Original Research

JNET 5:15-22, 2011

Clinical and Angiographic Effects of Endovascular Coil Embolization of Very Small Intracranial Aneurysms

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●Abstract●

Objective: Treatment of very small cerebral aneurysms remains challenging. The aim of the present study was to assess the feasibility and safety of endovascular treatment for these aneurysms.
Methods: Between 2003 and 2008, a total of 831 aneurysms were selectively occluded with coils. Of these aneurysms, 110 (13.2%) were very small (57 ruptured and 53 unruptured). We performed a retrospective analysis of these cases using the Glasgow outcome scale (GOS) for clinical follow-up and digital subtraction angiography (DSA) and/or MR angiography (MRA) for angiographic follow-up.
Results: Mean duration of follow-up was approximately one year. Overall clinical outcome of patients showed 78 patients (76.5%) with good recovery, six (5.9%) with moderate disability, nine (8.8%) with severe disability, five (4.9%) with vegetative state, and four (3.9%) that had died. All asymptomatic unruptured aneurysms showed good recovery. No delayed rebleeding was observed. There were no procedural related complications. We encountered major recanalization in four aneurysms (10%) of the followed-up ruptured aneurysms, requiring re-treatment with coils; there were no major recanalizations in cases of unruptured aneurysms. Six out of nine (67%) unruptured aneurysms showing initial body filling had changed into complete occlusion at later follow up.
Conclusions: Endovascular treatment may be a feasible and effective therapeutic alternative for very small aneurysms. Endovascular coil embolization of very small ruptured aneurysms was effective in controlling hemorrhage; however, this technique requires strict follow-up and may necessitate additional treatment. By contrast, outcome of very small unruptured aneurysms was excellent.

●Key Words●

coiling, endovascular treatment, ruptured aneurysms, small aneurysms, unruptured aneurysms

(Received February 12, 2011 : Accepted June 9, 2011)
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Introduction

Endovascular treatment of intracranial aneurysms is becoming increasingly accepted owing to technical refinements and enhanced clinical skills[9]. However, for very small aneurysms with a maximal diameter less than 3 mm the safety and efficiency of endovascular treatment remains controversial, with considerable disagreement concerning the management of small-sized asymptomatic unruptured aneurysms, even with respect to their relative rupture risk[19,20]. Although accumulating evidence suggests an influence of aneurysm size on rupture risk in patients with unruptured aneurysms, the critical size at which an aneurysm becomes hazardous remains unclear[17,20] Current evidence does not conclusively support a standard treatment strategy for these aneurysms, especially in patients without a previous history of subarachnoid hemorrhage (SAH)[13]. Further, ruptured small aneurysms may cause even more extensive SAH than larger aneurysms[15]. Small aneurysm

Table 1 Patient characteristics

	Ruptured		Unruptured		Total
Number	57		53		110
Female:Male	39 : 18		37 : 16		76 : 34
Age (mean)	27-90 (58.9)		22-90 (59.8)		22-90 (59.3)
	H/H grade		Reasons of detection		
	I	15	Incidental, single	11 (20.8%)	
	II	17	Incidental, multiple	14 (26.4%)	
	III	11	Associated with ruptured aneurysm/s	26 (49.1%)	
	IV	10	Associated with AVM	2 (3.7%)	
	V	4			

AVM : Arteriovenous malformation, H/H : Hunt and Hess scale.

size is a potential risk factor for procedure-related ruptures during endovascular treatment of cerebral aneurysms[8,11]. Direct clipping is also limited because these aneurysms are often thin-walled and have a risk of narrowing or tearing the parent vessel during clipping[10]. As such, in the present study we retrospectively reviewed our endovascular management of very small ruptured and unruptured aneurysms with respect to frequency, clinical results, complications, outcome, and retreatment rate with an assessment of its efficacy and safety.

Patients and methods

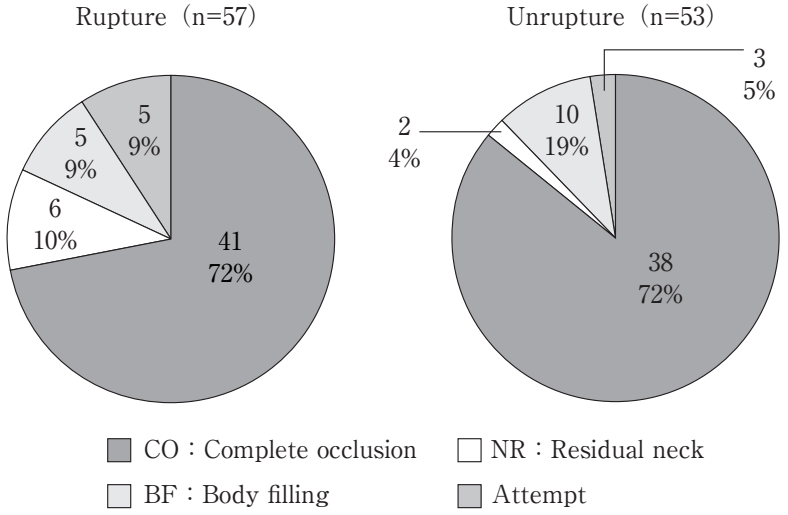
1. Patient characteristics

From April 2003 to May 2008, 831 aneurysms were occluded with detachable coils at our hospital and its affiliated institutions by the same working surgeons. Of these aneurysms, 110 (13.2%) measured less than 3mm in size, including 57 ruptured aneurysms manifesting by SAH and 53 unruptured aneurysms. The mean age of patients with ruptured aneurysms was 58.9 years (range, 27-90 years) and of patients with unruptured aneurysms was 59.8 years (range, 22-90 years). There were 76 (69%) females (39 ruptured, 37 unruptured) and 34 (31%) males (18 ruptured, 16 unruptured). Groups of patients with ruptured aneurysms were assessed by the Hunt and Hess scale (HH), and showed 15 patients with grade Ⅰ, 17 with grade Ⅱ, 11 with grade Ⅲ, 10 with grade Ⅳ, and four with grade Ⅴ. For groups of patients with unruptured aneurysms, lesions were either incidental (20.8% single, 26.4% multiple) or associated with other lesions (49.1% ruptured, 3.7% AVM) (Table 1). Aneurysm locations varied between the anterior and posterior circulation, internal carotid artery (ICA) (28%, n=31), anterior communicating artery (ACoA) (21%, n = 23), anterior cerebral artery (ACA) (12%, n=13), middle cerebral artery (MCA) (18%, n=20), and the posterior circulation (21%, n=23).

2. Therapeutic procedure

Endovascular coiling of aneurysms were chosen if it was deemed the best option after evaluation by the operating team, or if the patient refused surgery for clipping. The indications of therapies for unruptured aneurysms were based on the patients' decisions. All endovascular procedures were performed in a neuro-angiography suite equipped with digital subtraction angiography (DSA), road-mapping, and 3D rotational angiography (3DRA) capabilities under general anesthesia. A baseline activated clotting time (ACT) was obtained and then performed repeatedly throughout the operation in order to maintain ACT at 2-2.5 times that of control patients in order to adjust the dose of systemic heparinization (excluding cases with cerebral parenchymal hematoma). The aneurysms were coiled using Guglielmi detachable coils (GDC; Boston Scientific, Fremont, CA, USA), Orbit Trufill and MiniComplex fill coils (Cordis, Miami Lakes, FL, USA), and Electro Detach

Table 2　Immediate angiographic results



（ED）coil（Kaneka Medix Corporation, Osaka, Japan）. HyperGlide and HyperForm balloon microcatheters（eV3 Neurovascular, Irvine, CA, USA）were used when necessary during the procedure. Proper shaping of the microcatheter is mandatory to obtain its stability and to achieve optimum coiling. After the procedure, patients were moved into the neurointensive care unit until stable, and then to the neurosurgical ward.

3. Follow-up strategy

Clinical follow-up: The Glasgow Outcome Scale（GOS）was used to divide patients into five categories as follows: Good Recovery（GR）, resumption of normal activities even though there may be minor neurological or psychological deficits; Moderately Disabled（MD）, patient is independent as far as daily life is concerned; Severely Disabled（SD）, patient depends upon others for daily support due to mental or physical disability or both; persistent Vegetative State（VS）, patient exhibits no obvious cortical function; Death（D）. Scoring was performed during outpatient follow-up visits.

Angiographic follow-up: Angiographic results were recorded immediately after endovascular treatment and on follow-up, and classified according to Raymond et al.[12] as: Class 1, complete occlusion（CO）; Class 2, residual neck（NR）; or Class 3, residual aneurysm sac（body filling, BF）. Conventional angiography and/or magnetic resonance angiography were used for angiographic follow-up of patients. The degree of recanalization was assessed according to Roy et al.[14] as: unchanged, minor, major（if it is saccular and its size theoretically permits re-treatment with coils）, and thrombosed（showing healing change of the aneurysms）.

Results

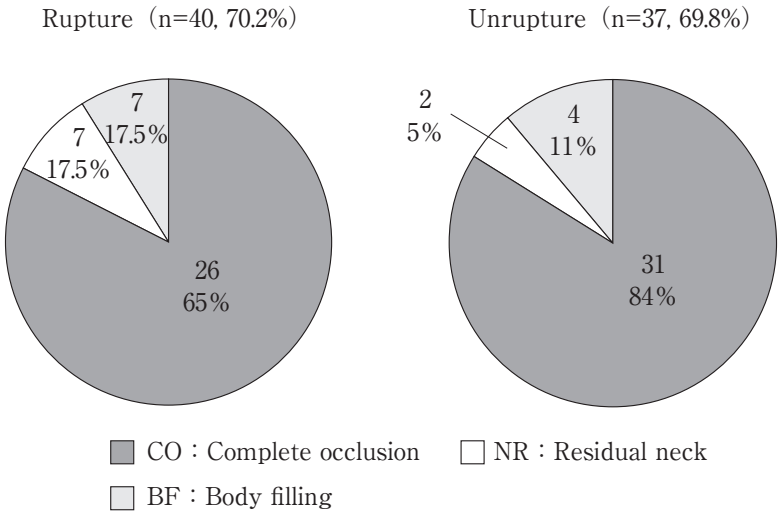
1. Immediate angiographic results

Immediate DSA of the ruptured aneurysms showed 41 aneurysms（72%）with complete occlusion, six（10%）with neck residual, five（9%）with aneurysm body filling, and five（9%）were attempted but failed coiling. DSA of the unruptured aneurysms showed 38（72%）with complete occlusion, two（4%）with neck residual, 10（19%）with aneurysm body filling, and three（5%）were attempted（Table 2）. There were no procedural related complications.

2. Angiographic follow-up

Seventy-seven patients（70%）underwent follow-up angiography. Of these patients, 40/57（70.2%）had ruptured aneurysms and 37/53（69.8%）had unruptured aneurysms. Of the group of ruptured aneurysms, 26 aneurysms（65%）showed complete occlusion, seven（17%）showed neck residual, and seven（18%）showed aneurysm body filling. By contrast, of the unruptured

Table 3 Angiographic follow up



aneurysms group, 31 aneurysms (84%) showed complete occlusion, two (5%) showed neck residual, and four (11%) showed aneurysm body filling (Table 3).

For assessment of the degree of recanalization, major recanalization was observed in four aneurysms (10%) of the followed-up ruptured aneurysms, and required re-treatment with coils (Fig. 1). By contrast, no recanalization was required in cases of unruptured aneurysms. Three out of the four major recurrence cases required a second treatment, and another one case refused additional treatment. The ruptured aneurysms with major recurrence at follow-up showed an increase in size relative to their original size. Thrombosis (indicating healing process) occurred in six of the unruptured aneurysms (16%) compared to two of the ruptured aneurysms (5%). Of the 10 patients with unruptured aneurysms showing initial body filling, one case was missed in the follow-up, while in the remaining nine cases, six aneurysms changed into complete aneurysm occlusion (Fig. 2).

3. Clinical follow-up

The mean clinical follow-up was 381 days (range, 2–1688 days). No delayed re-bleeding was observed. Based on GOS scores, overall clinical outcome of patients harboring ruptured aneurysms showed 33 patients (58%) with a good recovery, six (10%) with a moderate disability, nine (16%) with a severe disability, five (9%) with a vegetative state, and four (7%) died. All patients with asymptomatic unruptured aneurysms showed good recovery.

Discussion

In the present study we retrospectively analyzed our endovascular management of cases of ruptured and unruptured very small aneurysms. Conservative management is a clinically preferred treatment modality in the subgroup of unruptured aneurysms, particularly in old patients with no history of SAH. In such cases, it is likely that clinicians rely on previously published estimates of annual bleeding rates of these aneurysms. However, these estimates vary considerably and depend on study design, study population, and aneurysm characteristics[13,20]. In a study by Wiebers et al.,[20] the 5-year cumulative rupture rates for unruptured aneurysms located in the ICA, anterior communicating artery ACA, or MCA were 0%, 2.6%, 14.5%, and 40% for aneurysms < 7mm, 7–12 mm, 13–24 mm, and ≥ 25 mm, respectively, compared with rates of 2.5%, 14.5%, 18.4%, and 50%, respectively, for the same-sized categories involving posterior circulation and posterior communicating artery aneurysms. Other studies also reported annual ranges of rupture rates among patients with asymptomatic unruptured aneurysms that varied from 0.05–2.3% per year[4,21,22]. Ishibashi et al. also assessed the hazard ratio for

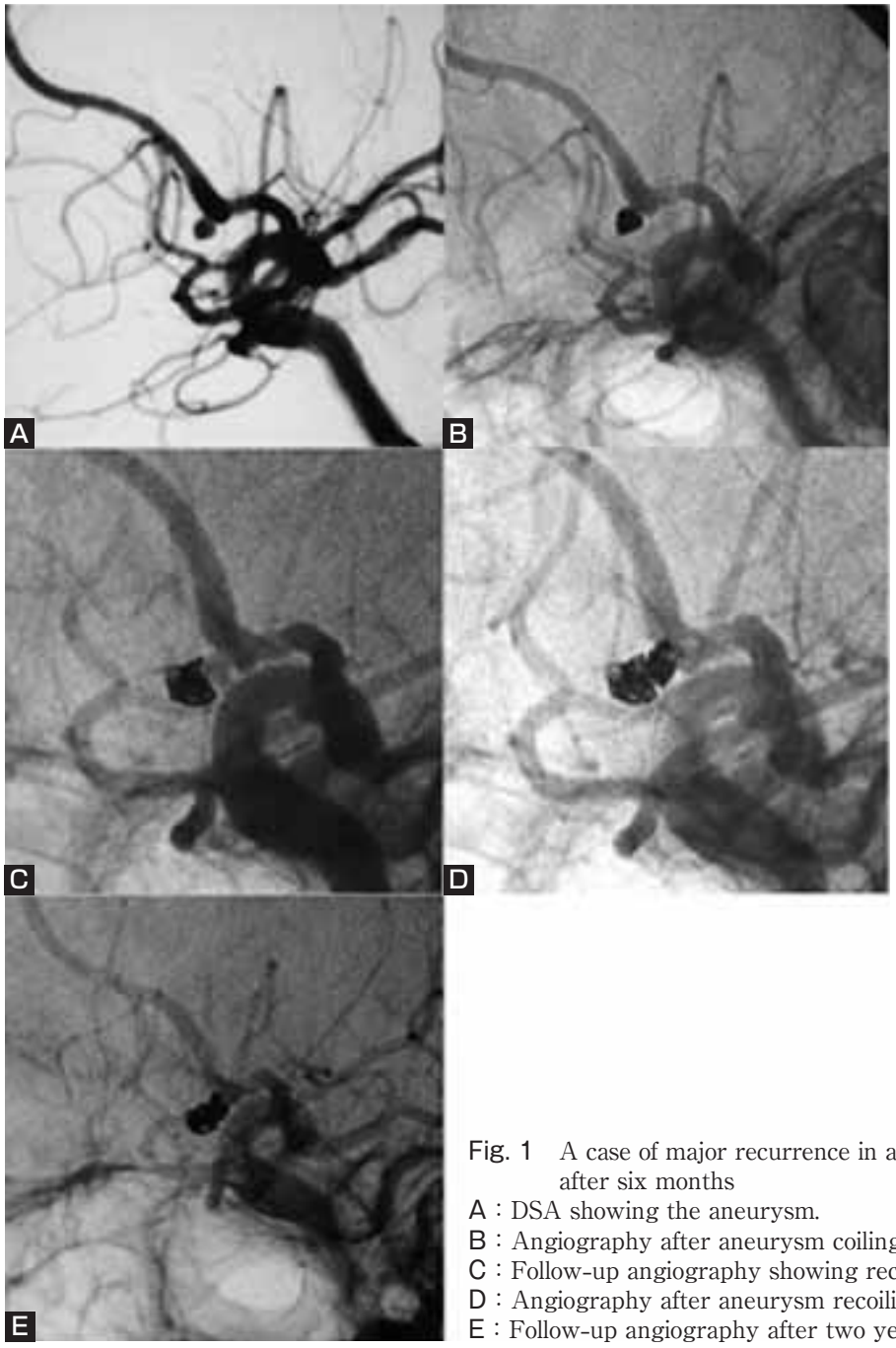


Fig. 1 A case of major recurrence in a coiled ruptured aneurysm after six months
A : DSA showing the aneurysm.
B : Angiography after aneurysm coiling.
C : Follow-up angiography showing recurrence of the aneurysm.
D : Angiography after aneurysm recoiling.
E : Follow-up angiography after two years from recoiling.

aneurysm rupture in cases of unruptured aneurysms with different sizes, and found that history of SAH in the group of small-sized aneurysms greatly increased this ratio to 5.5 (0.9-32.4), and that 25% of the aneurysms developed rupture (two out of eight cases)[2].

Although the risk of rupture is relatively low for aneurysms, there is no evidence validating conservative management for the treatment of small asymptomatic unruptured aneurysms[13]. Additionally, there is evidence that ruptured small aneurysms may cause even more extensive SAH than larger aneurysms[15]. In the present study we had relatively equal numbers of ruptured (n=57) and unruptured (n=53) aneurysms, and found that attempted coiling was higher among ruptured aneurysms (9%) than unruptured aneurysms (5%), likely due to increased coiling difficulty in ruptured

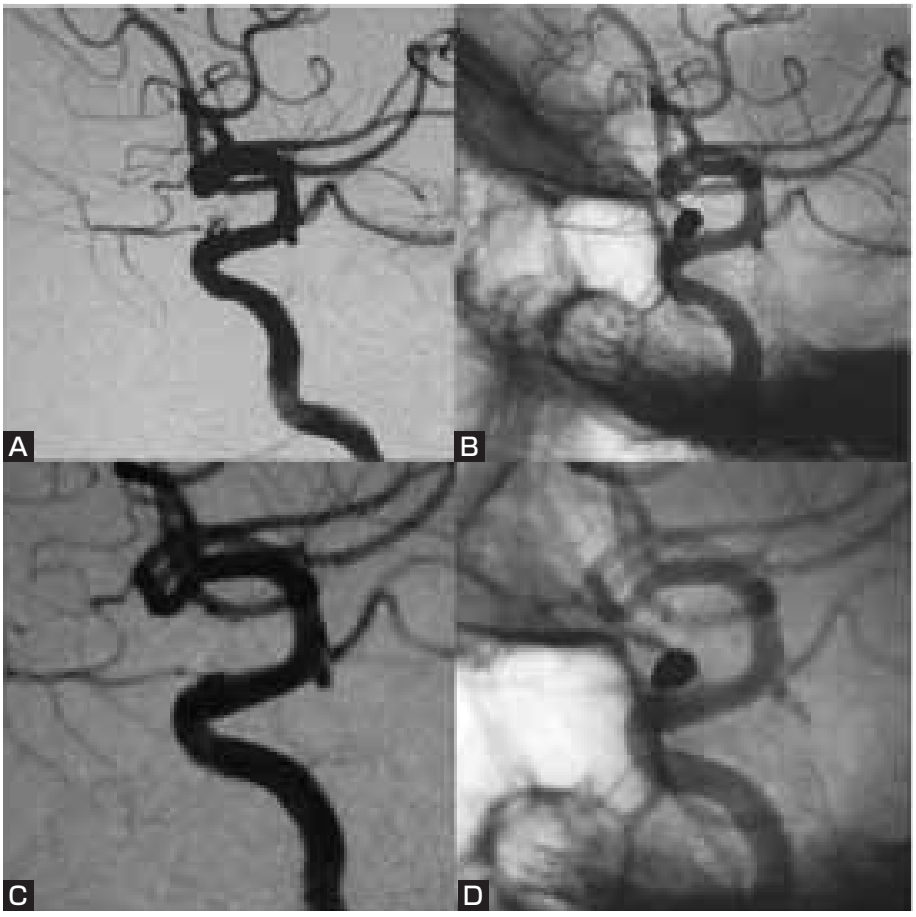


Fig. 2
Healing thrombosis of a coiled aneurysm (A). Immediate DSA and (B) nonsubtracted image after coiling showing body filling (C). DSA and (D) nonsubtracted image after one year the coiled aneurysm showed complete occlusion.

aneurysms. Additionally, our radiological follow-up (one year mean duration) confirmed better results among unruptured aneurysms, as shown by a higher percentage of aneurysms developing thrombosis (a healing effect) that exhibit initial body filling and turning into complete occlusion at follow-up (16% of unruptured aneurysms and 5% of ruptured aneurysms). Six out of nine (67%) unruptured aneurysms showing initial body filling turned into complete occlusion. Further, there was major recurrence in cases of ruptured aneurysms only (10%, n=4). Of note, the size of recanalized ruptured aneurysms after coiling was relatively larger than the original aneurysm size. Enlargement of the aneurysm lumen may result from resolution of the intraluminal thrombus or from resolution of the thrombus in a pseudoaneurysm in an adjacent intraparenchymal hematoma[16]. This may be the one of the reason for high recanalization rate in ruptured aneurysms group. In a study of 489 aneurysms after embolization, Murayama et al.[7] reported that most recanalizations occurred within three months. Further, Vinuela et al.[18] reported that most aneurysm recanalizations with GDCs occurred within three months. Follow-up angiography is essential after embolization of cerebral aneurysms, while post-embolization aneurysm recanalization is usually an early phenomenon. Although endovascular coil embolization appears to be used with increasing frequency, it requires long-term follow-up to ensure the absence of recurrence[3].

In our series, clinical outcome showed that all coiled asymptomatic unruptured aneurysms had good recovery by GOS; however, this was not the case for coiling of ruptured aneurysms. These data suggest that

endovascular treatment is superior to conservative management in this group of small aneurysms. Brinjikji et al. reported in there meta-analysis the risk of periprocedural rupture of the endovascular treatment of very small intracranial aneurysm is higher for larger aneurysms[1]. There were no procedural complications in our cases, which may be the result of precise selection of patients. The proper shaping and positioning of the microcatheter is most important. We chose balloon remodeling technique for 9 aneurysms (16%) in ruptured aneurysms group, and for 11 aneurysms (21%) in unruptured aneurysms group when it was beneficial. A purpose of balloon remodeling technique is mainly supporting a microcatheter. Coiling of very small aneurysms is more challenging than coiling of larger aneurysms[6]. Preventive treatment of unruptured aneurysms should be undertaken by experienced surgeons to obtain optimal outcomes. Moreover, technologic innovations and optimized treatment regimens such as antiplatelet and anticoagulation have significantly reduced morbidity rates in recent years[5]. Limitations of our study are its retrospective design and relatively short follow-up period. Future studies with longer follow-up durations, larger numbers of cases, and a prospective design are required.

Conclusions

Endovascular treatment may be a feasible and effective therapy for very small aneurysms. Coiling of small ruptured aneurysms was effective in controlling hemorrhage. However, this requires strict follow-up and might require additional treatment. By contrast, coiling outcome for small unruptured aneurysms was excellent.

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