Endovascular treatment of anterior choroidal artery aneurysms

Traitement endovasculaire des anévrismes de l’artère choroïdienne antérieure

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\textbf{KEYWORDS}
Intracranial aneurysms; Endovascular treatment; Detachable coils

\textbf{Summary}

\textit{Introduction.} — Endovascular treatment (EVT) of anterior choroidal artery aneurysms (AChAA) may be challenging because of the close relationship with the parent artery. The aim of this study was to report our experience with EVT of AChAA.

\textit{Methods.} — A retrospective review of our prospectively maintained database identified all AChAA treated by embolization. The clinical charts, procedural data and angiographic results were reviewed.

\textit{Results.} — From April 2004–August 2008, 11 patients were identified. Five patients presented with a subarachnoid hemorrhage (SAH) and six patients were asymptomatic. Aneurysms size varied from two to 13 mm (mean size = 3.6 mm) and nine had an unfavourable neck/sac ratio (≥ 0.7). The anterior choroidal artery was arising from the sac (n = 6) or from the neck (n = 5). Endovascular treatment consisted of balloon-assisted coiling (n = 8), coiling (n = 2) and stent-assisted coiling (n = 1). No procedural complication occurred and all patients had an excellent outcome except one patient who died because of severe vasospasm 8 days after an uneventful EVT. Immediate angiographic control showed six complete occlusions, one neck remnant and four incomplete occlusions. Follow-up controls (mean = 18 months) were obtained in eight patients and showed five stable occlusions and three further thrombosis achieving complete occlusion.

\textit{Conclusion.} — EVT of AChAA is associated with very good clinical and long-term anatomical results. Because of their small size, unfavourable neck/sac ratio and close relationship with...
Introduction

Anterior choroidal artery aneurysms (AChAA) are rare (2–5% of all aneurysms) but the close relationship with the parent artery makes their treatment technically challenging [1,2,5,6,12,13,16,17]. Surgical clipping of AChAA may be associated with severe neurological complications in 5% to 50% of cases [1,13,16]. Endovascular treatment (EVT) has been evaluated in only two series that have shown lower rates of morbidity and mortality when compared with surgery [5,6,12]. However, both neurosurgical and endovascular series have shown that ischemic complications are more frequent when the anterior choroidal artery is incorporated into the neck or the aneurysmal sac [2,5,6,13,17]. The aim of our study is to report our experience with EVT of 11 patients with 11 AChAA.

Patients and methods

Therapeutic protocol

Since April 2004, daily interventional neuroradiology is available in our institution and a therapeutic protocol has been established for the management of patients with ruptured and unruptured intracranial aneurysms. Therapeutic alternatives are discussed between neurosurgical and neurointerventional teams in a multidisciplinary decision-making process. For all patients who present with an intracranial aneurysm, EVT is considered as first-intention treatment if it is judged feasible by the senior neurinterventionalist (BL) except for ruptured aneurysms associated with a compressive haematoma that requires emergency surgical treatment.

Population

Between April 2004 and August 2008, 341 patients with 436 aneurysms were treated in our institution. Among them, 14 patients presented with an AChAA (14/436 aneurysms = 3.2%). Clinical presentation is summarised in Table 1. There were seven men and seven women with a mean age of 45 years (range, 21 to 56). Five patients presented with a subarachnoid haemorrhage (SAH) and were classified according to the Hunt and Hess (HH) scale [3]: three patients were grade I, one patient was grade II and one patient was grade III. In nine patients, the aneurysm was unruptured.

In this series, the definition of AChAA was the presence of an aneurysmal sac with anterior choroidal artery arising from the neck or from the sac. The AChAA size varied from 1.3 to 13 mm in diameter (mean size = 3.6 mm) and nine out of 14 aneurysms had an unfavourable neck/sac ratio (≥ 0.7). The anatomical configuration of AChAA was classified according to the anterior choroidal artery location:

- at the neck (n = 7);
- arising from the sac (n = 7).

Two patients (patients 6 and 7) were not treated because of the very small size of the AChAA; in one patient (patient 13), surgical clipping of a 1.3 mm AChAA was performed at the same time of another aneurysm clipping. The remaining 11 patients were treated by embolization including five women and six men with a mean age of 45 years (range, 21 to 56 years). Among them, six patients had an aneurysm with the anterior choroidal artery arising from the sac and five patients had an aneurysm with the artery at the neck.

Endovascular procedure

In all patients, EVT was performed under general anaesthesia and systemic heparinization. The adequacy of systemic anticoagulation was monitored by frequent measurements of the activated clotting time (ACT). A baseline ACT was obtained prior to the bolus infusion of heparin (30 to 50 IU/kg body weight) and hourly thereafter. The bolus infusion of heparin was followed by a continuous drip (1000 to 1500 IU/h) with the purpose of doubling the baseline ACT. All procedures were performed by the senior interventional neuroradiologist (BL). All patients were treated by selective embolization with Microplex coils (MicroVention, Aliso Vieja, CA) or Guglielmi detachable Coils (Target Therapeutics, Fremont, CA). When the aneurysm size was ≤ 3 mm in diameter, a Prowler 10 microcatheter (Cordis, Miami Lakes, FL) was used whereas a Prowler Select LP (Cordis, Miami Lakes, FL) was used in larger aneurysm. In case of wide-necked aneurysms (neck/sac ratio ≥ 0.7), a protecting-neck device (remodelling balloon or stent) was required. When the remodelling technique [10] was used, a 7 × 7 mm HyperForm (Micro Therapeutics, Irvine, CA) balloon was first placed across the aneurysm neck and a second microcatheter was positioned within the aneurysm to deliver coils [7]. The balloon was inflated in order to protect the anterior choroidal artery at the neck of the aneurysm. When the branch was arising from the sac, the “over-inflation” technique was used to preserve the branch [8]. In one patient, (patient 5) the stent-assisted technique was needed because of coil instability despite the use of a balloon; a self-expandable stent (Enterprise, Cordis, Miami Lakes, FL) was thus placed during the procedure. This latter patient received IV abciximab during EVT and was maintained on clopidogrel (75 mg/day) for a month and aspirin (160 mg/day) for 6 months.

Systemic heparinization was prolonged for 24 to 48 h when a balloon or a stent was used. In patients harbouring
Table 1  Characteristics of 14 patients with AChA.

<table>
<thead>
<tr>
<th>Pt</th>
<th>Sex/Age</th>
<th>Presentation</th>
<th>AchA configuration</th>
<th>Aneurysm neck/sac ratio</th>
<th>Treatment</th>
<th>Clinical outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M/55</td>
<td>Previous SAH</td>
<td>From the sac</td>
<td>0.76 (2/2.6)</td>
<td>Remodeling</td>
<td>Excellent</td>
</tr>
<tr>
<td>2</td>
<td>F/21</td>
<td>Incidental</td>
<td>From the sac</td>
<td>0.97 (2/2.7)</td>
<td>Remodeling</td>
<td>Excellent</td>
</tr>
<tr>
<td>3</td>
<td>M/49</td>
<td>Incidental</td>
<td>At the neck</td>
<td>0.37 (2/5.4)</td>
<td>Coiling</td>
<td>Excellent</td>
</tr>
<tr>
<td>4</td>
<td>M/56</td>
<td>Previous SAH</td>
<td>From the sac</td>
<td>0.9 (2/2.2)</td>
<td>Remodeling</td>
<td>Excellent</td>
</tr>
<tr>
<td>5</td>
<td>F/48</td>
<td>Previous SAH</td>
<td>At the neck</td>
<td>0.93 (3/3.2)</td>
<td>Remodeling+ stenting</td>
<td>Excellent</td>
</tr>
<tr>
<td>6</td>
<td>F/52</td>
<td>Incidental</td>
<td>At the neck</td>
<td>0.77 (1/1.3)</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>M/55</td>
<td>Previous SAH</td>
<td>From the sac</td>
<td>0.93 (1.5/1.6)</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>M/48</td>
<td>Previous SAH</td>
<td>From the sac</td>
<td>0.88 (2.2/2.5)</td>
<td>Remodeling</td>
<td>Excellent</td>
</tr>
<tr>
<td>9</td>
<td>F/56</td>
<td>SAH</td>
<td>At the neck</td>
<td>0.76 (1.9/2.5)</td>
<td>Remodeling</td>
<td>Death</td>
</tr>
<tr>
<td>10</td>
<td>F/43</td>
<td>SAH</td>
<td>From the sac</td>
<td>0.56 (2.7/4.8)</td>
<td>Remodeling</td>
<td>Excellent</td>
</tr>
<tr>
<td>11</td>
<td>M/38</td>
<td>SAH</td>
<td>At the neck</td>
<td>0.29 (3.8/13)</td>
<td>Coiling</td>
<td>Excellent</td>
</tr>
<tr>
<td>12</td>
<td>M/55</td>
<td>SAH</td>
<td>At the neck</td>
<td>0.87 (2.1/2.4)</td>
<td>Remodeling</td>
<td>Excellent</td>
</tr>
<tr>
<td>13</td>
<td>F/39</td>
<td>Previous SAH</td>
<td>At the neck</td>
<td>0.58 (1/1.7)</td>
<td>Clipping</td>
<td>Excellent</td>
</tr>
<tr>
<td>14</td>
<td>F/24</td>
<td>SAH</td>
<td>From the sac</td>
<td>0.77 (2.1/2.7)</td>
<td>Remodeling</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

AChA: anterior choroidal artery; SAH: subarachnoid hemorrhage.

an AChAA with the artery arising from the sac, aspirin (160 mg/day) was administered for a month. After EVT, patients were transferred to the intensive care unit and fluid balance, neurological status, blood pressure were carefully monitored.

Immediate outcome

Patients were evaluated by angiography to document aneurysm obliteration. Angiographic results were classified as: complete occlusion (no contrast filling the aneurysmal sac), neck remnant (residual contrast filling the aneurysmal neck) and incomplete occlusion (residual contrast filling the aneurysmal body). A senior neurosurgeon and/or neuroradiologist (MB, BL) recorded the clinical course, including worsening of symptoms and death. Clinical outcome was graded according to a modified Glasgow Outcome Scale (GOS) [4] as follows:

- excellent (neurologically intact);
- good (mild hemiparesis, cranial nerve palsy, or other deficit that does not interfere with daily functioning or work);
- fair (significant hemiparesis, aphasia, confusion, or other deficit that interferes with daily activities or prevents a return to work);
- poor (coma or severe neurological deficit rendering the patient dependent on family or nursing staff).

Patient follow-up

Our imaging follow-up protocol included magnetic resonance angiography (MRA) at 6, 12, and 36 months after treatment and a conventional angiography at 12 months. Follow-up conventional and MR angiograms were compared to immediate postembolization angiograms and were then assigned to one of three categories:

- further thrombosis, when the amount of contrast agent filling the aneurysm decreased;
- unchanged, when a similar degree of aneurysm occlusion in multiple projections was found;
- recanalization, when an increase of the amount of contrast filling in the aneurysm was observed.

Conventional angiographies, MRA were reviewed for all patients by two senior neuroradiologists together (CS, AB, BL).

Illustrative cases

Case 1

A 48-year-old woman (patient 5), with previous history of SAH from another ruptured aneurysm, presented with an unruptured AChAA. Conventional (Fig. 1A) and 3D (Fig. 1B) angiographies showed a right AChAA with an unfavourable neck/sac ratio (0.93) and the anterior choroidal artery at the neck. Balloon-assisted coiling was performed and the first coil could safely be placed while preserving the anterior choroidal artery. However, this coil appeared unstable once delivered because of the very large neck of the aneurysm. Therefore, a self-expandable stent was delivered across the aneurysm neck to prevent coil protrusion. Then, one more coil was added achieving an incomplete aneurysm occlusion (Fig. 1C). The patient woke-up with a normal neurological exam and was discharged 2 days later. Angiographic control at 12 months showed further aneurysm thrombosis and complete occlusion (Fig. 1D).

Case 2

A 48-year-old man (patient 8), with previous history of SAH from another ruptured aneurysm, presented an unruptured AChAA. Conventional (Fig. 2A) and 3D (Fig. 2B) angiographies showed an AChAA with an unfavourable neck/sac ratio (0.88) and the parent artery arising from the sac. Selective EVT was performed with the help of the over-inflation technique achieving a satisfying aneurysm occlusion and preservation of the anterior choroidal artery. (Fig. 2C).
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Figure 1  Unruptured AChAA in a 48-year-old woman. A. Conventional. B. Three-dimensional angiographies show a very wide-necked aneurysm with the anterior choroidal artery at the neck. C. Endovascular treatment by stent-assisted coiling: conventional unsubtracted. D. Subtracted angiographies at the end of the procedure shows an incomplete aneurysm occlusion. E. Angiographic control at 12 months shows a further thrombosis achieving complete aneurysm occlusion. The parent artery is patent and no in-stent stenosis is objectived.

Figure 2  Unruptured AChAA in a 48-year-old man. A. Conventional. B. Three-dimensional angiographies show a wide-necked aneurysm with the anterior choroidal artery arising from the sac. C. Balloon-assisted coiling was performed to protect the anterior choroidal artery. D. Angiographic control shows a complete aneurysm occlusion and patency of the anterior choroidal artery.

patient woke-up with a normal neurological examination and was discharged home 2 days later. Angiographic control at 12 months showed further aneurysm thrombosis and complete occlusion (Fig. 2D).

Results

EVT feasibility

EVT was successfully performed in all patients. In two patients who had an aneurysm with a favourable neck/sac ratio, conventional coiling was performed. In nine patients harbouring an aneurysm with an unfavourable neck/sac ratio, EVT was performed with the assistance of a remodelling balloon. Thanks to the use of the very compliant HyperForm balloon, the anterior choroidal artery could be preserved in all cases. Finally, in patient 5 with the most unfavourable neck/sac ratio (3/3.2 = 0.93), a self-expandable stent was used because of coil instability within the sac despite the use of a remodelling balloon. No procedural complication occurred during endovascular procedures.

Clinical and anatomical outcome

All patients showed an unchanged neurological exam immediately after EVT. During follow-up, 10 patients showed an excellent outcome and one patient (patient 9) died 8 days after an uneventful EVT because of severe SAH-related vasospasm. Immediate angiographic control showed a complete aneurysm occlusion in six cases (54%), a neck remnant in one (9%), and an incomplete occlusion in four cases (37%). Follow-up imaging was obtained in eight patients, ranging from 12 to 36 months (mean = 18 months) and it showed five stable occlusions and three further thrombosis achieving complete aneurysm occlusion.

Discussion

This study shows that EVT of AChAA is associated with excellent clinical and anatomical long-term results. Because of the close relationship between the anterior choroidal artery and the aneurysmal sac, adjunctive techniques are frequently required to safely treat these aneurysms.
Many series presenting results of AChAA surgical clipping have been published [2,5,13,16,17]. The earliest series from Drake et al. [1] and Yasargil et al. [17] reported morbidity and mortality rates of 33% and 12.5%, respectively. In the largest surgical series published by Friedman et al. [2], these rates were clearly correlated with the anatomical configuration of the aneurysm and the location of the parent artery. In this series, 41 out of 51 aneurysms had a classical configuration with the sac arising near or adjacent to the origin of the anterior choroidal artery [2]. In this group, four patients had an arterial spasm giving a stroke risk of 9.8%. In the remaining patients harbouring an AChAA with the anterior choroidal artery arising from the sac, postoperative stroke rate was 44%. Friedman et al. [2] concluded that aneurysm originating from the trunk of the anterior choroidal artery was a significant predictor of postoperative stroke.

The first series of AChAA treated by selective embolization was published in 2004 by Piotin et al. [12]. They have shown that EVT was effective to protect from rebleeding with lower morbidity and mortality rates when compared with surgical clipping. In the second endovascular series, 83.8% of patients had good recoveries with no procedure-related mortality [5,6]. However, anterior choroidal artery occlusion was detected in five patients in whom the anterior choroidal artery was incorporated into the neck or sac of the aneurysm. Thus, both surgical and endovascular series pinpoint the higher risk of AChAA treatment when the parent artery was arising from the sac.

In our series, most patients had an AChAA with an unfavourable neck/sac ratio and/or with the parent artery arising from the sac. Indeed, our definition of AChAA was more restrictive than the usual one used in the previously published series. Only aneurysms, that presented with the anterior choroidal artery arising from the neck or from the sac, were included in the present paper. Therefore, adjunctive techniques (balloon or stent-assisted coiling) were frequently required and they appeared very helpful to preserve the parent artery patency. Indeed, balloon-assisted coiling, that is especially helpful for EVT of wide-necked aneurysms, may also be used to protect an arterial branch and as a rescue treatment in case of rupture [7—11,14,15]. Our study is in accordance with these findings because EVT was successful in all wide-necked aneurysms and the anterior choroidal artery could be preserved in all cases. Nevertheless, in one patient the balloon was not sufficient to prevent coil instability and a stent had to be used and achieved an excellent long-term anatomical outcome. Clinically, these adjunctive techniques appeared safe because no complication occurred in the present series confirming that these techniques are not associated with higher complication rate when they are frequently and routinely used [9,10].

Concerning anatomical results, our study showed stable or improved aneurysm occlusion rate during follow-up. Stable occlusion or further thrombosis resulting in complete occlusion can easily be explained:

- the size of AChAA is frequently small;
- AChAA are sidewall aneurysms that are less prone to recanalization.

**Conclusion**

This study shows that EVT of AChAA is associated with very good clinical and anatomical results. Because of the close relationship between the anterior choroidal artery and the aneurysmal sac, adjunctive techniques are frequently required to safely treat these aneurysms.

**References**