New developments in imaging and treatment of intracranial aneurysms

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Chapter 5

Midterm clinical and magnetic resonance imaging follow-up of large and giant carotid artery aneurysms after therapeutic carotid artery occlusion

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ABSTRACT

OBJECTIVE
The purpose of this study was to evaluate aneurysm size and clinical symptoms midterm after therapeutic carotid artery occlusion in 39 patients with large or giant carotid artery aneurysms.

METHODS
Between January 1996 and August 2004, 39 patients with large or giant carotid artery aneurysms were treated with therapeutic carotid artery occlusion and had clinical and magnetic resonance imaging follow-up of at least 3 months (mean, 35.9 mo; median, 29 mo; range, 3–107 mo; 117 patient-yr). Initial clinical presentation was mass effect caused by the aneurysm in 32 (82%) of the 39 patients. Three patients presented with subarachnoid hemorrhage (SAH) and one presented with epistaxis; two aneurysms were an incidental finding and one was additional to another ruptured aneurysm.

RESULTS
There were no early or late complications of therapeutic carotid artery occlusion. All aneurysms seemed to have thrombosed completely after carotid artery occlusion as observed on early and late magnetic resonance imaging (MRI) and magnetic resonance angiographic (MRA) follow-up studies. At the time of the most recent MRI follow-up study, 29 (74%) of the 39 aneurysms involuted totally, two aneurysms decreased to 25% of the original diameter, two aneurysms decreased to 50%, and five aneurysms decreased to 75%. Two aneurysms remained unchanged in size after 49 and 58 months, respectively. At the most recent clinical follow-up evaluation, symptoms of mass effect were cured in 19 (60%), improved in 10 (31%), and remained unchanged in 3 (9%) of the 32 patients.

CONCLUSION
Therapeutic carotid artery occlusion was a simple, safe, and effective treatment for large and giant carotid artery aneurysms. Almost all aneurysms involute completely or substantially decrease in size. Alleviation of symptoms of mass effect was achieved in most patients.

KEY WORDS
Aneurysm, Follow-up, Magnetic resonance imaging, Therapeutic carotid artery occlusion
INTRODUCTION

Large and giant carotid artery aneurysms are located extradurally in the cavernous sinus or intradurally in its supraclinoid segments. Clinical presentation is usually with symptoms of mass effect on one or more of the adjacent cranial nerves (CN) II–VI resulting in diplopia, ophthalmoparesis, decreased visual acuity, trigeminal neuralgia, or a combination thereof. Rupture may result in SAH, carotid cavernous fistulae, or epistaxis, depending on aneurysm location.

For large and giant aneurysms of the internal carotid artery, therapeutic carotid artery balloon occlusion is a simple, safe, and effective therapy in patients who can tolerate sacrifice of the carotid artery. Tolerance to internal carotid artery occlusion can be evaluated reliably by angiographic test occlusion, even in patients under general anesthesia. The aim of therapeutic carotid artery occlusion is thrombosis of the internal carotid artery, including the aneurysm. In this study, we evaluated aneurysm size and clinical symptoms midterm after therapeutic carotid artery occlusion in 39 patients with large or giant carotid artery aneurysms.

PATIENTS AND METHODS

PATIENTS

Between January 1996 and August 2004, 52 patients were treated with carotid artery balloon occlusion for large or giant carotid aneurysms. Technical and clinical aspects of carotid artery occlusion in these patients have been published in previous articles. During the same period, another 26 patients with carotid artery aneurysms intended to be treated with carotid artery occlusion did not tolerate the test occlusion. Of these 26 patients, four with cavernous sinus aneurysms symptomatic only by abducens palsy were not treated at all. Seven patients had bypass surgery preceding carotid artery occlusion. Fifteen aneurysms were coiled, two of them after placement of a stent and six with the aid of a supporting balloon. In June 2005, a follow-up survey was completed by the 52 patients with aneurysms treated with carotid artery balloon occlusion without preceding bypass surgery. Eight patients died during the follow-up period: one patient died shortly after carotid occlusion of the initial SAH, one patient died of trauma, two elderly patients died in the hospital from pneumonia and multiple organ failure, one patient died in the hospital as a result of chronic obstructive pulmonary disease, one patient died of lung cancer, one patient died in the hospital from cardiac infarction, and one patient died at home of old age. None of these patients died as a result of SAH. Of the 44 surviving patients, seven could not be located in June 2005 but had previous follow-up data. The remaining 37 patients were contacted and asked to complete a phone questionnaire about the evolution of their clinical symptoms after carotid artery occlusion and their current state of health. Follow-up MRI and MRA on a 3.0 Tesla system (Philips Intera RIO; Philips Medical Systems, Best, The Netherlands) were offered to all 37 patients.
and were eventually performed in 26. Basic ophthalmological assessment was performed at the same time. Of the 11 patients who refused long-term MRI follow-up, the seven patients who could not be located, and the eight patients who had died, previous clinical and MRI follow-up data for 3 months or longer was available in the medical records of 13, allowing these patients to be included in the analysis. Thus, the final study group consisted of 39 patients with large or giant carotid artery aneurysms treated with therapeutic carotid artery occlusion and with clinical and MRI follow-up of at least 3 months (mean, 35.9 mo; median, 29 mo; range, 3–107 mo; 117 patient yr). There were 32 women and 7 men with a mean age of 56 years (range, 26–78 yr) at the time of carotid artery occlusion. The location of the large and giant carotid artery aneurysms was the carotid cavernous sinus in 28 of the patients, the carotid hypophyseal segment in four, the carotid ophthalmic segment in three, the carotid supraclinoid segment in three, and the internal carotid bifurcation in one.

The initial clinical presentation was mass effect caused by the aneurysm in 32 (82%) of the 39 patients. Oculomotor dysfunction with intact visual acuity was present in 27 patients with large or giant cavernous sinus aneurysms, including isolated abducens palsy in five patients and ophthalmoparesis in 22 patients (in two patients with additional trigeminal neuralgia). Decreased visual acuity was the presenting symptom in four patients with carotid ophthalmic or hypophyseal aneurysms; one patient with an internal carotid bifurcation aneurysm presented with hemiparesis. Retro-orbital pain accompanied symptoms of mass effect in 18 of the 32 patients. Three patients presented with SAH and were treated with carotid artery occlusion more than 3 weeks after SAH, two of them after initial coiling in the acute phase of SAH. One patient presented with epistaxis. Two aneurysms were an incidental finding and one aneurysm was additional to another ruptured aneurysm. Seven (18%) of the 39 aneurysms contained intraluminal thrombus at the time of presentation. The presence of intraluminal thrombus was assessed from both cross-sectional imaging and angiography. This study was approved by the ethical committees of both participating hospitals.

INITIAL AND FOLLOW-UP MRI PROTOCOL
In all 39 patients, MRI was performed before carotid artery occlusion. MRI was repeated 2 to 5 days after carotid artery occlusion and again 3 months later. Extended MRI follow-up (>3 mo) was performed in 35 of the 39 patients. MRI was performed on a 0.5-, 1.0-, or 1.5-Tesla system (Philips T5, T10, or T15; Philips Medical Systems) and consisted of transverse and coronal T1 weighted images and transverse T2 weighted images. In 26 patients, midterm MRI scanning was performed on a 3.0-Tesla system.

Initial and follow-up MRI studies were compared by two experienced neuroradiologists (WJvR, MS) in consensus. Thrombosis of the aneurysm after carotid artery occlusion was assessed by typical signal changes of the aneurysmal lumen on MRI scans over time, including loss of flow void and the appearance of T1-weighted hyperintensities (Fig. 1). Aneurysm diameter on follow-up MRI scans was categorized as 100, 75, 50, 25, or 0% of the initial
aneurysm diameter. Differences in aneurysm size reduction, dichotomized as 50% or more and less than 50%, were assessed for supraclinoidal aneurysms and cavernous sinus aneurysms. The evolution of clinical symptoms was categorized as worsened, unchanged, improved, or cured. All patients and their family physicians were informed regarding the imaging findings.

**STATISTICAL ANALYSIS**

Aneurysm size reduction for aneurysms with initial intraluminal thrombus was compared with size reduction of aneurysms without initial intraluminal thrombus using Fisher’s exact test. Differences in aneurysm size reduction, dichotomized as 50% or more and less than 50%, were compared for supraclinoidal aneurysms and cavernous sinus aneurysms using the $x^2$ test. In 32 patients, the relationship between aneurysm size reduction at the most recent follow-up examination and clinical symptoms of mass effect was assessed as follows: the proportion of aneurysms with almost complete obliteration (0 or 25% of the initial aneurysm diameter) was assessed for patients with clinical cure, for patients with improved symptoms, and for patients with unchanged symptoms. The $x^2$ test was used to identify statistical relations.
Fig 1. This 51-year-old woman presented with decreased visual acuity. A, bilateral internal carotid artery angiogram demonstrating a giant carotid ophthalmic aneurysm. B, coronal T1-weighted MRI scan obtained 5 days after left internal carotid artery balloon occlusion showing complete aneurysm thrombosis. Note the mass effect on the optic chiasm. C, MRI scan obtained 2 weeks later showing unchanged aneurysm size. D, MRI scan obtained after 4 months showing complete aneurysm involution. At the time of the last clinical follow-up examination (50 mo after carotid artery occlusion), vision had markedly improved.
Fig 2. Graph showing the reduction in aneurysm size over time for 39 large and giant carotid artery aneurysms treated with carotid artery balloon occlusion. For 29 aneurysms that involuted totally, the x axis indicates the shortest available follow-up MRI scan with complete involution; for the 10 other aneurysms, the x axis indicates last follow-up MRI scan. Multiple circles with the same coordinates are piled. Solid circles, aneurysms with initial intraluminal thrombus; open circles, aneurysms without initial intraluminal thrombus.

RESULTS

ANEURYSM SIZE REDUCTION

All aneurysms seemed to have thrombosed completely after carotid artery occlusion as seen on early and late MRI scans and magnetic resonance angiography follow-up. At the time of the last MRI follow-up, 29 of the 39 aneurysms (74%) were totally involuted, two decreased to 25% of the original diameter, two decreased to 50%, and five decreased to 75%. Two aneurysms remained unchanged in size after 49 and 58 months, respectively. A reduction in aneurysm size related to the MRI follow-up period is illustrated in Fig 2. Complete aneurysm involution was obvious within 3 months for nine aneurysms, within 12 months for another nine aneurysms, and between 17 and 98 months for the remaining 11 aneurysms. Seven (64%) out of 11 supraclinoidal aneurysms and 25 (89%) out of 28 cavernous sinus aneurysms had a reduction of 50% or more in diameter size during the follow-up period. This difference was not significant (P = 0.17). Three (43%) out of seven aneurysms with initial intraluminal thrombus and 26 (81%) out of 32 aneurysms without initial intraluminal thrombus involuted completely. This difference was not statistically significant (P = 0.11). Illustrative cases are presented in Fig 1, 3, and 4.
Fig 3. This 69-year-old woman presented with acute right-sided ophthalmoplegia. A, transverse T2-weighted MRI scan demonstrating a giant cavernous sinus aneurysm with flow effects. B, angiography showing the giant right cavernous sinus aneurysm. C, MRI scan obtained 3 months later showing that the aneurysm has markedly decreased in size. D, MRI scan obtained 16 months after carotid artery occlusion showing that the aneurysm is involuted completely. The patient's ophthalmoplegia was cured.
Fig 4. This 71-year-old woman presented with acute complete left ophthalmoplegia. A, transverse T2-weighted MRI scan showing a large left cavernous sinus aneurysm with intraluminal thrombus. B, bilateral internal carotid artery angiogram showing the lumen of the cavernous sinus aneurysm. C and D, transverse and coronal MRI scans obtained 32 months after left internal carotid artery occlusion showing a decrease in aneurysm size to 50% of the original diameter. The patient’s ophthalmoplegia was cured.
CLINICAL FOLLOW-UP
There were no early or late complications of the therapeutic artery occlusion (14, 15). At the time of the last clinical follow-up evaluation, symptoms of mass effect were cured in 19 (60%), improved in 10 (31%), and unchanged in three (9%) out of 32 patients. Although four patients reported worsening of symptoms in the first several weeks after carotid artery occlusion, none of the patients had aggravation of existing symptoms or new clinical symptoms at the time of the last follow-up evaluation. The relationship between the initial type of clinical symptoms and evolution during the follow-up period is listed in Table 1. Accompanying retro-orbital pain was cured in all 18 patients. For most patients with clinical improvement or cure, this was obvious in the first year after carotid artery occlusion.

The proportion of aneurysms with almost complete involution was 89% (17 out of 19) in patients with clinical cure, 80% (8 out of 10) in patients with improved symptoms, and 100% (3 out of 3) in patients with unchanged symptoms. These differences were not significant (P > 0.9).

DISCUSSION
In this study, we found that alleviation of the symptoms of mass effect is achieved in the vast majority of patients treated with therapeutic carotid artery occlusion for large and giant carotid artery aneurysms. None of the patients in this series had new clinical symptoms or aggravation of existing symptoms during the follow-up period. In addition, most aneurysms involuted totally or decreased substantially in size over time, particularly in the first year after carotid artery occlusion. Aneurysm size reduction over time was independent of the presence of intraluminal thrombus at presentation and on location (supraclinoid versus cavernous sinus). Similar good outcomes have also been reported in previous studies (1,3,6,8,16).

Although a relationship between aneurysm size reduction and improvement of symptoms of mass effects seems likely, we were unable to identify a definite relationship: some aneurysms in cured patients were unchanged in size and some patients with totally involuted aneurysms had unchanged symptoms of mass effect. Apparently, mere thrombosis of the aneurysm may be sufficient to alleviate the symptoms of mass effect. On the other hand, when cranial nerve damage is permanent, clinical symptoms remain unchanged even after complete aneurysm shrinkage. A limitation of our retrospective study, although relatively large and with midterm follow-up data, is the wide variation in follow-up intervals: imaging and clinical findings at various points in time could have been present at an earlier stage. Moreover, we were unable to use a validated questionnaire to determine the clinical status of the patients, and medical records were not always complete (i.e., the duration of symptoms at the time of presentation to our hospital was not always known).

Most of our patients had symptomatic aneurysms located in the cavernous sinus. There is some controversy regarding whether or not to treat these aneurysms...
because their natural history is relatively benign \((3,5,7,13)\). The favorable long term results obtained with therapeutic carotid artery occlusion combined with the absence of complications may justify this treatment for both symptomatic and asymptomatic large and giant cavernous sinus aneurysms in patients who can tolerate carotid artery sacrifice. We generally do not treat patients with asymptomatic cavernous sinus aneurysms who cannot tolerate carotid artery occlusion.

Table 1. Evolution of clinical symptoms of mass effect at the last follow-up evaluation for 32 patients with large or giant carotid artery aneurysms treated with carotid occlusion

<table>
<thead>
<tr>
<th>Symptom</th>
<th>No. of patients</th>
<th>Cured</th>
<th>Improved</th>
<th>Unchanged</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolated abducens palsy</td>
<td>5</td>
<td>4</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Ophthalmoparesis (a)</td>
<td>22</td>
<td>15</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Visual field deficit</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Hemiparesis</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
<td>19 (60%)</td>
<td>10 (31%)</td>
<td>3 (9%)</td>
</tr>
</tbody>
</table>

\(a\) Two patients presented with additional trigeminal neuralgia that was cured in both patients at the time of the last follow-up evaluation.

In recent years, new endovascular techniques for occlusion of carotid aneurysms with sparing of the patency of the internal carotid artery became available in clinical practice: coiling of aneurysms with a protective balloon or stent and filling of the aneurysm with a liquid embolic agent (Onyx; Microtherapeutics, Irvine, CA). These methods are technically more challenging and complications such as thromboembolic events, instant thrombosis, stent malpositioning, carotid dissection, or migration of Onyx may occur \(4,9,10,11\). Moreover, when coils are used to occlude large and giant aneurysms, compaction is likely over time and repeat treatment is necessary \(15\). In our practice, these techniques are restricted to patients with intradural aneurysms or symptomatic cavernous sinus aneurysms who cannot tolerate carotid artery occlusion.

There is some concern that hemodynamic changes in the circle of Willis predispose to the formation of new aneurysms on the anterior communicating artery or on the contralateral carotid artery many years later. In our patient group, 26 patients had midterm (mean, 50 mo) follow-up magnetic resonance angiography at 3 Tesla; no new aneurysms were found in these patients \(2\). However, longer term follow-up data will be needed to draw definitive conclusions regarding new aneurysm formation.
CONCLUSION

Therapeutic carotid artery occlusion is a simple, safe, and effective treatment for large and giant carotid artery aneurysms. Almost all aneurysms involute completely or substantially decrease in size, and most aneurysms do so in the first year after carotid occlusion. Alleviation of symptoms of mass effect is achieved in most patients. Aggravation of clinical symptoms did not occur.
REFERENCES


