saccular aneurysm. No abnormalities were observed in the brains of these dogs. In aneurysms treated with CAP that had reformed after 2 months, the appearance of the aneurysm was

<table>
<thead>
<tr>
<th>TABLE 1. Results of Angiography for Each Group</th>
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<td><strong>Group</strong></td>
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<tr>
<td></td>
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<tr>
<td>Control</td>
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<tr>
<td>CAP</td>
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<td>GDC</td>
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CAP indicates cellulose acetate polymer; GDC, Guglielmi detachable coils.

* One 100% occluded, two 90% occluded.
† Four 100% occluded, one 90% occluded.

### TABLE 2. Rate of Complete Obliteration of Aneurysms and of Arterial Occlusions at 2 Months in Dogs

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>GDC</th>
<th>CAP</th>
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</thead>
<tbody>
<tr>
<td>Complete occlusion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sidewall</td>
<td>0/3 (0)</td>
<td>4/5 (80)</td>
<td>0/5 (0)*</td>
</tr>
<tr>
<td>Terminal</td>
<td>0/2 (0)</td>
<td>1/3 (33)</td>
<td>1/5 (20)</td>
</tr>
<tr>
<td>Parent/branch artery occlusion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sidewall</td>
<td>0/6 (0)</td>
<td>0/10 (0)</td>
<td>6/15 (40)*</td>
</tr>
<tr>
<td>Terminal</td>
<td>0/6 (0)</td>
<td>0/12 (0)</td>
<td>8/10 (80)*</td>
</tr>
<tr>
<td>Aneurysm reforming</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sidewall</td>
<td>–</td>
<td>0/5 (0)</td>
<td>1/5 (20)*</td>
</tr>
<tr>
<td>Terminal</td>
<td>–</td>
<td>0/3 (0)</td>
<td>2/5 (40)*</td>
</tr>
</tbody>
</table>

GDC indicates Guglielmi detachable coils; CAP, cellulose acetate polymer. Values in parentheses are percentages.

* \( P, .05 \) compared with GDC.
similar to that of an untreated aneurysm with an endothelial cell–lined sac. In one case there was some residual CAP within the aneurysm. The aneurysm successfully treated with CAP showed a complete endothelial cell layer across the orifice of the aneurysm (Fig 5). The CAP was infiltrated with inflammatory cells and cells that appeared to be fibroblasts. There were occasional giant cells. There was one small penetrating artery territory infarction in the brain of a CAP-treated animal. This was months old at the time of euthanasia and had been asymptomatic during life. No CAP was seen in brain arteries.

Two histopathological patterns were observed in aneurysms treated with GDC. The first pattern was exhibited by 2 of 3 terminal (67%) and 3 of 5 sidewall (60%) aneurysms. These aneurysms were completely filled with a solid mass of fibrous tissue that on histopathological examination appeared to be fibroblasts with collagen and connective tissue. There was minimal or no inflammatory cell infiltrate with only occasional mononuclear white blood cells visible. The fibrous tissue was infiltrated by thin-walled capillaries. The fibrous tissue mass completely filled the aneurysm sac and engulfed the coils, filling

Figure 2. Angiograms of terminal and sidewall aneurysms before treatment (left) and immediately after cellulose acetate polymer (CAP) treatment, showing 90% obliteration (center). There is a thin rim of contrast between the terminal aneurysm and the CAP. Two months later (right), the CAP has disappeared and the aneurysm is filling again.

Figure 3. Angiograms of terminal and sidewall aneurysms before treatment (left) and immediately after treatment of the terminal aneurysm with cellulose acetate polymer (CAP) (center). There is overflow of CAP into the left branch artery. This resulted in complete carotid artery occlusion 2 months later (right).
the intersticies between the coil loops (Fig 6). In these aneurysms, there was a layer of endothelial cells covering the luminal side of the coils and the fibrous tissue mass where the latter was adjacent to the arterial lumen. The endothelial cell layer did not necessarily develop flush with the arterial wall but in most cases (2 of 3 terminal and 2 of 5 sidewall aneurysms) was up to several millimeters deep to the junction of the aneurysm with the arterial lumen, leaving a very small aneurysm remnant (Fig 7).

The remaining terminal (1 of 3) and sidewall (2 of 5) aneurysms exhibited the second histological pattern. Even though there did not appear to be contrast filling, these aneurysms on angiography and histopathological examination showed that the aneurysms were filled with coils and thrombus of varying ages (Fig 8). There was no organized fibrous tissue within the aneurysm. In these cases there was a slitlike cavity of varying size between the aneurysm wall and the coil and thrombus mass within the aneurysm. Unorganized thrombus of recent age was found around and in the coil mass. There was no endothelialization across the neck of these aneurysms. Thus, there was an association between endothelialization across the neck or orifice of the aneurysm and the formation of a presumably stable fibrous tissue mass within the aneurysm. Aneurysms with the first histopathological pattern above developed endothelial cells across the aneurysm orifice, whereas

Figure 4. Angiograms of terminal and two sidewall aneurysms before treatment (left), immediately after Guglielmi detachable coils treatment showing >90% obliteration in all aneurysms (center), and unchanged appearance 2 months later (right).

Figure 5. Gross photograph (left) of orifice and photomicrograph (right) of aneurysm filled with cellulose acetate polymer (CAP) 2 months earlier, showing a complete layer of endothelial cells across the neck of the aneurysm (arrows) with underlying CAP and fibrous tissue with giant cells (hematoxylin and eosin; bar = 50 μm).
aneurysms that were still filled with thrombus after 2 months did not endothelialize.

In all of the cases with the second histopathological pattern with fresh thrombus, there were coils protruding out of the aneurysm and into the residual aneurysm neck or arterial lumen. While it seemed that an aneurysm that was more tightly packed with coils on angiography was more likely to completely occlude and fill with fibrous tissue, this was not easily reconcilable with the histopathological findings that in some cases the aneurysm became completely filled with large masses of fibrous tissue despite a relative paucity of coils (Fig 7). On the other hand, the aneurysms with thrombus in them were never tightly packed with coils. In cases with fresh thrombus within the sac, angiography did not show aneurysm filling. In one completely obliterated terminal aneurysm treated with GDC, the coils eroded through the wall of the aneurysm and were visible in the loose connective tissue around the aneurysm (Fig 9). There were no brain lesions in animals treated with GDC. Complete endothelialization was statistically more likely to occur with GDC than with CAP (P<.05).

Discussion

These results show that aneurysm treatment with CAP has a higher likelihood of producing arterial thrombosis and a lower likelihood of obliterating the aneurysm than aneurysm treatment with GDC. If CAP is allowed to overflow into the feeding or branch artery, thrombosis of these arteries generally occurs. If it remains in the aneurysm, there is some chance of the CAP dissolving and the aneurysm reforming. This may be prevented by mixing the CAP with less dimethyl sulfoxide (H. Ohmoto, personal communication, March 1997). The problems with GDC tend to be the opposite. There were no arterial thromboses, despite the coils protruding into the arterial lumen to some extent in some cases. The aneurysm, however, only obliterated and filled with solid tissue approximately 63% of the time.

Previous studies of CAP have produced more favorable results. In two experimental studies, 29 sidewall aneurysms were able to be completely obliterated in dogs with a risk of arterial occlusion of approximately 13% and complete aneurysm obliteration in approximately 67%. Histologically,
endothelialization across the orifice of the aneurysm seemed to occur after about 3 weeks. Of 21 human aneurysms that have been treated, one regrew and bled after partial treatment. Of 21 human aneurysms that have been treated, one regrew and bled after partial treatment.6,20 This may be a phenomenon similar to the disappearance of CAP that we observed, although in the human case there appeared to still be CAP in the aneurysm when regrowth occurred. There also were two arterial occlusions from overflow of CAP into the parent or branch arteries. The present results suggest significant technical difficulties with the use of CAP, including dissolution of CAP and arterial occlusion. In fact, only one of 11 (9%) aneurysms was successfully treated with CAP. However, since it is believed that the goal of aneurysm endovascular treatment is to induce stable thrombus formation that will allow for ingrowth of fibrous tissue as a prerequisite to permanent aneurysm obliteration, CAP offers at least some theoretical advantages over less thrombogenic systems such as GDC. It is open to question whether this process will result in a reconstituted arterial wall that is as resistant to aneurysm regrowth as the wall that is reconstructed after surgical clip application.17

Previous studies reported findings with GDC that are similar to ours. In three reports, 40 sidewall experimental aneurysms were treated with GDC in pigs, dogs, or monkeys.11,14,16 Between 67% and 100% of aneurysms were completely obliterated angiographically and were filled with fibrous tissue covered by an endothelial cell layer after months. Graves and colleagues reported a 31% initial complete obliteration of experimental aneurysms in dogs and noted coil compaction in 85% of cases over 6 to 12 months.21 There were no complete arterial occlusions and 8% partial occlusions. Sidewall, terminal, and bifurcation-type aneurysms were studied, and this may have accounted for the lower success rate since the hemodynamics of terminal and bifurcation aneurysms render them more resistant to successful endovascular treatment. In a rabbit model of bifurcation aneurysms, 6 of 16 could be completely obliterated with GDC as judged by immediate posttreatment angiography, whereas only 4 appeared completely obliterated angiographically 3 to 6 months later.17 Histopathological examination of 8 of the 16 showed no endothelialization across the aneurysm orifice and fresh thrombus in the aneurysm.

Other types of coils have been studied less thoroughly, but the following conclusions have been drawn.3,10,12,22 The coil mass must be stable within the aneurysm. If it extends out of the aneurysm, there is a risk of artery thrombosis, although this depends on how thrombogenic the coils are. The GDC coils are not as thrombogenic as collagen-coated coils.22 A denser packing of the aneurysm with coils increases the chance of stable thrombosis, although it might be sufficient to pack an inflow area adequately.3,19 Sidewall aneurysms are more likely

Figure 8. Photograph of mouth of a sidewall aneurysm treated with Guglielmi detachable coils 2 months previously, showing protrusion of the coils into the arterial lumen, lack of endothelialization, and persistent fresh and poorly organized thrombus present in the aneurysm.

Figure 9. Angiogram of terminal and sidewall aneurysms immediately after treatment with Guglielmi detachable coils (left). Two months later angiography suggests that the coils protrude through the aneurysm (center), a finding confirmed on gross examination of the aneurysm (right).
than bifurcation or terminal aneurysms to thrombose and endothelialize with imperfect coil treatment.

It should be recognized that all experimental studies have used models of aneurysms that differ from human intracranial aneurysms. There are some differences in the coagulation system between dogs and humans. The hemodynamic properties of the terminal aneurysms used in this study, however, approximate those that might occur in humans. An important difference that has not been discussed previously is that the thick wall of experimental aneurysms may be able to supply a large number of fibroblasts and proliferating cells that can fill the aneurysm. This may be more than can proliferate to fill an intracranial human aneurysm. In the only cases in which histopathological findings were noted after GDC treatment of aneurysms in humans, there was only thrombus in aneurysms 2 and 6 months after treatment. These aneurysms, however, were giant and not as easy to obliterate as small aneurysms.

It is concluded that both treatments have limitations. Complete packing of aneurysms with GDC obliterates the aneurysm, but endothelialization does not always occur within 2 months. There are substantial problems with CAP. It is thrombogenic and carries a higher risk of causing arterial thrombosis. Even if an aneurysm is successfully obliterated initially with CAP, the CAP may disappear, leaving the aneurysm completely untreated.

Acknowledgments
This study was supported by a grant from the Illinois–Eastern Iowa Kiwanis Club and by grants from the National Institutes of Health to Dr Macdonald (RO8 NS01831) and Dr Weir (NS25946). Dr Macdonald is supported by an American College of Surgeons Faculty Fellowship and a Young Clinician Investigator Award from the American Association of Neurological Surgeons. We thank Target Therapeutics for supplying the Guglielmi detachable coils.

References

with coils protruding through the aneurysm wall in the clinical situation, as was shown to happen here under experimental conditions.

An important question is whether the inflow opening of the aneurysm will be covered with endothelium after endovascular treatment. This would prevent aneurysm regrowth at the neck and also would allow for safe partial extirpation of the aneurysm in case endovascular treatment would have occluded a giant aneurysm but not (completely) removed its mass effect. With GDC treatment this apparently occurs in somewhat more than 50% of the experimental and human cases; with angiographically successful treatment with CAP this percentage of endothelization appears to be higher, but of course the angiographic success rate is much lower.

Although in the United States the GDC is the only FDA-approved device for endovascular treatment of intracranial saccular aneurysms, the search for even better alternatives is still on. The accompanying article clearly gives a nod to GDC over CAP.

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Stroke. 1998;29:478-486
doi: 10.1161/01.STR.29.2.478

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