Endovascular treatment of very small intracranial aneurysms

Clinical article


Neuroradiology Department, West Wing, John Radcliffe Hospital, Oxford, United Kingdom

Object. Endovascular treatment of very small aneurysms poses a significant technical challenge for endovascular therapists. The authors review their experience with a series of patients who had intracranial aneurysms smaller than 3 mm in diameter.

Methods. Between 1995 and 2006, 97 very small aneurysms (defined for purposes of this study as < 3 mm in diameter) were diagnosed in 94 patients who were subsequently referred for endovascular treatment. All patients presented after subarachnoid hemorrhage, which was attributed to the very small aneurysms in 85 patients. The authors reviewed the endovascular treatment, the clinical and angiographic results of the embolization, and the complications.

Results. Five (5.2%) of the 97 endovascular procedures failed, and these patients underwent craniotomy and clip ligation. Of the 92 aneurysms successfully treated by coil embolization, 64 (69.6%) were completely occluded and 28 (30.4%) showed minor residual filling or neck remnants on the immediate postembolization angiogram. Complications occurred in 7 (7.2%) of 97 procedures during the treatment (3 thromboembolic events [3.1%] and 4 intraprocedural ruptures [4.1%]). Seventy-six patients were followed up angiographically; 4 (5.3%) of these 76 showed angiographic evidence of recanalization that required retreatment. The clinical outcomes for the 76 patients were also graded using the Glasgow Outcome Scale. In 61 (80.3%) cases the outcomes were graded 4 or 5, whereas in 15 (19.7%) they were graded 3. Seven patients (7.4%) died (GOS Grade 1), 2 due to procedure-related complications (intraoperative rupture) and 5 due to complications related to the presenting subarachnoid hemorrhage.

Conclusions. Endosaccular coil embolization of very small aneurysms is associated with relatively high rates of intraprocedural rupture, especially intraoperative rupture. With the advent of more sophisticated endovascular materials (microcatheters and microguidewires, soft and ultrasoft coils, and stents) endovascular procedures have become feasible and can lead to a good angiographic outcome. (DOI: 10.3171/2008.8.17657)

Key Words • aneurysm • aneurysm size • embolization

Intracranial aneurysms are common. Autopsy studies have shown that the frequency in the general population ranges from 0.4 to 10%. The majority of cerebral aneurysms remain undetected until they rupture. Intracranial aneurysms are commonly classified by locations and sizes because these parameters are important risk factors for rupture. Various thresholds of size have been proposed. The most commonly used system divides aneurysms into 3 groups: small (< 10 mm), large (10–25 mm), and giant (> 25 mm). However, Yaşargil suggested that very small aneurysms should be considered separately and he proposed that aneurysms smaller than 3 mm in diameter should be termed “baby” aneurysms.

The International Study of Unruptured Intracranial Aneurysms (ISUIA) reported that, in the absence of a history of previous rupture, the risk of rupture for small (< 7 mm) anterior circulation aneurysms was low, at only 0.1% per year. However, many experienced neurosurgeons and endovascular therapists report that, in practice, most ruptured aneurysms encountered are small. According to other reports, the extent of SAH after the rupture of small aneurysms is often greater than after the rupture of larger aneurysms.

Endosaccular coil embolization has been widely used to treat ruptured intracranial aneurysms since the introduction of Guglielmi detachable coils and is currently an accepted modality of treatment. This treatment modality has proved to be effective at preventing
rebleeding after aneurysm rupture, and has been shown to provide better outcome in terms of disability-free survival than neurosurgical clip ligation, if the aneurysm is amenable to treatment by either technique.

The aim of this study was to assess treatment results in a series of very small aneurysms to compare rates of morbidity arising from procedural complications, together with patient outcomes, with morbidity rates and patient outcomes found for endovascular coil embolization in aneurysms of all sizes and those reported in the literature.

**Methods**

Between 1995 and 2006, a total of 94 patients with 97 cerebral aneurysms smaller than 3 mm in diameter were referred for endovascular treatment. These patients form the subject cohort for this study. Details of the endovascular treatment of these patients were recorded prospectively in a dedicated database, and additional data were obtained from hospital records, angiograms, and procedure reports.

The cohort included 27 male and 67 female patients, with a mean age of 55 years (median 56 years; range 27–80 years). All patients presented with SAH. Of the 97 aneurysms, 85 were ruptured and 12 were additional aneurysms found in patients after investigation for SAH. These aneurysms were treated during the same procedure because of concern about which aneurysm had ruptured. All patients with SAH were classified immediately prior to endovascular treatment using the WFNS grading scale to determine the clinical severity of the SAH (Table 1); outcomes were graded using the GOS.

Clinical presentation, symptoms, the size and shape of the aneurysm sac, the size of the aneurysm neck, and the patient’s age were evaluated by a multidisciplinary team including neurosurgeons and neuroradiologists. Aneurysm size was measured by visual estimation of 2D DS angiography, performed with a reference calibration object taped to the patient’s head, or by 3D reconstructed rotational angiography. These measurements were qualified by comparison with the diameter of the first coil used. All patients were evaluated clinically 3–6 weeks after the treatment. Follow-up imaging was performed 6 months posttreatment and included DS angiography. Further follow-up was performed by means of DS or MR angiography. If stable occlusion was confirmed in imaging performed 2 or more years postembolization, follow-up surveillance was discontinued.

Endovascular treatment was performed using our previously described protocol which involves general anesthesia, systemic heparinization, and transfemoral arterial access (Figs. 1–3). Only 6 aneurysms were treated with the aid of a remodeling balloon (Fig. 2). In 55 of the successfully embolized aneurysms we deployed 1 coil, whereas in 38 we deployed 2 coils. When a second coil was used, it was most often a soft or ultrasoft coil. We only used coils produced by 3 manufacturers in our series, namely the Guglielmi detachable coil (GDC, Boston Scientific Corp.), the Micrus ACT MicroCoil (Micrus Endovascular), and the Trufill DCS Orbit detachable coil (Cordis Neurovascular). Treatment success was graded according to the extent of occlusion of the treated aneurysm as defined by an “occlusion grade” score. Occlusion grades were defined as: OG1, total occlusion, no contrast filling of the aneurysm sac; OG2, subtotal occlusion, minor residual sac filling or neck remnant; and OG3, incomplete occlusion, substantial residual sac filling.

![Figure 1](image1.png)

**Fig. 1.** Preembolization (left) and postembolization (right) angiograms of a very small ACoA ruptured aneurysm.
Results

The study cohort consisted of 94 patients with 97 very small aneurysms.

Location of the Embolized Aneurysms

The aneurysms were located in the ACoA (43 aneurysms), PCoA (18), MCA (14), AChA (8), PerA (4), ICA bifurcation (1), ACA (1), SCA (3), basilar tip (3), and PCA (1) (Table 2).

Unsuccessful Procedures

In 5 (5.1%) of patients, initial attempts at placing coils failed. All 5 of these patients subsequently underwent craniotomy, and successful clipping was performed in 4.

In 1 of these 4 patients, endovascular treatment of a PCoA aneurysm was completed after deployment of one coil in the aneurysm, but 6-month follow-up DS angiography showed asymptomatic migration of the coil to the ipsilateral MCA with the aneurysm remaining open. A second attempt to occlude this aneurysm endovascularly failed, and the patient underwent successful craniotomy and clipping.

In the fifth patient, an attempt to clip the aneurysm was unsuccessful due to IOR of the aneurysm. This patient then underwent a second session of endovascular treatment which led to complete occlusion of a PCoA aneurysm.

Immediate Angiographic Results

Of the 92 (94.8%) of 97 aneurysms that were treated by coil embolization, 64 (69.6%) were completely occluded (OG1) (Figs. 1–3), and 28 (30.4%) showed minor residual filling or neck remnants (OG2) on an angiogram immediately postembolization.

Procedural Complications

Procedural complications occurred in 7 (7.2%) of 97 procedures, resulting in the death of 2 (2.1%) of the 94 patients and in permanent disability in 1 patient. Complications included intraoperative aneurysm rupture in 4 procedures (4.1%) and thromboembolic events in 3 (3.1%). In 4 of these 7 cases, the complications—2 procedural ruptures and 2 thromboembolic events—were without clinical sequelae. In 3 of these patients, protrusion of a coil loop to the parent vessel was evident without angiographic or clinical consequences. In the fourth patient, who had a PCoA aneurysm, coil migration was evident in the follow-up DS angiogram obtained 6 months posttreatment, but the patient remained clinically asymptomatic. All complications appeared in aneurysms that were ruptured and considered as the cause of hemorrhage.

Clinical Outcome

Clinical follow-up data were available for 83 (92.2%) of the 90 patients who were treated endovascularly. Seven
patients died (GOS Score 1), 2 due to procedure-related complications (namely, IOR), and 5 due to complications related to the initial SAH. Only 1 of these 5 patients was Grade III, according to WFNS grading system; the other 4 patients were Grade IV or V.

The mean duration of clinical follow-up in the 76 surviving patients was 23 months (range 6–60 months). In 61 (67.7%) of these patients the outcome was Grade V or IV, and in 15 (16.6%) it was Grade III.

There were no episodes of recurrent hemorrhages during the follow-up period.

**Imaging Follow-Up**

Angiographic follow-up was performed in 76 (91.6%) of the 83 surviving patients who underwent successful endovascular treatment. In 58 (76.3%) of these 76 cases, follow-up was discontinued after 2 years of angiographic follow-up without evidence of recurrence. In 14 patients (18.4%), follow-up angiography demonstrated very small remnants. As the remnants were very small and considered to be stable in size and shape and not amenable to endovascular treatment, we decided to continue the follow-up with MR angiography.

**Retreatment**

Of the 76 aneurysms that were followed up angiographically, retreatment was considered necessary in 4 (5.3%) due to significant recanalization. These 4 aneurysms were located on the basilar tip, in the PCoA, in the PerA, and in the ACA. Balloon remodeling was used to retreat the PCoA aneurysm. In all cases, retreatment involved the placement of 1 additional coil.

The basilar tip and the PerA aneurysms were each retreated twice, so that each of these 2 aneurysms was treated a total of 3 times. The follow-up scans after the second retreatments both showed small remnants, not amenable to further intervention. Both patients are still being followed up.

Follow-up scans performed after re-embolization showed stable complete occlusion of the 2 other aneurysms.

**TABLE 1: Summary of WFNS SAH grades in 94 patients with very small aneurysms**

<table>
<thead>
<tr>
<th>Grade</th>
<th>No. of Patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>15 (16)</td>
</tr>
<tr>
<td>II</td>
<td>40 (42.6)</td>
</tr>
<tr>
<td>III</td>
<td>28 (29.8)</td>
</tr>
<tr>
<td>IV</td>
<td>11 (11.7)</td>
</tr>
<tr>
<td>V</td>
<td>0</td>
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**Discussion**

The ISUIA data suggest that aneurysms smaller than 10 mm in diameter have higher rates of rupture than previously predicted in the earlier report of this research group. The authors of the study recommend treatment with either microsurgical or endovascular techniques in aneurysms larger than 7 mm, but a significant number of patients seek treatment in daily clinical practice for SAHs resulting from aneurysms 7 mm or smaller. Other studies have shown that, among patients with aneurysms 7 mm or smaller, significant risk factors for rupture are hypertension, younger age, and posterior circulation.

The possibility that small aneurysms are associated with more extensive SAH was first suggested by Roos et al. Taylor et al. also evaluated a series of 127 patients treated over a 2-year period and reported that very small aneurysms (< 5 mm) were more likely to be associated with a higher Fisher grade, although there was no difference in the incidence of vasospasm or overall outcome. Russell et al., in a review of a 100 consecutive patients with SAH, reported that the volume of cisternal blood was inversely related to aneurysm size. This relationship was stronger for ACoA and PCoA aneurysms. In a recent report, however, Salary et al. found no relationship between aneurysm size, volume of subarachnoid blood, and clinical outcome.

The endovascular treatment of very small aneurysms can be technically demanding. Suzuki et al. reported that a series of 21 patients with very small ruptured an-
The incidence of thromboembolic events was low in our series (3 [3.1%] of 97 procedures). This may be explained by the following reasons: First, the necks of very small aneurysms are small, making the coil surface that is in contact with blood flow in the parent artery minimal. Second, our use of a remodeling balloon was limited to very few procedures.

The recanalization and retreatment rate (5.3%) in our group was also low compared with rates reported for larger series involving aneurysms of various sizes.5,18,20 There are other reports in the literature stating that satisfactory stability was achieved in small aneurysms treated with a single coil despite a low average packing attenuation. The coil-embolization ratio (packing density) was not predictive of recurrence in small intracranial aneurysms treated with a single detachable coil.1 However, to increase packing density in very small aneurysms and therefore to prevent recanalization, we used a soft or ultrasoft coil as the second coil whenever this was technically feasible.

The technical difficulties and the higher incidence of complications in the management of very small aneurysms has prompted some to propose alternative techniques. Henkes et al.15 reported 3 endovascular techniques for the treatment of very small aneurysms: stent grafts, coaxial deployment of 2 stents, and intraneurymal glue injection. Doerfler et al.9 described a double-stent technique for the treatment of small, wide-necked, ruptured aneurysms. Any advantage of such techniques has yet to be assessed in larger series.

Conclusions

A significant number of SAHs are caused by very small aneurysms. In this case series, endosaccular coil embolization of very small aneurysms was associated with relatively high rates of complications, specifically IOR, but recanalization rates proved modest despite nearly a third of aneurysms showing residual filling at the end of procedures. With the advent of more sophisticated endovascular materials (microcatheters and microguidewires, soft and ultrasoft coils, and stents) endovascular procedures are likely to improve, leading to better angiographic and clinical outcomes.

Disclaimer

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

References


I. Ioannidis et al.

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Address correspondence to: Ioannis Ioannidis, Erythrou Stavrou 4, 15123 Marousi, Athens, Greece. email: iioann@hotmail.com.