Long term follow-up of patients with coiled intracranial aneurysms
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Chapter 8

Intracranial aneurysms that repeatedly reopen over time after coiling: imaging characteristics and treatment outcome

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ABSTRACT

Background and Purpose: To report incidence, imaging- and clinical characteristics of patients with aneurysms that repeatedly reopened over time and were coiled three times or more during follow up of 2-11 years.

Methods: At angiographic follow up of 624 of 827 aneurysms coiled between 1995-2005, 74 aneurysms (8.9%) reopened and were additionally coiled. During extended follow up, 12 of these aneurysms (1.5%) in 12 patients repeatedly reopened and were repeatedly coiled. Initial aneurysm size ranged from 15-30 mm. Four aneurysms contained intraluminal thrombus. Eight aneurysms presented with SAH, two with mass effect and two were incidentally discovered. Location of aneurysms was basilar artery (8), carotid artery (2), anterior communicating artery (1) and middle cerebral artery (1).

Results: Altogether, 49 coil treatments were performed in the 12 aneurysms, ranging from 3-6 coil treatments per aneurysm. Reopening was by compaction in 9 aneurysms and by migration of coils into intraluminal thrombus in 3 aneurysms. In two aneurysms, late regrowth became apparent at 76 and 95 months after last coiling. Twenty of 49 coil treatments (41%) were performed with a supporting device. There were no procedural complications (0%, 97.5% CI 0-5.7%). Mean clinical follow up period was 70.6 months (median 60, range 25-135 months). All 12 patients are neurologically intact (GOS 5).

Conclusion: Aneurysms that reopen over time and need to be coiled for a second time should be imaged at regular intervals to detect repeated reopening or regrowth. A treatment strategy of regular follow up and additional treatments when necessary is effective and safe.
INTRODUCTION

Endovascular treatment with detachable coils has become the preferred treatment of both ruptured and unruptured intracranial aneurysms. 1-4 A drawback of coiling is the possibility of reopening of the aneurysm lumen over time, necessitating follow up angiography or MRA in all patients. 5 When reopening occurs, additional coiling or surgical treatment is indicated, since incompletely occluded aneurysms may bleed again. 4-6 Aneurysm reopening usually occurs within the first 6 months after coiling and the most important risk factors for reopening over time are large aneurysm size 5,7 and the presence of intraluminal thrombus. In our practise, aneurysms that have reopened at the 6 months follow up interval and are coiled for the second time, are monitored at regular intervals with angiography or MRA to detect possible repeated reopening or regrowth and additional treatment (additional coiling, surgery or parent vessel occlusion) is performed when necessary and possible. In this paper, we report the incidence, imaging- and clinical characteristics of patients with aneurysms that repeatedly reopened over time and were treated three times or more for the same aneurysm with emphasis on clinical outcome during extended follow up of 2-11 years.

METHODS

Between January 1995- January 2005, 827 aneurysms were coiled in 756 patients. Patients that survived the hospital admission period were scheduled for clinical follow up in the outpatient clinic at 6 weeks and for angiographic follow up at 6 and 18 months. Of 827 aneurysms, 624 (76%) had at least one follow up angiogram. Incomplete aneurysm occlusion at any point in time was considered an indication for further therapy (additional coiling, surgery or parent vessel occlusion) unless clinical or anatomical factors dictated otherwise. Clinical follow up was assessed according to the Glasgow Outcome Scale (GOS) at every outpatient clinic visit and at every admission for follow up angiography. Results and consequences of clinical and angiographic follow up were discussed in a weekly joint meeting of neuroradiologists, neurosurgeons and neurologists. Notes of the meeting were made by a secretary and implemented in the patient record. When appropriate, during the meeting a decision was made for the need for additional treatment or extended angiographic or MRA follow up. When additional coiling was performed, the result was evaluated in the weekly meeting and 6 months follow up angiography was scheduled. If aneurysm occlusion was stable at 6 months after additional coiling, extended follow up angiography or MRA was scheduled 1-2 years later. When reopening reoccurred, additional treatment was again considered and performed when judged necessary and possible. Of patients with aneurysms that repeatedly reopened after second coiling and were treated three times or more for the same aneurysm, clinical and imaging records were retrospectively reviewed. Imaging data (CT, MRI and angiography) were evaluated for aneurysmal size and location as well as the presence of partial thrombosis of the aneurysm lumen. Aneurysm reopening was classified as caused mainly by compaction (decrease in size of the coil mesh with unchanged size and shape of the aneurysm) or by migration of coils into intraluminal thrombus. If aneurysm growth was apparent during follow up, this growth was classified as gradual increase in size of the whole aneurysm or local regrowth.
47 year old woman (patient # 8) with an incidentally discovered, partially thrombosed basilar tip aneurysms coiled 6 times in a 6 year period.

A: MRI performed for headaches shows large, partially thrombosed and calcified basilar tip aneurysm with a wide neck.

B: initial angiogram before first coiling shows aneurysmal lumen

C: follow up angiogram 6 months after third coiling shows enlargement and reopening of the aneurysm.

D and E: subtracted (D) and unsubtracted (E) angiogram after sixth coiling demonstrates complete occlusion of the enlarged aneurysm.

F: MRI after sixth coiling illustrates aneurysm enlargement with compression of the brain stem. The patient is asymptomatic.
RESULTS

At angiographic follow up of 624 of 827 aneurysms, 74 aneurysms (8.9%) in 74 patients reopened and were additionally coiled. All 74 aneurysms had at least one follow up angiogram at 6 months after additional coiling. During extended follow up, 15 of 74 aneurysms that were coiled twice (2.4% of all 624 aneurysms with angiographic follow up and 20% of 74 aneurysms that were additionally coiled) repeatedly reopened and were treated for a third time. These patients are the subject of this study. Twelve of the 15 aneurysms in 12 patients were coiled three times or more and 3 aneurysms in 3 patients were additionally surgically treated. Patient- and aneurysm characteristics are summarized in Table 1.

There were 8 women and 7 men with a mean age of 49.2 years (range 38-66 years). Mean initial size of the aneurysms was 22.9 mm (median 23.5, range 15-30 mm). Four aneurysms were partially thrombosed. Eight aneurysms presented with SAH, two with symptoms of mass effect and two were incidentally discovered. Eight of 12 aneurysms were located on the basilar artery, two on the carotid artery, one on the anterior communicating artery and one on the middle cerebral artery. Seven wide necked aneurysms were coiled once or more with the aid of a supporting balloon (Sentry 15 mm, Boston Scientific, Fremont, CA) and one aneurysm with aid of a TriSpan device (Boston Scientific, Fremont, CA). Altogether, 49 coil treatments were performed in the 12 aneurysms: five aneurysms were coiled three times, two aneurysms four times, four aneurysms five times and one aneurysm six times. Twenty of 49 coil treatments (41%) were performed with a supporting device. In the two patients with (giant) aneurysms on the carotid artery, angiographic balloon test occlusion was performed (and not tolerated) before coiling. There were no procedural complications of coiling, carotid artery balloon test occlusions or follow up angiograms (complication rate 0%, 97.5% CI 0-5.7%).

Mean clinical follow up period was 70.6 months (median 60, range 25-135 months). All 12 patients are alive and neurologically intact (GOS 5) at the time of writing in July 2006. Symptoms of mass effect in two patients improved in both.

Mechanism of aneurysm reopening over time was mainly by compaction in 9 aneurysms and by migration of coils into intraluminal thrombus in 3 partial thrombosed aneurysms. Two aneurysms gradually increased in size over time (Figure 1 and 2). In two aneurysms, late regrowth of the aneurysm at the base near the inflow zone was apparent at 89 and 130 months after first coiling (Figure 3). None of the patients with aneurysms that enlarged had symptoms of mass effect.

Interval between coilings in the 12 patients is graphically displayed in Figure 1. Third coiling was performed at an interval of median 19.5 months (range 12-130 months) after first coiling. Shortest interval between coilings was 6 months and longest interval was 95 months.
DISCUSSION

In this study, we found that 1.5% of 827 intracranial aneurysms that were coiled in the period January 1995- January 2005 needed three or more coil treatments during a median follow up of five years. Incidence may probably rise in the years to follow since reopening after additional coiling may occur many years after first and second coiling. All aneurysms coiled three times or more were large or giant and most aneurysms were located on the basilar artery. Large or giant aneurysm size is a well known risk factor for the occurrence of compaction and reopening, since dense packing cannot be obtained in these aneurysms. The fact that most aneurysms were located on the basilar artery may be explained by our treatment strategy for large and giant aneurysms: when located on the carotid or vertebral artery, parent vessel occlusion, when tolerated, is the preferred therapy. Giant aneurysms on other locations are infrequent and may be treated with surgery. For large and giant aneurysms on the basilar artery however, coiling is the only treatment option with a low complication rate.

All 12 patients with repeatedly reopened and recoiled aneurysms do clinically well to date: although treatment of most aneurysms was challenging and many coil treatments needed the aid of a supporting device, no complications occurred in 51 treatments. Also all follow up angiograms were without complications. In our opinion, the treatment strategy of regular follow up and additional treatments when necessary is effective and safe in these large and difficult to treat aneurysms. Our patients tolerated the follow up and repeated treatments well, despite the fact that the aneurysm was never considered cured. With the availability of high resolution non- enhanced 3T MRA, we now follow all patients with MRA instead of angiography.

Most reopenings of aneurysms over time were caused by coil compaction and 3 of 4 partially thrombosed aneurysms repeatedly reopened by migration of the coil mesh into the thrombus. Two aneurysms showed, besides compaction, a gradual increase in size and another two aneurysms showed local regrowth at the base near the inflow zone many years after last coiling. Our data...
suggest that true aneurysm (re)growth during extended follow up is a rare phenomenon accounting for only 4 of 827 (0.5%) coiled aneurysms in our practice. Since proportion of aneurysms with long term imaging follow up in our practice is high, in combination with clinical follow up of nearly all patients, it is unlikely that other aneurysms with regrowth might have gone undetected. In a previous long term follow up study about late rebleeding after coiling in 393 of our patients, only one patient died of rebleeding (after refusal of third coiling) of a repeatedly reopened and enormously enlarged aneurysm. The findings of the present study indicate that aneurysms that reopen over time and need to be coiled for a second time, should be followed continuously with angiography or MRA at regular intervals (1-2 years), even when aneurysm occlusion is stable during some years. It seems safe to expand this follow up regimen to all large and giant aneurysms that have been coiled and to all large aneurysms that are partially thrombosed, since reopening rate in these aneurysms is higher than in other aneurysms. In previous studies, we have shown that aneurysms that are completely occluded at first coiling and remain stable after 6 months remain occluded at extended follow up and patients do clinically well the first years that follow. Currently, we are conducting a long term MRA follow up study in these patients to find out whether this stable occlusion at 6 months remains so at follow up of 5 years or more and preliminary results indicate indeed a stable occlusion. However, definite results have to be awaited.

**Figure 4**
Interval between coiling in 12 patients with aneurysms coiled three times or more during follow up.
CONCLUSION
Aneurysms that reopen over time and need to be coiled for a second time should be imaged at regular intervals to detect repeated reopening or regrowth. The treatment strategy of regular follow up and additional treatments when necessary is effective and safe.
Figure 3
39 year old man (patient # 5) with SAH from giant basilar tip aneurysm in 1996.
A: vertebral angiogram shows wide necked giant basilar tip aneurysm.
B: complete occlusion after first coiling.
C: follow up angiogram 6 months later demonstrates reopening at the base by compaction.
D: complete occlusion after second coiling
E: follow up angiogram 5.5 years after second coiling reveals regrowth at the base of the aneurysm near the inflow zone.
F: complete occlusion after third coiling
G: 27 months after third coiling repeated regrowth, note cranial migration of coil mesh of third coiling.
H and I: subtracted (H) and nonsubtracted (I) angiogram after fourth coiling shows again complete occlusion. The coil meshes of third and fourth coiling can be discerned separately.
REFERENCES


### Table 1
Patient- and aneurysm characteristics of 12 patients with aneurysms that repeatedly reopened over time and were coiled three times or more

<table>
<thead>
<tr>
<th>Patient #</th>
<th>gender and age</th>
<th>aneurysm location and size</th>
<th>partial thrombosis</th>
<th>clinical presentation</th>
<th>mechanism of reopening</th>
<th>additional coilings (months after 1st coiling)</th>
<th>additional surgery</th>
<th>growth</th>
<th>outcome (duration of follow up)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>F, 60</td>
<td>basilar trunk, 18 mm</td>
<td>yes</td>
<td>SAH</td>
<td>coil migration in thrombus</td>
<td>9, 17, 32, 77</td>
<td>no</td>
<td>no</td>
<td>no symptoms (90 mo)</td>
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<td>2</td>
<td>M, 50</td>
<td>MCA, 30 mm</td>
<td>yes</td>
<td>SAH</td>
<td>coil migration in thrombus</td>
<td>12, 23, 42</td>
<td>no</td>
<td>no</td>
<td>no symptoms (58 mo)</td>
</tr>
<tr>
<td>3</td>
<td>M, 32</td>
<td>basilar tip, 22 mm</td>
<td>no</td>
<td>SAH</td>
<td>compaction</td>
<td>12, 23, 52</td>
<td>no</td>
<td>no</td>
<td>no symptoms 60</td>
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<td>4</td>
<td>F, 38</td>
<td>basilar tip 18 mm</td>
<td>no</td>
<td>SAH</td>
<td>compaction, later regrowth</td>
<td>35, 130</td>
<td>late regrowth</td>
<td>no</td>
<td>no symptoms 135</td>
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<td>5</td>
<td>M, 39</td>
<td>basilar tip, 30 mm</td>
<td>no</td>
<td>SAH</td>
<td>compaction, later regrowth</td>
<td>13, 89, 116</td>
<td>late regrowth</td>
<td>no</td>
<td>no symptoms 121</td>
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<td>compaction</td>
<td>8, 22, 37, 51</td>
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<td>no</td>
<td>no symptoms 75</td>
</tr>
<tr>
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<td>AcomA, 15 mm</td>
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<td>SAH</td>
<td>compaction</td>
<td>9, 18</td>
<td>gradual growth</td>
<td>no</td>
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<td>8</td>
<td>F, 47</td>
<td>basilar tip, 26 mm</td>
<td>yes</td>
<td>incidental (TIA)</td>
<td>compaction</td>
<td>7, 17, 23, 42, 49</td>
<td>gradual growth</td>
<td>no</td>
<td>no symptoms 72</td>
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<tr>
<td>9</td>
<td>F, 43</td>
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<td>no</td>
<td>headaches</td>
<td>compaction</td>
<td>6, 16, 26, 63</td>
<td>no</td>
<td>no</td>
<td>no symptoms 78</td>
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<tr>
<td>10</td>
<td>F, 38</td>
<td>carotid hypophyseal, 25 mm</td>
<td>no</td>
<td>decreased vision</td>
<td>compaction</td>
<td>3, 12</td>
<td>no</td>
<td>no</td>
<td>no symptoms 30</td>
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<tr>
<td>11</td>
<td>F, 63</td>
<td>cavernous sinus, 25 mm</td>
<td>yes</td>
<td>ophthalmoplegia</td>
<td>coil migration in thrombus</td>
<td>6, 14</td>
<td>no</td>
<td>no</td>
<td>no symptoms 24</td>
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<tr>
<td>12</td>
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<td>basilar tip, 15 mm</td>
<td>no</td>
<td>SAH</td>
<td>compaction</td>
<td>9, 21</td>
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<td>no</td>
<td>no symptoms 55</td>
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<td>13</td>
<td>M, 45</td>
<td>carotid tip, 18 mm</td>
<td>no</td>
<td>SAH</td>
<td>compaction and regrowth</td>
<td>7 bypass ICA-M2 (16) bypass ACA-M2 (28) bypass ICA-M1 (12)</td>
<td>gradual growth</td>
<td>no</td>
<td>no symptoms (101)</td>
</tr>
<tr>
<td>14</td>
<td>F, 51</td>
<td>carotid tip, 15 mm</td>
<td>no</td>
<td>additional</td>
<td>compaction</td>
<td>7</td>
<td>no</td>
<td>died of complications of surgery at 13 mo</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>M, 62</td>
<td>AcomA, 22 mm</td>
<td>no</td>
<td>SAH</td>
<td>compaction</td>
<td>12 direct clipping (16)</td>
<td>no</td>
<td>cognitive impairment, short memory dysfunction (21 mo) died at 43 months of MI</td>
<td></td>
</tr>
</tbody>
</table>

F=female, M=male, MCA=middle cerebral artery, AcomA=anterior communicating artery, SAH=subarachnoid hemorrhage, TIA=transient ischemic attack, ICA=internal carotid artery, ACA=anterior cerebral artery, MI=myocardial infarction