

Chapter 2

Treatment of Ruptured Cerebral Aneurysms – Clip and Coil, Not Clip Versus Coil

Yasuhiko Kaku, Kentarou Yamashita, Jouji Kokuzawa, Naoki Hatsuda, and Takashi Andoh

Abstract *Background and aims:* Recent advances in neurosurgery and interventional neuroradiology have brought us a new aspect in the treatment of cerebral aneurysms. The present single-surgeon series provides a balanced overview of the treatment of ruptured aneurysms in surgical clipping and coil embolization.

Clinical materials and methods: One hundred consecutive patients with ruptured cerebral aneurysms underwent surgical clipping or endovascular coil embolization between January 2005 and December 2007. All patients underwent clipping or coil embolization of at least one ruptured cerebral aneurysm by a single neurosurgeon (YK) who performed both the surgical clipping and endovascular coiling.

Results: Of the 48 surgically treated patients, 37 (77.1%) achieved a favorable outcome. Of the 52 patients who underwent endovascular embolization, 37 (71.2%) achieved a favorable outcome. No significant difference was observed regarding the proportion of favorable outcomes between the two treatment modalities. Five patients (9.6%) who underwent endovascular embolization needed re-treatments, while no re-treatment was necessary in the surgically treated patients. The rates of symptomatic vasospasm and shunt dependent hydrocephalus were 18.8% and 14.6%, respectively, in the clipped patients, and 19.2% and 21.2%, respectively, in the coiled patients. Endovascular coiling of ruptured aneurysms has a tendency towards a higher risk of developing shunt dependent hydrocephalus.

Conclusion: A combined microsurgical-endovascular approach can achieve the best outcomes for patients with ruptured cerebral aneurysms. Our findings support the policy of “Clip and Coil, not Clip versus Coil.”

Keywords Cerebral aneurysm · Subarachnoid hemorrhage · Microsurgery · Coil embolization

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Introduction

Recent advancements in neurosurgery and interventional neuroradiology have led us to develop new strategies in the treatment of cerebral aneurysms. There is now a choice of several therapeutic alternatives for the management of cerebral aneurysms. The present series provides a balanced overview of the treatment of aneurysms in surgical clipping and coil embolization. Our findings thus support the policy of “Clip and Coil, not Clip versus Coil.”

Clinical Material and Methods

A total of 100 consecutive patients with ruptured cerebral aneurysms underwent endovascular embolization and/or surgical clipping at Murakami Memorial Hospital, Asahi University, over the period of January 2005 to December 2007. All patients suffered aneurysmal subarachnoid hemorrhage (SAH) and were admitted within 48 h after onset of SAH, 30 patients were male, and 70 were females ranging in age from 23 to 93 years (63.4 ± 9.3 years (mean \pm SD)).

Decisions on how to treat an aneurysm were made on a case-by-case basis, depending on the 3D CT angiography findings (aneurysm location, size, shape, dome–neck ratio, incorporation of normal branches, and tortuosity of the proximal vessels) and the clinical data (patient age, baseline neurological condition, and systemic comorbidities). Endovascular treatment was chosen as the first-line treatment for patients with aneurysms that had the following characteristics; a dome–neck ratio >1.25 , neck <5 mm and no incorporation of normal branches. Patients over 80 years of age or with poor medical condition and poor grade patients (WFNS grade 4) were also candidates for endovascular treatment as first choice treatment. Surgical clipping was applied to other patients and it was also performed in the instance of either failed or attempted endovascular treatment.

All endovascular and surgical procedures were performed by the first author. All endovascular procedures were performed under local anesthesia with/without intravenous infusion of Propofol. A bolus of 3,000 units of heparin was administered after the first coil delivery and full heparinization was maintained thereafter. The trans-brachial approach was performed in most of the cases. GDC coils (Boston Scientific, Fremont, CA) were used for dome embolization. No balloon assisted remodeling technique or stent assisted technique was applied in this series.

All surgical procedures were performed within 48 h of aneurysmal rupture. A simple and less invasive pterional approach or supraorbital approach with a small craniotomy was applied in most cases to avoid any unnecessary insult to the brain parenchyma and vascular structures. Only related cisterns were opened to gain access to the aneurysm, and a minimal amount of the subarachnoid clot was removed around the aneurysm. Titanium clips were routinely used. No drainage catheter was inserted into the CSF pathway, unless hydrocephalus was confirmed.

Postoperatively, all patients were monitored in the stroke care unit until day 14 post SAH. A regimen of normovolemia and normotension was administered for each patient. The daily use of 80 mg of Ozagrel sodium and 90 mg of Fasudil hydrochloride was routinely continued for the prophylaxis of vasospasm. Induced hypertension was started immediately in cases of neurological deterioration attributed to vasospasm. Balloon angioplasty and/or superselective infusion of papaverine hydrochloride was applied for medically intractable symptomatic vasospasm. Either MR angiography for cases that underwent coil embolization or 3D CT angiography for cases that underwent surgical clipping was performed on day 7 post-SAH. Follow-up angiography was performed 6 months following the endovascular procedures, unless a plain craniogram demonstrated coil deformity.

All surviving patients were evaluated on an outpatient basis following hospital discharge. On follow-up, the patients were evaluated to measure their functional ability based on the Glasgow Outcome Scale at 6 months, 1 year and then annually after treatment.

Results

The patients' clinical conditions at the time of admission and the treatment modalities used are shown in Table 1, while the locations of the aneurysms and the treatment modalities used are shown in Table 2. Almost half of the patients underwent surgical clipping or coil embolization, and four cases underwent coil embolization followed by surgical clipping. The proportion of poor grade patients was higher in the coil embolization group than in the clipping group.

Table 1 Summary of clinical conditions at the time of admission and the treatment modalities in 100 patients with aneurysmal SAH

Grade	Clipping	Embolization	Coil→Clip	Total
1	21	19	1	41
2	10	7	1	18
3	5	4	0	9
4	12	18	2	32
Total	48	48	4	100

Table 2 Treatment modality in 100 cerebral aneurysms according to lesion location

Location	Clipping	Embolization	Coil→Clip	Total
ICA	15	13	1	29
MCA	20	5	1	26
ACA	9	23	2	34
BA	1	5	0	6
VA	2	1	0	3
PCA	1	1	0	2
Total	48	48	4	119

Of the 29 internal carotid artery (ICA) aneurysms, 15 (51.7%) were treated using surgical clipping, while 13 (44.8%) underwent endovascular embolization, and one patient underwent coil embolization followed by surgical neck clipping. Of the 26 middle cerebral artery (MCA) aneurysms, 20 (76.9%) were treated using surgical clipping, 5 (19.2%) underwent endovascular embolization, and one patient with a ruptured right MCA aneurysm with an ill-defined neck and mild vasospasm adjacent to the aneurysm underwent tentative coil embolization followed by definitive neck clipping in the chronic stage. Of the 34 anterior cerebral artery (ACA) aneurysms, 9 (26.5%) were treated using surgical clipping, 23 (67.6%) underwent endovascular embolization, and two cases underwent coil embolization followed by surgical neck clipping. Of the 11 posterior circulation aneurysms, four (36.4%) were treated using surgical clipping, including one patient with a posterior inferior cerebellar artery dissecting aneurysm treated by occipital artery to PICA anastomosis and surgical trapping, and seven (63.6%) underwent endovascular embolization.

In the follow-up of the 48 surgically treated patients, 37 (77.1%) achieved a favorable outcome (good recovery: GR and moderately disabled: MD). Of the 52 patients that underwent endovascular embolization, 37 (71.2%) achieved a favorable outcome. No significant difference was observed regarding the proportion of favorable outcome between the two treatment modalities. The outcome of the surgically treated group and the group of patients that underwent endovascular embolization, according to the admission WFNS grade, are summarized in Tables 3 and 4, respectively. The rates of symptomatic vasospasm and shunt dependent hydrocephalus were 18.8% and 14.6%, respectively, in the clipped patients, and 19.2% and 21.2%, respectively, in the coiled

Table 3 Outcome of the surgically treated group according to the admission WFNS grade

Grade	GR	MD	SD	V	D	Total
1	20	1	0	0	0	21
2	8	0	1	0	1	10
3	5	0	0	0	0	5
4	0	3	3	1	5	12
Total	33	4	4	1	3	48

Table 4 Outcome of the group of patients who underwent endovascular embolization according to the admission WFNS grade

Grade	GR	MD	SD	V	D	Total
1	19	0	0	0	1	20
2	7	0	1	0	0	8
3	1	2	1	0	0	4
4	6	2	4	4	4	20
Total	33	4	6	4	5	52

Table 5 Rates of symptomatic vasospasm and shunt-dependent hydrocephalus

	Clipping	Coil mobilization
Symptomatic vasospasm	9/48 (18.8%)	10/52 (19.2%)
Permanent shunt	7/48 (14.6%)	11/52 (21.2%)

Table 6 Causes of unfavorable outcome and death according to the treatment modality in 100 patients with aneurysmal SAH

Cause of unfavorable outcome	Clipping	Embolization
Effect of primary bleed	5	8
Complication of treatment	1	2
Rebleeding	0	1
Vasospasm	4	3
Systemic complication	1	1
Total	11	15

patients (Table 5). Endovascular coiling of ruptured aneurysms has a tendency towards a higher risk for developing shunt dependent hydrocephalus. There was, however, still no significant difference. The causes of unfavorable outcome (severely disabled: SD, Vegetative survival: V and Dead: D) of the surgically treated group and the group of patients that underwent endovascular embolization are listed in Table 6. One patient with a basilar apex aneurysm underwent endovascular embolization, had a rebleeding of the aneurysm 16 days after the initial endovascular treatment and died; another patient with an IC-P-com aneurysm had a minor rebleeding 22 months after the initial endovascular coiling, while no rebleeding was observed in the surgically treated patients. Five out of 52 patients (9.6%) who underwent endovascular embolization needed re-treatment following the initial endovascular treatment, while no re-treatment was necessary in the surgically treated patients.

Figures 1 and 2 demonstrate a typical case treated with efficient collaboration between two treatment modalities.

Discussion

Recent advances in neurosurgery and interventional neuro-radiology have led us to develop new strategies in the treatment of cerebral aneurysms. The published reports of early clinical and angiographical results of endovascular treatment have been promising [1]. The International Subarachnoid Aneurysm Trial (ISAT) is a well-designed and well-executed, randomized, controlled trial on a large number of patients. These data provide the highest level of evidence supporting the use of detachable coils for patients with ruptured cerebral aneurysms suitable for endovascular therapy [2, 3]. The study data allow us to conclude that patients with subarachnoid hemorrhage and aneurysm indicating a high likelihood of success with endovascular therapy should be offered that option. The publication of the results of this trial has sparked heated debate regarding the best current treatment for ruptured intracranial aneurysms [4–6]. In Europe, particularly in the United Kingdom, the study has had a profound effect on the management of ruptured intracranial aneurysms. On the other hand, the ISAT has not had such a significant impact on the neurosurgical vascular practices in Japan and the US. A major criticism of the ISAT is that only a minority of the patients evaluated at the participating centers were indeed enrolled in the trial. For inclusion in the study, the patient in question had to have an aneurysm judged by both a neurosurgeon and a neurointerventionalist to be equally amenable to surgery or endovascular embolization. As a result, only 2,143 of the 9,559 patients screened at the participating centers were actually enrolled in the trial, 78% were excluded. Nine percent of the exclusions were for refusal to participate, while the remaining 69% were excluded from the study because the aneurysm could not be treated by either procedure. A large proportion of these aneurysms were excluded because they probably had a configuration that was not suitable or ideal for coiling. The results of this study therefore do not necessarily justify embracing endovascular embolization as the therapy of choice for the entire population of patients with ruptured intracranial aneurysms. Furthermore, the endpoint in ISAT was assessed at 1 year. The longer-term durability of endovascular therapy, however, remains to be determined. It is possible that an early gain in the lowered rate of periprocedural morbidity and mortality from endovascular therapy, such as that found in this study, could be offset to some degree by a later increase in morbidity and mortality from later aneurysm rebleeding related to aneurysm remnants or recurrences [7–11]. In fact, in the ISAT, the rate of post-procedural hemorrhage up to 1 year in the endovascularly treated patients was 2.6 times that in the surgically treated ones. The long-term follow-up data from the ISAT and other studies should therefore help provide an answer to these questions.

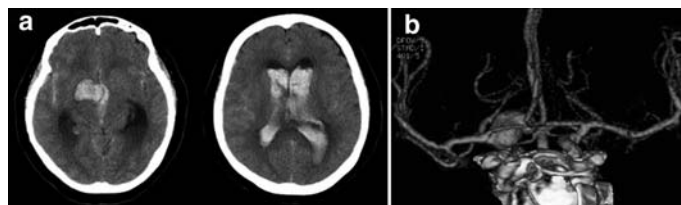


Fig. 1 A 64 year-old woman had a grade 4 subarachnoid hemorrhage due to rupture of a right IC large aneurysm. (a) CT demonstrating a small intracerebral hematoma and massive intraventricular hemorrhage. (b) 3D CT angiography demonstrating a ruptured right IC large aneurysm with a large bleb considered as a rupture point

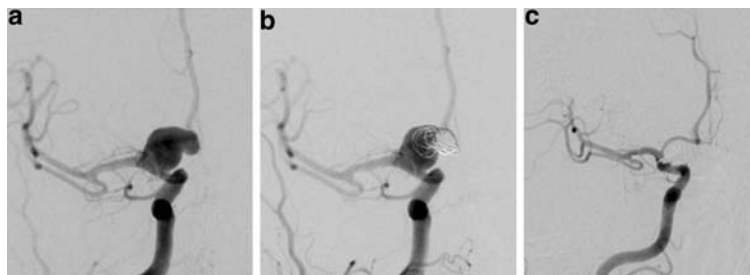


Fig. 2 The treatment strategy for this poor grade patient was as follows: at first tentative coiling for obliteration of the rupture point to prevent acute subsequent bleeding, whereas the configuration of the aneurysm was not suitable for coil embolization. Ventricular drainage was then set with intraventricular UK fibrinolysis. The definitive clipping was, finally, completed at the chronic stage following the recovery

of neurological status. (a) Right carotid angiogram demonstrating a right IC large aneurysm with ill-defined neck. (b) Following the tentative coil embolization, angiogram demonstrating obliteration of the large bleb of the aneurysm. (c) Right carotid angiogram following the definitive surgical clipping, demonstrating complete obliteration of the aneurysm. The patient recovered well and achieved favorable outcome

When making case-by-case evaluation by a combined team of microsurgical and endovascular therapists based on the individual characteristics of each aneurysm, it is likely that a combined microsurgical-endovascular team approach will provide the means to achieve the best outcomes for the entire population of patients with ruptured intracranial aneurysms [12–15]. In treating an individual patient with a ruptured aneurysm, multiple factors must be considered when choosing the optimal course of treatment. Such factors include the aneurysm location, size, shape, and orientation; the tortuosity of the proximal vessels and the parent artery; the presence of calcifications at the aneurysm neck; neck-dome ratio; and patient's chronological and biological age, systemic comorbidities, life expectancy, and neurological condition. For example, it might be more appropriate for an elderly patient or a poor-grade patient with a limited life expectancy to receive no specific treatment or a treatment that is safer than one that provides decades of cure. Similarly, a young patient might forego a safer treatment for one that is more permanent. Excellent results can be obtained with complementary surgical clipping and coil embolization. The two treatment options can be successfully used interchangeably and at times in a complementary fashion to protect the patient from an aneurysm rupture while trying to minimize the complications related to treatment.

To minimize complications, it is very important to assess the risk–benefit ratio constantly even in the advanced phases of surgical or endovascular procedures. If risks greater than those originally estimated or if unexpected findings are encountered while performing either surgery or endovascular embolization, the procedure can be halted and then the patient should be treated with an alternative method.

Conclusion

The selection of interventional neuroradiological techniques requires the careful consideration of the various available neurosurgical techniques, just as the selection of neurosurgical treatment requires an analysis of the endovascular alternatives. The method of treatment for each individual patient should be based on an objective selection of the safest and the most effective treatment, rather than the physician's preference for any specific treatment modality. It is likely that a combined microsurgical-endovascular team approach will provide the best means to achieve favorable outcomes for the entire population of patients with intracranial aneurysms.

Conflict of Interest Statement We declare that we have no conflict of interest

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