Progressive Occlusion and Recanalization After Endovascular Treatment for 287 Unruptured Small Aneurysms (<5mm): A Single-Center 6-Year Experience

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■ OBJECTIVE: **We aimed to investigate the effect of coiling for small unruptured intracranial aneurysms (UIAs) (<5 mm) on progressive occlusion and recanalization, and the dubious factors related to progressive occlusion and recanalization among UIAs without complete occlusion.**

■ METHODS: **A total of 264 patients with 287 small UIAs were coiled in our institution between June 2009 and December 2014. All UIAs were divided into small (3–5 mm) and very small (<3 mm) groups, and UIAs without initial complete occlusion were divided into progressive, stable, and recanalization groups. Baseline characteristics, procedure-related complications, angiographic follow-up results, and clinical outcomes were statistically analyzed.**

■ RESULTS: **Among 287 aneurysms, 211 aneurysms (73.5%) were completely coiled, 3 (1.2%) had intraoperative ruptures, and 12 (4.2%) had perioperative thromboembolic events. Angiographic follow-up was available for 174 patients (65.9%), and the incidence of recanalization was 5.7%. Among 56 aneurysms without complete occlusion, 43 (76.8%) had progressive occlusion and 6 (10.7%) had recanalization. Anatomic results of initial and follow-up between the small and very small groups were similar. On logistic regression analysis, smaller size (<3 mm) without complete occlusion related to recanalization (odds ratio, 8.0, 95% confidence interval 1.3–50.0; $P = 0.026$).**

■ CONCLUSIONS: **Our study suggested that coil embolization of small UIAs can achieve a high rate of progressive occlusion and a low rate of recanalization during follow-up. Anatomic results of initial and follow-up between small (3–5 mm) and very small (<3 mm) groups were similar. Smaller size (<3 mm), without complete occlusion, may relate to recanalization.**

INTRODUCTION

Despite great technologic improvements and the published results of The International Study of Unruptured Intracranial Aneurysms (ISUIA), the endovascular treatment of small unruptured intracranial aneurysms (UIAs) has still been debated regarding the indication and use of endovascular treatment as a preventive treatment modality.[1-3] There is no evidence confirming the long-term natural history of small UIAs in unselected populations or advantages to their conservative management versus endovascular coil embolization.[3,4] The challenges of coiling a small UIA are related to the inability to obtain a stable microcatheter position, initial selection, or reselection during coil packing, and risk of intraprocedural rupture due to perforation from packing coils into a shallow, confined sac.[5-7]

Studies comparing the outcomes and complication rates between the endovascular treatment of small and large intracranial aneurysms have found a nonsignificant increase in the frequency of intraprocedural rupture, thromboembolism, and recanalization on angiographic follow-up with coiling of small aneurysms compared with larger aneurysms.[7-9] However, no studies on single or multiple aneurysms have evaluated the factors related to the progressive occlusion and recanalization of small UIAs.

Key words
- Follow-up study
- Recanalization
- Small
- Unruptured intracranial aneurysms

Abbreviations and Acronyms
3D: 3-dimensional
AR: Aspect ratio
DSA: Digital subtraction angiography
mRS: modified Rankin scale
RS: Raymond score
UIA: Unruptured intracranial aneurysm

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In the present study, we performed a retrospective review of 287 UIAs coiled at our institution to investigate the effect of coiling for small UIAs (<5 mm) on progressive occlusion and recanalization, factors related to progressive occlusion and recanalization among UIAs without complete occlusion were also investigated.

METHODS

Study Population

In total, 287 consecutive patients undergoing endovascular coil embolization for small aneurysms at our institution between June 2009 and December 2014 were enrolled. The indication for treatment and its modality depended on interdisciplinary consensus between a vascular neurosurgeon and a neurointerventional specialist based on amenability to embolization considering factors such as irregular or with daughter sac, wide-neck, and bifurcation location. All patients in this study chose endovascular embolization as a primary treatment, and all decisions of treatments were made by these patients after knowing the condition of their aneurysm.

All patients in this study were examined using 3-dimensional (3D) rotational angiography. The exclusion criteria were as follows: 1) patients who had not undergone endovascular treatment; 2) patients without follow-up digital subtraction angiography (DSA) data; 3) inability to evaluate aneurysm geometry, morphology based on 3D rotational angiography; and 4) patients rejected to participate in this study (Figure 1). For all patients, we retrieved data on sex, age, smoking habits, alcohol use, and from medical records, data on hypertension, hyperlipidemia, and diabetes mellitus.

Angiographic Assessment of Morphologic Features

All patients received conventional DSA of the internal and external carotid arteries. Thereafter, 3D rotational angiography was performed to identify aneurysmal morphologic features. Aneurysmal morphology included identification of the following features: multiple intracranial aneurysms (yes/no), irregular shape (yes/no), location, bifurcation aneurysm (yes/no), parent artery diameter (in millimeters), aneurysm neck diameter (in millimeters), maximum aneurysm width (in millimeters), maximum aneurysm width aspect ratio (AR, dome-to-neck ratio), size ratio (ratio of the maximum aneurysm diameter to the average vessel diameter), width/height ratio (ratio of maximum aneurysm width to maximum aneurysm height), and inflow angle. Inflow angle was defined as the angle between the axis of flow in the parent vessel at the level of the aneurysm neck and the aneurysm's main axis from the center of the neck to the tip of the dome.

Endovascular Treatment

All endovascular treatments were performed under general anesthesia. After the 6F arterial sheath was placed in the common femoral artery, 3000 IU of heparin was administered. During the procedure, heparin (3000 IU/500 mL saline) was continually used to rinse the guiding catheter. A 6F guide catheter (Envoy; Codman, Miami Lakes, Florida, USA) was selectively positioned into the parent artery. After a working projection of rotational 3D angiography was obtained, a microcatheter (Echelon-10; ev3, Irvine, California, USA) and a microguidewire (Traxcess-14; Microvention, Aliso Viejo, California, USA) was used for coil embolization of the aneurysm. In most cases, 2 types of coils were used: Axium coils (ev3) and Microplex coils (Microvention). In cases of wide-neck small aneurysms with difficult coiling or for optimal microcatheter support, we used a stent-assisted technique or dual microcatheter technique. For the stent-assisted technique, coil embolization of the aneurysm was performed by recrossing the stent or with the jailed-catheter technique. Two types of stents were used: the Solitaire stent (ev3) and the Enterprise stent (Codman Neurovascular). Aneurysms were packed as densely as possible and it was not possible to implant any coil, and immediate imaging results were systematically confirmed.

Patients with stent-assisted coiling were pretreated with dual antiplatelet therapy (100 mg/d aspirin and 75 mg/d clopidogrel) for 3–5 days. If a stent was deployed, patients were administered clopidogrel (75 mg/d) for 6 weeks and aspirin (100 mg/d) for at least 6 months.

A perioperative thromboembolic event in our study was defined as a clinically evident transient ischemic attack or stroke within 1 month of endovascular treatment or cerebral infarction confirmed by computed tomography or magnetic resonance imaging within 1 month after coil embolization.

Angiographic occlusion at the end of the procedure was assessed by a 3-point Raymond score (RS) as follows: RS 1 was defined as complete occlusion; RS 2, neck remnant; and RS 3, residual sac.[10] We defined the residual neck (<2 mm or Raymond-Roy Scale II) as near-complete occlusion and RS 3 as the incomplete occlusion.

Imaging Follow-Up and Clinical Evaluation

Angiographic follow-up results were evaluated using the RS. Recanalization was defined as an increase in contrast filling at follow-up compared with the initial post-coiling results.[11] Those assessments were made by 2 neuroendovascular specialists who perform the treatment for patients (with an average of 10 years practical neuroendovascular experience). Each patient's clinical status was evaluated using the modified Rankin scale (mRS) by a telephone survey.

Statistical Analysis

Normally distributed continuous data were presented as mean ± standard deviation and categorical data as frequency and percentage. Analysis was carried out with the Student's t-test or the χ^2, Fisher's exact tests, and U test. As predetermined, variables with a $P < 0.20$ in the univariate logistic regression analysis were evaluated in our multivariate analysis. A P value of 0.05 was considered significant. All statistical analyses were carried out with SPSS Statistics for Windows, version 22.0 (SPSS Inc., Chicago, Illinois, USA).

RESULTS

Between June 2009 and December 2014, 264 patients with 287 small UIAs underwent endovascular treatment at our institution. The patient inclusion flow chart is shown in Figure 1. Basic characteristics of included patients are shown in Table 1. Of 264 patients, 201 (71.1%) were women and 83 (28.9%) were men. The mean age of patients was 54.0 ± 9.4 years (range, 22–77 years).