Endovascular coil occlusion of 152 middle cerebral artery aneurysms: initial and midterm angiographic and clinical results

Clinical article

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Object. The object of this study was to evaluate the initial and mid-term angiographic and clinical results after endovascular coil occlusion of middle cerebral artery (MCA) aneurysms at the authors’ institution.

Methods. The authors conducted a retrospective analysis of a consecutive series of 152 MCA aneurysms (73 ruptured) treated by endovascular coiling in 140 patients. Angiographic and clinical data at initial and midterm follow-up as well as procedure-related complications were prospectively registered.

Results. At discharge, favorable clinical outcomes (Glasgow Outcome Scale score of 1 or 2) were obtained in 89.3% of patients (125/140). Seven patients (5%) were in a vegetative state or had died. Complications were encountered in association with 11.8% of the procedures (18/152), and most (13/18) involved thromboembolic events (which led to permanent ischemia in 4 cases and death in 1). The overall procedure-related mortality rate was 0.7%, and the rates of permanent and transient morbidity were 2.6 and 2%, respectively. At a mean follow-up duration of 4.3 years there had been 4 cases of rebleeding: early rebleeding occurred during the initial postoperative period in 3 cases and later in 1. Total or subtotal occlusion was obtained in 84.2% of aneurysms (128/152). At follow-up, this satisfactory occlusion persisted in 83.3% of aneurysms (110/132) at 1 year posttreatment, 79.5% (89/112) at 3 years, and 80.2% (73/91) at 5 years.

Conclusions. Risks and initial and midterm angiographic and clinical results after endovascular treatment of MCA aneurysms are nearly identical to other locations. Endovascular treatment may thus be proposed as an alternative to surgical clipping at this location. Nevertheless, a longer follow-up period is necessary to determine its efficacy, particularly in cases of unruptured aneurysms. (DOI: 10.3171/2009.6.JNS09483)

Key Words • cerebral aneurysm • middle cerebral artery • endovascular treatment

Surgical clipping of MCA aneurysms is usually preferred to EVT. This preference is largely the result of a relatively easy surgical access and unfavorable endovascular approach due to the complex branching pattern of the MCA. As of this writing, no direct comparison between results of endovascular and surgical treatment of MCA aneurysms has been published in the literature, leaving the optimal treatment strategy unclear and choices depending mainly on the practice at different centers. We therefore considered it important to study procedure-related risks as well as the immediate and midterm angiographic and clinical results after EVT of MCA aneurysms.

Abbreviations used in this paper: EVT = endovascular treatment; GOS = Glasgow Outcome Scale; MCA = middle cerebral artery.

Methods

From October 1992 to October 2001, a total of 940 patients with 1120 cerebral aneurysms were seen in our institute. Of these 940 patients, 202 (21.5%) were found to have MCA aneurysms (a total of 238 [21.3% of all identified aneurysms]). The closing date was chosen to have more than 5 years of follow-up data.

Since the first use of detachable coils in our department in October 1992, data pertaining to all patients referred for EVT have been prospectively recorded. These data include: patients’ demographic characteristics, mode of presentation, aneurysmal angiographic features, angiographic outcome at immediate post-EVT and follow-up examinations, procedure-related complications, and clinical status, using Hunt and Hess grading (in case of hemorrhage) on admission and GOS scores upon discharge.
and at subsequent follow-up visits at 6 months, 1, 3, and 5 years. Retrospective review of the data concerning all MCA aneurysms formed the basis of the present study.

We excluded all MCA aneurysms in patients referred to surgery or followed up with no proposed treatment. The excluded aneurysms fell into 3 groups as follows: 1) Fifty-two aneurysms (21.8% of all MCA aneurysms) were excluded because they were assigned from the beginning to surgery due to an associated compressive hematoma or because arterial bypass was performed prior to endovascular parent vessel occlusion (and the recurrence issue would thus not apply). 2) Twenty aneurysms were initially proposed for EVT but referred secondarily to surgery (10.8% of the 186 aneurysms proposed for EVT) due to infeasible or failed embolization; EVT was judged infeasible in 13 (7%, 5 ruptured, 8 unruptured) after the initial angiogram due to unfavorable geometry (wide neck, incorporation of a branch within the sac, or small sac size). For the remaining 7 aneurysms (3.8%, 2 ruptured, 5 unruptured) EVT failed due to an unstable position of the first coil or its protrusion into the parent vessel prior to its detachment. 3) In 14 unruptured aneurysms (7.5% of aneurysms proposed for EVT), neither EVT nor surgery was considered necessary (due to small size of the aneurysm and estimated low risks of bleeding) and patients were kept under angiographic follow-up and hence excluded from the study population.

The present study therefore included 152 aneurysms in 140 patients treated only with coil placement (81.7% of all MCA aneurysms assigned for EVT). Seventy-three aneurysms (48%) were ruptured and 79 (52%) were not. Female predominance was noted (92 patients [65.7%] were female and 48 [34.3%] were male).

Aneurysmal Angiographic Features

Aneurysms were classified according to the length of their longest axis into: small (< 4 mm), medium (4–10 mm), large (> 10 and ≤ 20 mm), and giant (> 20 mm). The ratio of aneurysm neck width to sac diameter was evaluated, and 3 groups were defined on this basis of relative neck size: small (ratio ≤ 0.5), medium (ratio > 0.5 and ≤ 1), and large (ratio > 1).

Endovascular Treatment

All endovascular embolizations were performed using a biplane angiographic machine (Advantix System, GEMS) with standard angiographic projections before 1997, and an additional rotational acquisition with 3D reconstruction (Butterfly System, GEMS) afterward. All procedures were performed with the patient in a state of general anesthesia with adequate heparin anticoagulation (loading dose of 2000 to 3000 IU followed by continuous infusion of 20 to 40 IU/kg/hour) and intravenous nimodipine (Nimotop, 2 mg/hour). In cases of ruptured aneurysms, intraarterial papaverine (320 mg) was added through the guiding catheter’s perfusion bag. At the end of the procedure, intravenous heparin was discontinued.

The postoperative medical treatment regimen included: low-molecular weight heparin for 48 hours to 1 week depending on estimated risks of potential late thromboembolism as judged by the neuroradiologist; anti–platelet aggregation agents (aspirin until 1998 and flurbiprofen [Cebutid] thereafter; daily dose of 100 mg) for 1 month; and in cases of ruptured aneurysms only, nimodipine (Nimotop, 120 mg/day) for 2–3 weeks.

All endovascular embolizations were achieved using bare platinum coils. Adjunctive techniques such as balloon remodeling or stent-assisted coiling were not applied in this series. Ruptured aneurysms were treated as quickly as possible and most were coiled within the first 3 days.

Angiographic and Clinical Assessment

Angiographic and clinical results (at initial and follow-up sessions) were assessed by one of the senior interventional neuroradiologists (S.B., L.P., R.A., or A.L.).

Our angiographic follow-up protocol consists of at least 1 digital subtraction angiogram during the 1st year (anteroposterior, lateral, and working projections) and MR angiography at 6 months, 3, and 5 years after treatment.

The degree of angiographic occlusion was classified as: total (complete occlusion of the sac and neck), subtotal (residual neck opacification), or partial (residual sac opacification). We have used this classification in our prospective data entry since 1992; it is similar to that proposed later by Roy et al.18 Total and subtotal occlusions were considered as satisfactory results. Recurrence was classified as minor (regression of total to subtotal occlusion) or major (regression of total or subtotal to partial occlusion).

Results

Initial Angiographic Results

Of the 152 coiled MCA aneurysms, 37 (24.3%) were small, 90 (59.2%) were medium, 12 (7.9%) were large, and the remaining 13 (8.6%) were giant. The aneurysm neck/sac ratio was < 0.5 in 61 aneurysms (40.1%), between 0.5 and 1.0 in 76 (50%), and > 1 in 15 (9.8%). Satisfactory (total and subtotal) occlusion was obtained in 84.2% of cases (128/152). The results were somewhat better for unruptured than ruptured aneurysms (87% vs 80%), yet not statistically significant (p = 0.71) (Table 1).

Sac size and the neck/sac ratio were contributing factors for the degree of occlusion. Total occlusion was more frequent among small aneurysms (43.2% of small vs 23.1% of giant sacs). In contrast, partial occlusion predominated when the sacs were giant (53.8% of giant vs 2.7% of small sacs) and when the necks were large with respect to the sacs (60% of cases with large necks vs 3.3% of those with small ones) (Tables 2 and 3).

Procedure-Related Complications

Complications occurred in relation to treatment of 11.8% of the endovascularly treated aneurysms (18/152). The procedure-related complications included 3 aneurysm sac perforations (2%), 1 coil migration (0.7%), 1 femoral puncture hematoma, and 13 thromboembolic events (8.6%) (in 10 of the 73 ruptured [13.7%] and 3 of the 79 unruptured [3.8%] aneurysms), of which 10 were
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Angiographic Follow-Up

Table 5 summarizes the evolution of angiographic results. The rate of satisfactory occlusion (total or subtotal) was almost stable during the follow-up period—68.3% (110/162) of aneurysms at 1 year, 79.5% (89/112) at 3 years, and 80.2% (73/91) at 5 years. Anatomical improvement (from subtotal to total occlusion) occurred in 19 cases (14.4%) at 1 year. Among 19 aneurysms initially treated with partial occlusion and followed up at 1 year after treatment, 14 (73.7%) were stable with no further recanalization and the remaining 5 (26.3%) showed anatomical improvement (to subtotal occlusion). These lesions remained stable all through the follow-up period. This result supports our policy in treating complex cases only partially and safely, rather than taking more risks just to achieve a better angiographic image.

Major recurrences were identified in 12 cases (7.6%) of aneurysms examined at 1-year follow-up and 4 (3.6%) of 112 at 3 years, while minor recurrence was observed in 12 (28.6%) of 42 initially totally occluded aneurysms (8 cases at 1 year and 4 cases at 3 years).

Second treatment (by EVT or surgery) was required in 7.6% of aneurysms (10/132) due to important aneurysm recurrence at 1 year. Retreatment led to satisfactory occlusion in 5 cases, and better quality of partial occlusion in the other 5. No complications occurred and no further treatment was required.

Factors Affecting the Degree of Occlusion at Follow-Up

The evolution of the degree of occlusion at the fol-
low-up examinations was mainly influenced by the initial grade of occlusion and the size of the aneurysm sac. Neither the mode of discovery (ruptured or unruptured) nor the neck size was a contributing factor.

Initial Grade of Occlusion. Ten (83.3%) of the 12 aneurysms that demonstrated major recurrence had initial subtotal occlusion, while the remaining 2 (16.7%) were totally occluded. An additional 6 cases with initial partial occlusion showed increased recanalization.

Mode of Aneurysm Discovery. At 1, 3, and 5 years, satisfactory occlusion was found in 83%, 74.5%, and 78% of unruptured aneurysms and in 79%, 78.5%, and 89% of ruptured aneurysms respectively. No influence is hence noted as regards the presentation.

Size of Aneurysm Sac. Initial total occlusion was noted in 31.5% of the small and the medium sacs (≤ 10 mm) versus 24% of the large and the giant sacs (> 10 mm). At 1 year these rates were 44% versus 15% and at 3 years, 41.4% versus 15.4%, respectively.

Neck/Sac Ratio. Initial satisfactory occlusion was obtained in 96.7% of the aneurysms with small necks, 82.9% of those with medium necks, and 40% of those with large necks (defined relative to sac size, as described in Methods). At follow-up these rates were 94%, 79%, and 74% at 1 year and 91%, 75%, and 50% at 3 years for lesions with small, medium, and large necks, respectively.

Discussion

Middle cerebral artery aneurysms are usually considered to require surgery, making large series of endovascularly treated MCA lesions relatively rare in the literature. This location represented 14.1% of all aneurysms included in the International Subarachnoid Aneurysm Trial (ISAT).11 In 2 large series dedicated to EVT of aneurysms at all intracranial locations, 14.4% and 6% of all coiled sacs were at the MCA bifurcation.

In the current series, MCA aneurysms constituted 21% of all aneurysms seen in our institute during the study period. Our feasibility rate of EVT at this loca-

Table: 4

<table>
<thead>
<tr>
<th>Aneurysm Status at Admission</th>
<th>GOS Score at Discharge</th>
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<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>unruptured</td>
<td></td>
</tr>
<tr>
<td>H &amp; H Gr I</td>
<td>12</td>
</tr>
<tr>
<td>H &amp; H Gr II</td>
<td>24</td>
</tr>
<tr>
<td>H &amp; H Gr III</td>
<td>4</td>
</tr>
<tr>
<td>H &amp; H Gr IV</td>
<td>2</td>
</tr>
<tr>
<td>H &amp; H Gr V</td>
<td>1</td>
</tr>
<tr>
<td>total</td>
<td>104 (74.3)</td>
</tr>
</tbody>
</table>

* Values represent numbers of patients (%). Abbreviations: Gr = Grade; H & H = Hunt and Hess.

Table: 5

<table>
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<tr>
<th>Aneurysm Status</th>
<th>Initial</th>
<th>1-Yr FU</th>
<th>3-Yr FU</th>
<th>5-Yr FU</th>
</tr>
</thead>
<tbody>
<tr>
<td>total occlusion</td>
<td>46 (30.3)</td>
<td>52 (39.4)</td>
<td>43 (38.4)</td>
<td>39 (42.9)</td>
</tr>
<tr>
<td>subtotal occlusion</td>
<td>82 (53.9)</td>
<td>58 (43.9)</td>
<td>46 (41.1)</td>
<td>34 (37.4)</td>
</tr>
<tr>
<td>partial occlusion</td>
<td>24 (15.8)</td>
<td>22 (16.7)</td>
<td>23 (20.5)</td>
<td>18 (19.8)</td>
</tr>
</tbody>
</table>

* There were 152 lesions evaluated on initial posttreatment angio- graphy and 132, 112, and 91, respectively, at 1-, 3-, and 5-year follow-up. Abbreviation: FU = follow-up.

Initial Angiographic Results

Initial satisfactory aneurysm occlusion was obtained in 84.2% of cases, a rate that is comparable to those reported in other series. Our results were obtained with simple coiling without any balloon remodeling or stent placement. In general, our policy is to use as few materials as possible to avoid complications—notably those due to thromboembolism. We did not use these adjunctive techniques, in part because the study period started before the introduction of remodeling balloons or stents, and later on, the availability of complex-shaped and 3D coils combined with the growing experience of our team offered us a better alternative. In our current practice we use remodeling techniques in no more than 10% of aneurysms at all locations and only in cases of failed or difficult simple coiling. We prefer not to use stents in the treatment of MCA aneurysms because we have found that it makes the procedure cumbersome and increases the level of risk.

Early rebleeding occurred in 3 of our partially occluded sacs. It has been shown that total occlusion of the aneurysm sac is sufficient to prevent rebleeding in 98.5% of acutely ruptured aneurysms. On the other hand, the presence of a residual aneurysm is associated with a 5% rate of rebleeding.

Treatment-Related Adverse Events

Procedure-related complications were encountered in 11.8% (18/152) of cases in the current series; they reached 18.8% in a series dedicated only to MCA aneurysms and ranged between 12 and 15.4% in the meta-analysis of Bristra et al. dealing with all intracranial locations. Thromboembolic complications occurred in 8.5% of our cases (13/152), a rate that is slightly lower than the rates reported for other MCA aneurysm case series (19.6%, 13.4%, and 13.1%). In a report of 203 aneurysms in all intracranial locations, EVT of MCA aneurysms was associated with 52% of all thromboembolic complications.

We also noted a higher incidence of thromboembol-
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lic complications in association with ruptured aneurysms (13.7% of ruptured vs 3.8% of unruptured). In the 2 largest series of MCA aneurysms, this finding was reported in one (18% in the ruptured group vs 9% in the unruptured group) and was equivocal in the second (50% for each group). Most of the thromboembolic events occurred early in our experience. We thus implemented our current preventive protocol of peri- and postoperative combined heparin with platelet-aggregation inhibitors. The occurrence of late thromboembolic complications (later than the 28th day) prompted us to prolong the anti–platelet aggregation therapy for at least 1 month posttreatment.

Clinical Outcome

In the present study, the procedure-related permanent morbidity and mortality rates were 2.6% and 0.7% respectively. These results compare favorably with those of 2 other MCA aneurysm series, which involved 149 and 59 aneurysms and had permanent morbidity rates of 4% and 5.9% and mortality rates of 7% and 2.0% respectively. In other large series involving aneurysms in all intracranial locations, rates of permanent morbidity ranged between 4% and 8.9% and mortality rates between 1.3% and 4.8%. In our series, there was no death among the patients with unruptured aneurysms as has been the case in other series dealing with unruptured aneurysms at all intracranial locations.

In our series, 43.8% (7/16) of patients whose initial Hunt and Hess grade was IV or V had a favorable clinical outcome (GOS Score 1 or 2). This result is similar to that reported for all locations of ruptured intracranial aneurysms with initial bad clinical Hunt and Hess grades as in other reported series.

Aneurysm Recurrence

There were 12 aneurysms that showed major recanalization, 8 at the 1-year follow-up (8/132 or 6.1%) and 4 at the 3-year follow-up (3/112 or 2.7%). At 1 year, we encountered minor recurrences in 8 (19%) of the 42 patients with initially totally occluded aneurysms, and at 3 years there were an additional 4 (9.5%) minor recurrences in these 42 patients. These results are comparable to those of Raymond et al. in their series of 501 aneurysms at all locations, from which they concluded that localization is not a contributing factor for recurrence. On the other side, the large aneurysm size and the initial suboptimal result were predictor factors for recurrence in our series as in other reports. Neither the mode of presentation nor the aneurysm neck size influenced the angiographic evolution of our cases, in contrast to what was demonstrated in other published series.

In 24 cases, the initial result of treatment was partial occlusion. Most of these lesions remained almost stable with no further regrowth. Our strategy of treating certain difficult aneurysms with only partial occlusion and not offering second treatment in every case in which there is residual sac might trigger criticism. We believe that the complex branching anatomy of the MCA reduces the safety of the procedure and leads to unintentional branch occlusion. This makes total occlusion impossible to achieve in certain cases. Also we try to avoid retreatment, which might carry higher risks as shown in the series of Henkes et al. The availability of noninvasive MR angiography has allowed close follow-up of recurring aneurysms, enabling us to limit retreatment to growing sacs. In our series most residual aneurysms remained stable after an early recurrence. This makes additional procedures of questionable worth.

Conclusions

Initial and midterm results of EVT of MCA aneurysms in the current series are more or less similar to those reported for aneurysms in other intracranial locations. Thromboembolic events were the most frequently encountered complications, yet the improvement in preventive protocols of anticoagulation and antiaggregation therapies has significantly decreased the clinical impact of such events. Endovascular treatment could thus be proposed as a suitable alternative to surgical clip placement for MCA aneurysms. Extended follow-up periods are still necessary to evaluate the efficacy of endovascular coil embolization, especially in cases of unruptured aneurysms.

Disclaimer

The authors do not report any conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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