CLINICAL ARTICLE

J Korean Neurosurg Soc 38 : 190-195, 2005

Six-year Experience of Endovascular Embolization for Intracranial Aneurysms

Yeun-Ho Jung, M.D.,[1] Seong-Hyun Park, M.D.,[1] Yong-Sun Kim, M.D.,[2] In-Suk Hamm, M.D.[1]

Departments of Neurosurgery,[1] Diagnostic Radiology,[2] School of Medicine, Kyungpook National University, Daegu, Korea

Objective : This study is performed to evaluate the procedural complications, aneurysm occlusion rate, and mid-term outcome of endovascular treatments in intracranial aneurysms.

Methods : We retrospectively investigated 135patients with 161 cerebral aneurysms who were treated by endovascular means at our institute from March 1999 to December 2004. We statistically analyzed overall outcome, occlusion rate, and occurrence of complications according to the location, size, rupture history, and neck size of aneurysms.

Results : Forty-nine patients (36.3%) had experienced acute intracranial or extracranial complications related to the procedure. Among these, there were 13cases of perforation of the aneurysm, 9 of local vasospasm, 8 of thromboembolism, 4 of coil migration, 3 of occlusion of parent vessels due to coil protrusion, and 1 of seizure. Extracranial complications occurred in 14cases including alopecia (9cases), femoral artery thrombosis (2cases), acute renal failure (2cases), and hypovolemic shock (1case). One hundred twenty-six aneurysms (78.3%) had complete occlusion of the aneurysm and 35 (21.7%) incomplete occlusion at 6months angiographic follow-up. Postembolization clinical follow-up ranged from 1 to 60months (mean, 14.2months). Seven of the 161 aneurysms underwent additional embolization and 2 incomplete embolized aneurysms required subsequent surgery.

Conclusion : The procedural complications and incomplete occlusion rates are substantial. Therefore, endovascular treatment needs close and continued neurosurgical and neuroradiological concerns for the therapy of intracranial aneurysms.

KEY WORDS : Intracranial aneurysm · Complication · Endovascular treatment.

Introduction

Endovascular treatment of intracranial aneurysms with Guglielmi detachable coils(GDCs) has become an important alternative to surgical clipping. Despite advances in endovascular therapy, aneurysm embolization may be associated with incomplete occlusion or serious complications, some of which require surgical intervention or additional coil embolization[4,9,12,14].

We undertook a study of 135patients who were treated by endovascular means for cerebral aneurysms to investigate treatment results including the procedural complications, aneurysm occlusion rate in our hospital.

We report our experience of 30patients who had incomplete aneurysm occlusion and 49patients who had 52cases of intracranial and extracranial complications following the embolization procedures.

Materials and Methods

Patients selection

Between March 1999 and December 2004, 135patients with 161 intracranial aneurysms were treated by endovascular treatment, or by a combination of endovascular treatment and surgery at our institute. The hospital records and radiographical studies of the patients were reviewed. Embolization was performed in those patients who either refused surgery or were considered to be at high risk from surgery. Selection of patients for embolization was conducted on an individual basis.

However, the standard indications for the embolization of aneurysms procedure at our institution include : 1) relative surgical contraindication due to difficult aneurysm location or configuration; 2) medically unstable condition (for example, cardiac or pulmonary failure); 3) advanced patient age (greater

• Received : March 3, 2005 • Accepted : May 12, 2005

• Address for reprints : Seong-Hyun Park, M.D., Department of Neurosurgery, School of Medicine, Kyungpook National University, 50 Samdeok 2-ga, Jung-gu, Daegu 700-721, Korea Tel : +82-53-420-5649, Fax : +82-53-423-0504, E-mail : nsdoctor@naver.com

than 75years 'physiologically'); 4) poor neurological status after SAH (Grade IV or V status); 5) recurrent or residual aneurysm after unsuccessful surgical clipping; 6) patient refusal of surgery; and 7) multiplicity.

We retrospectively investigated the clinical characteristics including Hunt-Hess grade, Fisher grade, and shape, type, size, and the location of aneurysms, and the results of treatment. The size of the aneurysms was determined by measuring their maximal diameters on each angiography. The aneurysms were divided into three groups based on the size of their diameters : small, less than 10mm; large, between 11 and 24mm; and giant, more than 25mm. The size of the aneurysmal neck was classified as small (≦4mm) and wide (>4mm). Neurological outcome was assessed during the 6 or 12months follow-up visit using the Glasgow Outcome Scale(GOS). According to this scale, outcome was divided into five categories : good recovery(GR), moderate disability(MD), severe disability(SD), persistent vegetative state(V), and death(D). A favorable outcome included GR, MD and an unfavorable outcome belonged SD, V, D.

Complications associated with endovascular treatment

Complications associated with embolization of aneurysms include intracranial hemorrhage from aneurysm rupture or vessel perforation, and ischemic symptoms. Intracranial hemorrhage may occur following perforation of the aneurysm or an intracranial vessel with the microcatheter or guide wire. And rebleeding may occur after incomplete occlusion.

Ischemic symptoms following embolization may be either acute or delayed. They may result from thromboembolic phenomena, local vasospasm, or from hemispheric hypoperfusion secondary to parent vessel occlusion.

Postembolization follow-up

The degree of aneurysm occlusion was classed as 'complete or near complete occlusion', which was defined as 90 to 100% obliteration of aneurysmal sac ; 'partial occlusion' which was defined as below 90% obliteration and some contrast filling of the sac still observed due to incomplete GDC packing[7,11,16]. Follow up was defined as the period of time from endovascular treatment to the last contact with the patient. Postembolization clinical follow-up duration ranged from 1 to 60months (mean, 14.2months). The follow-up angiographic study was performed 6months after endovascular treatment.

Statistical analysis

The data are expressed as mean values. For statistical comparison, we performed a Student unpaired t-test, and chi-square test using SPSS 11.0 windows. In all cases, p values less than 0.05 were considered to be statistically significant.

Results

Patients' selection criteria for embolization or surgery

One hundred thirty-five patients were treated by endovascular means or coil embolization at our institute. Endovascular treatment was chosen in 25patients due to difficult aneurysm location or configuration; 20 for medically unstable condition; 17 for patient refusal of surgery; 8 for recurrent or residual aneurysm; 6 due to advanced patient age; 5 due to multiplicity; 4 due to poor neurological status. Sixteen patients with two or more aneurysms underwent embolization in addition to direct clipping (Table 1).

Table 1. Criteria for endovascular treatment in 135patients with intracranial aneurysms

Reasons	No. of patients(%)
Difficult aneurysm location or configuration	75 (55.6)
Medically unstable condition	20 (14.8)
Patient refusal of surgery	17 (12.6)
Recurrent or residual aneurysm	8 (5.9)
Advanced patient age	6 (4.4)
Multiplicity	5 (3.7)
Poor neurological status after SAH	4 (3.0)

Table 2. Baseline clinical characteristics of 135patients with endovascular treatment of intracranial aneurysms

Clinical characteristics	No. of cases(%)
Sex	
Men	29 (21.5)
Women	106 (78.5)
Hunt–Hess grade	
0	25 (18.5)
I, II	52 (38.5)
III	39 (28.9)
IV, V	19 (14.1)
Fisher grade	
1	26 (19.3)
2	39 (28.9)
3	37 (27.4)
4	33 (24.2)
Type	
Ruptured	101 (62.7)
Unruptured	60 (37.3)
Size	
Small	101 (62.7)
Large	54 (33.6)
Giant	6 (3.7)
Neck size	
Wide	59 (36.6)
Small	102 (63.4)
Multiplicity	39 (28.9)
Overall outcome	
Favorable	113 (83.7)
Unfavorable	22 (16.3)

Demographic and clinical characteristics of endovascular treatment patients

Age and sex distribution

The patient population consisted of 29men (21.5%) and 106women (78.5%), and their average age was 58.5years (31~83). The baseline characteristics of the patients population are summarized in Table 2.

Location, type, and size of aneurysms

Fig.1 shows the diverse locations of aneurysm occurrence. The most frequent aneurysm location was posterior communicating artery (39cases, 24.2%), followed by the basilar tip (28cases, 17.4%), and ophthalmic artery (22cases, 13.7%). Ninety-eight lesions (60.9%) occurred in the anterior circulation and 63 (39.1%) in the posterior circulation. One hundred and one aneurysms (62.7%) were ruptured and 60 aneurysms (37.3%) were unruptured. Ninety-six patients (71.1%) had one aneurysm, 29 had (21.5%) two aneurysms, and 10 (7.4%) had three or more aneurysms. One hundred and one aneurysms (62.7%) were classified as small, 54 (33.6%) as large, and 6 (3.7%) as giant. The aneurysmal neck size was divided into small, 102 (63.4%), and wide, 59 (36.6%).

Neurological state and finding of computerized tomography(CT) scans on admission

On admission, the Hunt and Hess grade was evaluated as shown in Table 1. We classed 25patients as Grade 0, 52 as Grade I and II, 39 as Grade III, and 19 as Grade IV and V. The Fisher's grade on admission was also evaluated. Twenty-six (19.3%) patients did not show blood on brain CT (Grade 1), 39patients (Grade 2), 37 (Grade 3), and 33 (Grade 4).

Overall outcome of treatments

A favorable outcome (GR, MD according to GOS) was obtained in 113patients (83.7%); GR, 74.1%; MD, 9.6%, and an unfavorable outcome (SD, V, D) was observed in 22patients (16.3%); SD, 8.9%; V, 0.7%; D, 6.7%.

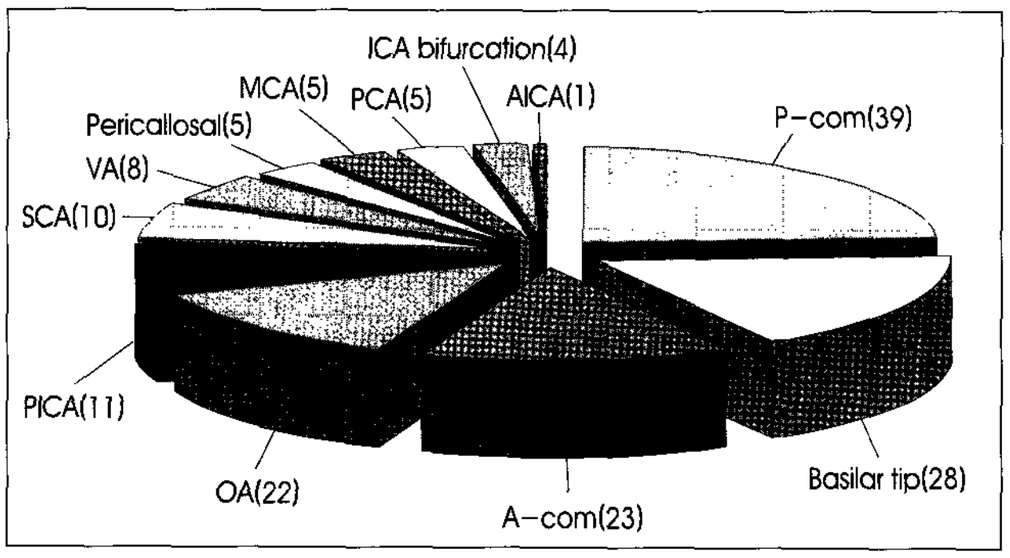

Fig. 1. Aneurysmal locations in 135patients with 161 aneurysms. P-com = posterior communicating artery ; A-com = anterior communicating artery ; OA = ophthalmic artery ; MCA = middle cerebral artery ; PICA = posterior inferior cerebellar artery ; SCA = superior cerebellar artery ; VA = vertebral artery ; PCA = posterior cerebral artery ; AICA = anterior inferior cerebellar artery.

Angiographic aneurysm occlusion & clinical outcome

One hundred twenty-six aneurysms (78.3%) had complete occlusion of the aneurysm and 35 (21.7%) incomplete occlusion at 6months angiographic follow-up. Table 3 shows the clinical characteristics of 35 aneurysms of 30patients with incomplete occlusion. In this group, 18 aneurysms (51.4%) were large and 26 aneurysms (74.2%) had a wide neck. Aneurysmal size and neck size were significantly related to the degree of aneurysm occlusion (each, $p<0.05$), but were unrelated to rupture history and aneurysmal location. The 30patients with incomplete occlusion were subcategorized according to GOS. A favorable outcome was obtained in 24patients : GR (21patients), MD (3patients). An unfavorable outcome was shown in 6patients : SD (5patients), D (1patient). There was no statistically significant difference in overall outcome between the complete and incomplete occlusion groups (p=0.52).

Of 30patients with incomplete obliteration, 7patients required additional embolization following incomplete embolization and 2patients underwent surgical treatment. Rebleeding was not found after primary GDC packing even in the incomplete occlusion group. However, two patients presented with rebleeding from remnant or recurrent aneurysms following

Table 3. Clinical characteristics of 35 aneurysms with incomplete occlusion

Clinical characteristics	No. of cases(%)	p value
Rupture history		0.43
Ruptured	24/101 (23.8)	
Unruptured	11/60 (18.3)	
Size		0.02
Small	15 (42.9)	
Large	18 (51.4)	
Giant	2 (5.7)	
Neck size		0.00
Small	9 (13.8)	
Wide	26 (74.2)	
Overall outcome		0.52
Favorable	24 (80.0)	
Unfavorable	6 (20.0)	
Location		0.86
P-com	11 (31.4)	
Basilar tip	7 (20.0)	
OA	6 (17.2)	
A-com	4 (11.4)	
ICA bifurcation	2 (5.7)	
PCA	2 (5.7)	
PICA	2 (5.7)	
Distal ACA	1 (2.9)	

P-com = posterior communicating artery ; OA = ophthalmic artery ; A-com = anterior communicating artery ; PCA = posterior cerebral artery ; PICA = posterior inferior cerebellar artery ; ACA = anterior cerebral artery

incomplete surgical clipping. The patients underwent GDC embolization as the second procedure, however, aneurysms were still partially occluded at 6months follow-up angiogram.

Procedural complications

Table 4 shows the procedural complications in 49 (49.3%) of 161patients. Forty-nine patients (36.3%) had experienced 52cases of acute intracranial (28.1%) or extracranial (10.4%) complications related to the procedure. Complications related to the embolization included 38 intracranial and 14 extracranial complications. Of 38 intracranial complications, there were 13cases of perforation of aneurysm, 9 of local vasospasm, 8 of thromboembolism, 4 of coil migration, 3 of occlusion of parent vessels due to coil protrusion, and 1 of seizure. Extracranial complications occurred in 14cases including alopecia areata (9cases), femoral artery thrombosis (2cases), acute renal failure (2cases). And, hypovolemic shock occurred in 1 case by the unskilled direct carotid artery puncture. Among 38patients with intracranial complications, 9patients (6.7%) had a permanent neurological deficit resulting from the embolization and 9 (6.7%) a transient deficit. Table 5 shows the clinical characteristics of 64 aneurysms with 52 procedural complications. The occurrence of procedural complications was not significantly related to aneurysm size, neck size, aneurysm location, or rupture history. The 49patients with procedural complications were divided according to GOS. A favorable outcome was obtained in 38patients : GR (31patients), MD (7patients). An unfavorable outcome was shown in 11patients : SD (6patients), D (5patient). There was no statistically significant difference of overall outcome between the groups with or without complications (p=0.14).

Table 4. Fifty-two procedural complications in 49patients

Complications	No. of cases(%)
Intracranial complications	38 (28.1)
Perforation of aneurysm	13 (9.6)
Local vasospasm	9 (6.7)
Thromboembolism	8 (5.9)
Coil migration	4 (3.0)
Parent artery occlusion	3 (2.2)
Seizure	1 (0.7)
Extracranial complications	14 (10.4)
Alopecia areata	9 (6.7)
Femoral artery thrombosis	2 (1.5)
Acute renal failure	2 (1.5)
Hypovolemic shock	1 (0.7)

Table 5. Clinical characteristics of 49patients with 64 aneurysms related to procedural complications

Clinical characteristics	No. of cases(%)	p value
Rupture history		0.09
Ruptured	35/101 (34.7)	
Unruptured	11/60 (18.3)	
Size		0.07
Small	40 (62.5)	
Large	19 (29.7)	
Giant	5 (7.8)	
Neck size		0.13
Small	45 (70.3)	
Wide	19 (29.7)	
Overall outcome		0.14
Favorable	38 (77.6)	
Unfavorable	11 (22.4)	
Location		0.93
P-com	15 (23.4)	
Bailar tip	12 (18.8)	
A-com	12 (18.8)	
OA	7 (10.9)	
SCA	5 (7.9)	
PICA	4 (6.3)	
PCA	2 (3.1)	
ICA bifurcation	2 (3.1)	
MCA	2 (3.1)	
VA	2 (3.1)	
Distal ACA	1 (1.5)	

P-com = posterior communicating artery ; A-com = anterior communicating artery ; OA = ophthalmic artery ; SCA = superior cerebellar artery ; PICA = posterior inferior cerebellar artery ; PCA = posterior cerebral artery ; MCA = middle cerebral artery ; VA = vertebral artery ; ACA = anterior cerebral artery

Discussion

Since 1990, embolization of intracranial aneurysms with coils have been commonly performed. This modern endovascular technique permits treatment of intracranial aneurysms in many circumstances, particularly when surgery is associated with significant morbidity[4,7,9,12-14,16]. In some institutes embolization is now proposed as the initial method of treatment[1,7,10]. As with all procedures, complications and treatment failures occur. Occasionally, embolization of aneurysms is unsuccessful or incomplete, or is followed by complications, in which case surgery or additional embolization is required. Our study showed that 36.3% of patients had procedural complications including variable intracranial (28.1%) or extracranial (10.4%) manifestations. Most literature has concentrated only on intracranial complications, therefore, a simple comparison with other reports about rate of occurrence of complications is not appropriate. The rate of complications was variable, however, the occurrence rate of procedural complications in our study seems to be higher than that in other reports. Ko et al. showed 22.5% of 40patients had procedural complications[6]. Vinuela et al. reported that technical intracranial complications (9.18%) were observed during or after the procedure. These complications included aneurysm perforation (2.7%), parent artery occlusion (3%), cerebral embolization (2.48%), coil migration (0.5%), and local vasospasm (0.5%)[17].

The perforation of the aneurysmal wall secondary to the force of the coils was the most common complication in our study (9.6%). The rupture can frequently be sealed with the immediate administration of protamine and with the rapid deposition of further coils into the aneurysm lumen.

Ischemic symptoms during or following embolization resulted from local vasospasm (6.7%), thromboembolism (5.9%), and parent artery occlusion (2.2%) in our study. Some authors reported that cerebral thromboembolism was the most frequent procedural complication and it was ranging from 1 to 17%[2,10]. We initially treated the patient with anticoagulation and/or antiplatelet therapy, and started with the hypertensive and hypervolemic therapy. Lack of response to this regimen required more aggressive intervention. Following intracranial complications related to the embolization, transient neurological deficit occurred in 6.7% and permanent deficit in 6.7% of our cases. These results are similar to those previously reported. Vinuela et al. reported that there was a 8.9% immediate morbidity rate related to technique[17]. Murayama revealed that the new deficit/death rate was 9.4%[10]. However, Sluzewski strongly suggested that selective occlusion of intracranial aneurysms with coils was a widely accepted treatment modality with a procedure-related permanent complication rate of 3.7%[15]. Asymptomatic coil migration into the parent vessel occurred in four of our cases (3.0%). This situation was not difficult to resolve using the above regimen without neurointervention. Failure of embolization may be a consequence of difficulty in positioning the microcatheter within the aneurysm in elderly, hypertensive patients with tortuous, atherosclerotic vessels. Usually, a direct carotid artery puncture will allow access to the aneurysm by bypassing a tortuous aorta. However, it is necessary to handle the carotid artery puncture catheter carefully to prevent a serious complication -hypovolemic shock in our case.

We observed alopecia areata in 9patients (6.7%). These patients had hair loss over their temporoparietal or occipital areas. The alopecia is considered to be related to repeated exposure to radiation during embolization. Therefore, radiation use should be limited to the least amount necessary to complete the endovascular procedure in order to prevent radiation-induced biological changes and morbidity. Patients should be well informed of adverse effects such as alopecia[8,18].

All techniques developed to date for the intravascular occlusion of aneurysms, whether relying on balloons or coils, may result in incomplete occlusion. This is particularly evident in giant aneurysms or those with wide necks[5,7,9]. Large or giant aneurysms have wide necks than small aneurysms, which increases the risk of coils herniating into the parent vessel, making successful occlusion more difficult to achieve. Our study shows that incomplete occlusion was significantly related to aneurysm size and neck size. Larger aneurysms with wider necks may show a higher rate of recanalization and therefore will more often need an additional treatment to prevent rupture in the long-term. Our study showed that 30patients (22.2%) had incomplete occlusion. Rebleeding from aneurysm with partial occlusion did not occur in those patients. These results are silmilar to a recently reported series of patients treated by endovascular means. Murayama et al. showed that the overall recanalization rate was 20.9% after 11years[10]. Park et al. reported that rebleeding from incomplete occluded aneurysms occurred in 1 (5.0%) of 20 aneurysms[11]. However, Murayama et al. revealed that recanalization was exhibited in 26.1% of aneurysms after initial 5year's experience and 17.2% of those after later 6year's experience using endovascular embolization. Feuerberg et al. reported an annual risk of rebleeding for residual aneurysms that may be as high as 0.79% per year, less than the risk from unclipped aneurysm but still significant[3]. They also suggested that small remnants can enlarge and rebleed. Thus, an attempt at complete obliteration of residual aneurysms would seem justified if the procedure can be performed with acceptably low risk.

Of 30patients with incomplete occlusion, 7patients required additional embolization for remnant or recurrent aneurysms and 2patients underwent surgical treatment. Twenty-one (70.0%) of 30patients have only been treated conservatively. The decision to conserve in those patients depended on multiple factors, including the location of the aneurysm, the age and condition of the patient, and the size of the remnant aneurysm. For example, we treated conservatively a stable 3mm remnant basilar tip aneurysm in older patients whereas operated or embolized recurrent aneurysms in the anterior circulation in young patients. In some cases, further embolization may risk branch vessel occlusion.

In our study, there was no significant difference in overall outcome between the groups with or without complications associated with embolization. Also, the degree of aneurysm occlusion did not have a statistically strong relation with treatment outcome. In our institute, 70% of patients with incomplete occlusion aneurysm were treated with conservative treatment and just followed up angiographically and clinically without further coiling or surgery. Also, no patient treated with GDC occlusion had aneurysmal rebleeding during follow-up; this observation suggests excellent mid-term effectiveness in preventing rebleeding. Furthermore, many procedural complications were generally well managed by medical treatment or interventional therapy without severe sequelae. Therefore, occurrence of procedural complications seem to have no significant relations with the patients' overall outcome. Our study has some weaknesses, of which the main one is the variability of angiographic follow-up after embo-

lization. Only 34.8% of patients visited for follow-up. The long-term completeness of occlusion after coiling, therefore, is still unknown.

Conclusion

The procedural complications and incomplete occlusion rates are substantial. Therefore, endovascular treatment needs close and continued neurosurgical and neuroradiological concerns. Especially, those patients with larger aneurysms with wider necks are in greater need of after-care. With increasing experience, both completeness of occlusion and clinical results are expected to improve.

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Commentary

The authors present a retrospective study of 135patients with 161 cerebral aneurysms who were treated by endovascular coil embolization during six years. The aim of the study was to evaluate the complications related to endovascular procedure, aneurysm occlusion rate and mid-term outcome after endovascular treatment of aneurysm. The result shows the rate of complete occlusion of aneurysm with coil embolization was 78.3% at six months angiographic follow-up, the rate of complications related to the endovascular procedure was 36.3% and the rate of a favorable outcome was 83.7%. As expected, large and wide neck of aneurysm were associated with lower occlusion rate.

The rate of complete occlusion and favorable outcome after treatment of aneurysm with coiling correspond to other series[1,2] in spite of high occurrence rate of complication related to endovascular procedure. Recently more and more patients prefer to be treated by coiling rather than clipping. therefore, it is important to analyse the complication rate and outcome with endovascular treatment of aneurysm. This article has the value in this point and contribution to growing literatures demonstrating that endovascular coil embolization is an effective and safe therapy for intracranial aneurysm. However, we need to know more long-term follow-up results occlusion rate of aneurysm, management morbidity and mortality rate of aneurysm patient who had been treated with coil embolization.

Man-Bin Yim, M.D.
Keimyung University School of Medicine

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