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Therapeutic strategies for residual or recurrent intracranial aneurysms after microsurgical clipping

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ABSTRACT

Objectives: Therapeutic strategies for residual or recurrent aneurysm (RRA) after microsurgical clipping have not been well established. The purpose of this study was to report our retreatment experiences with previously clipped aneurysms and to demonstrate retreatment strategies for these RRAs.

Patients and Methods: From 1996–2016, we treated 68 RRAs after previous clipping. Among them, 34 patients underwent microsurgical retreatment, and the other 34 underwent endovascular retreatment. Radiographic images and clinical data were reviewed retrospectively to determine the treatment efficacy, clinical outcomes, and important factors for selecting the proper treatment modality.

Results: The most common aneurysm location was the middle cerebral artery (50%) in the microsurgery group and the internal carotid artery (47.1%) in the endovascular surgery group ($p = 0.001$). In the microsurgery group, 16 (47.1%) patients had additional clipping without removal of previous clips, 17 (50.0%) had clipping with removal of previous clips, and 1 (2.9%) had bypass surgery with trapping. In the endovascular surgery group, 28 (82.4%) patients had simple coiling, 5 (14.7%) had stent-assisted coiling, and 1 (2.9%) had a flow diverter. Procedure-related complications during retreatment occurred in 4 (5.9%) patients. Complete obliteration was achieved in 51 (75.0%) patients (microsurgery group, 82.4% and endovascular surgery group, 67.6%; $p = 0.002$).

Conclusions: In properly selected cases, treatment of RRAs could be safely performed either by microsurgery or endovascular surgery and result in a good clinical outcome with acceptable morbidity. The decision to choose the treatment modality for RRAs after clipping is not easy but should be considered to lower the risk of retreatment.

1. Introduction

Durability of treatment is a major concern in choosing the proper treatment modality for intracranial aneurysms. Generally, microsurgical clipping is believed to provide definitive and long-term treatment of intracranial aneurysms [1]. However, residual and recurrent intracranial aneurysms (RRAs) can occur after treatment, and RRAs after microsurgical clipping are challenging for neurosurgeons to retreat. Several studies have reported that the RRA incidence after clipping was 5%–8% and that RRAs had a risk of bleeding and growing [2–4]. RRAs after clipping can be treated by microsurgery or endovascular treatment [5–9]. One study reported that surgical treatment was safe and efficient for securing RRAs [6]. Another reported that endovascular treatment was safe as the first line treatment for RRAs [5]. However, retreating RRAs after clipping presents some technical difficulties. The previous clips can obscure an RRA in the operating field and make applying new clips difficult. Arachnoid adhesions caused by the previous operation delay the approach to the RRA and prevent the exposure of normal anatomy, inducing premature RRA rupture, parent artery injury, and brain injury. Though several studies have reported on RRA treatment after clipping, therapeutic strategies for those aneurysms have not been well established. Thus, the purpose of this study was to report our retreatment experience with previously clipped aneurysms and to demonstrate retreatment strategies for these RRAs.

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2. Materials and methods

This retrospective study was approved by our institutional review board, and informed consent was waived. All patients who had cerebral aneurysms and underwent microsurgical clipping at our institution were retrospectively reviewed. Between 1996 and 2016, 6036 aneurysms were treated with either microsurgery or endovascular treatment. We treated ruptured aneurysms. And, treatment criteria of unruptured intracranial aneurysms were (1) patients with symptoms, (2) patients below 60 years of age, (3) with aneurysms larger than 5 mm, (4) with a daughter sac, (5) with prior subarachnoid hemorrhage (SAH) or family history, or (6) change of shape during the follow-up period. For the first treatment, treatment modality was selected based on characteristics of individual patients and intracranial aneurysms through interdisciplinary decision making, offering microsurgery as a primary treatment. The patients' preferences for treatment were also considered. Two microvascular neurosurgeons and two endovascular neurosurgeons decided the treatment strategy, initial treatment plan, and retreatment plan in all cases.

An RRA was defined as an aneurysm previously treated by microsurgical clipping with a remnant, regrowth, or rebleeding during the follow-up period. In the present study, 68 patients with previously clipped RRAs undergone retreatment were included. Our indications for the retreatment of RRAs are as follows: (1) rebleeding, 2) symptomatic RRAs, 3) regrowth of the aneurysms during the follow-up period, or 4) residual sacs due to incomplete or partial clipping. Retreatment was performed when the length of the residual sacs of the aneurysm neck represented enough space (more than 1.5 mm) for the placement of clips or coils.

Forty-nine patients had previous clipping at our institution and 19 at other hospitals. Forty-seven (69.1%) patients were female and 21 (30.9%) male with a mean age of 49.3 ± 11.2 years at the time of retreatment. Thirty-four patients underwent microsurgery, and the other 34 patients underwent endovascular surgery for RRA. Radiographic images and clinical data were retrospectively reviewed to determine the treatment efficacy, clinical outcome, and important factors for selecting the treatment modality. Aneurysm size was classified as small (< 10 mm), large (10–24 mm), or giant (≥ 25 mm). Completeness of retreatment was confirmed by digital subtraction angiography (DSA) or CT angiography (CTA). Clinical outcomes (Glasgow Outcome Scale, GOS) were determined independently by a neurovascular nurse practitioner and two neurosurgeons. A favorable outcome was defined as a GOS of 4 or 5 (moderate disability or better), and an unfavorable outcome was defined as a GOS of 2 or 3 (severe disability or vegetative state). A GOS of 1 indicates death. Thirty-nine patients had a postoperative DSA, and all had a CTA.

2.1. Statistical analysis

Statistical analysis was performed with SPSS 20.0 (IBM software). Baseline characteristics and clinical outcomes were compared between the microsurgery and endovascular surgery groups with the Mann-Whitney U test or Student's *t*-test for continuous variables and the Chi-square test or Fisher exact test for categorical variables. A *p*-value of less than 0.05 was considered statistically significant.

3. Results

Clinical data and patient outcomes are summarized in Table 1. On admission for initial treatment, 58 (85.3%) patients presented with aneurysmal subarachnoid hemorrhage (aSAH). Retreatment was required for rebleeding in 31 (45.6%) patients, regrowth in 20 (29.4%), and remnant in 17 (25.0%). The median interval from the initial clipping until retreatment was 4.9 years (range, 0–20). Patient factors did not differ significantly between the microsurgery and endovascular surgery groups. Aneurysms were small in 52 (74.3%) patients, large in 15 (21.4%), and giant in 3 (4.3%). The RRAs were in the internal carotid artery (ICA) in 20 (29.4%) patients, anterior cerebral artery (ACA) in 21 (30.9%), middle cerebral artery (MCA) in 21 (30.9%), and vertebrobasilar artery-posterior cerebral artery (VB-PCA) in 6 (8.8%). The most common aneurysm location was the MCA (50%) in the microsurgery group and the ICA (47.1%) in the endovascular surgery group, which showed statistical significance ($p = 0.001$).

Procedure-related complications during retreatment occurred in 4 (5.9%) patients: two (2.9%) experienced parent artery injury during microsurgery, one (1.5%) experienced thromboembolic infarction during endovascular surgery, and one (1.5%) experienced postoperative frontal contusion during microsurgery (Table 2). The rate of procedure-related complications did not differ between microsurgery (8.8%) and endovascular surgery (2.9%; $p = 0.609$).

RRAs were completely obliterated in 51 (75.0%) patients, 13 (19.1%) had a neck remnant, and 4 (5.9%) were incomplete. The microsurgery group (82.4%) had more patients with complete obliteration than did to the endovascular surgery group (67.6%, $p = 0.002$). Fifty-one (75.0%) patients had favorable clinical outcomes at discharge, 14 (20.6%) had unfavorable outcomes, and 3 (4.4%) died. All 3 deaths were caused by brain injury due to rebleeding on admission for retreatment. Clinical outcomes at discharge did not differ between groups ($p = 0.584$).

Our treatment strategies for RRAs are listed in Table 3. In the microsurgery group, 16 (47.1%) patients had additional clipping without removal of previous clips, 17 (50.0%) had clipping with removal of previous clips, and 1 (2.9%) had bypass surgery with trapping. In the endovascular surgery group, 28 (82.4%) patients had simple coiling, 5 (14.7%) had stent-assisted coiling, and 1 (2.9%) had a flow diverter in.

3.1. Representative cases

3.1.1. Clipping with removal of previous clips

A 34-year-old woman came to our hospital owing to a left upper extremity paresis and dysarthria. On her MRI, acute infarction was on the right basal ganglia and a giant thrombosed aneurysm was on the right middle cerebral artery bifurcation. The aneurysm was treated by microsurgical clipping and complete obliteration was achieved and confirmed by postoperative 3D digital subtraction angiography (DSA). After 7 years from the clipping, regrowth of the aneurysm was found on her follow-up 3D DSA (Fig. 1a). The recurred aneurysm had a triangular shape and was recurred from the neck portion. It could not be clipped completely without removing three old clips (Fig. 1b). We removed old clips carefully and performed re-clipping (Fig. 1c). Complete obliteration was achieved and confirmed by postoperative 3D DSA (Fig. 1d).

3.1.2. Simple coiling

A 41-year-old man came to our hospital with an asymptomatic giant aneurysm on the left P1-2 junction. The aneurysm was treated by microsurgical clipping using the orbito-pterional approach. While we were removing intra-aneurysmal thrombus to expose the aneurysm neck, massive bleeding from the aneurysm was encountered. We decided to stop the bleeding with partial clipping of the aneurysm and perform endovascular treatment for the residual aneurysm. The residual aneurysm, sized about 2.25 × 1.10 mm, was confirmed on the immediate postoperative 3D DSA (Fig. 2a). Coil embolization without using stents was performed and achieved near complete obliteration of the aneurysm (Fig. 2b).

4. Discussion

Because the incidence of RRAs after microsurgical clipping has been estimated at 5%–8% [2–4], retreatment of these lesions must be discussed individually. RRAs carry a risk of bleeding and growing. The annual hemorrhage risk of RRAs was about 1.9% in dog-ear remnants [3]. The growth rates of dog-ear remnants and broad neck remnants