의학석사 학위논문

Recanalization of posterior communicating artery aneurysm after coil embolization

코일 색전술 후 후교통동맥 동맥류의 재관류(recanalization)

2016 년 02 월

서울대학교 대학원

의학과 석사과정

한 상 현

A thesis of the Degree of Master of Science

코일 색전술 후 후교통동맥 동맥류의 재관류(recanalization)

Recanalization of posterior communicating artery aneurysm after coil embolization

February 2016

The Department of Medicine,
Seoul National University
College of Medicine
Sang-Hyun Han

Recanalization of posterior communicating artery aneurysm after coil embolization

Sang-Hyun Han, M.D.

Director: O-Ki Kwon, M.D., Ph.D.

A thesis submitted to the Department of Medicine in partial fulfillment of the requirements for the Degree of Master of Science in Medicine at Seoul National University College of Medicine

February 2016

Approved by Thesis Committee:

Professor Mun-Ku Han **Chairman**

Professor O-Ki Kwon **Vice chairman**

Professor Seung-Jae Hyun

ABSTRACT

Introduction: The purpose of this study is to investigate clinical and radiological outcomes related to the recanalization of posterior communicating artery (PcomA) aneurysms after coiling. Comparative analysis was conducted to determine the factors related to the recanalization of PcomA aneurysms after coil embolization and rupture of the recanalized aneurysms.

Methods: This study included 176 PcomA aneurysms in 169 patients treated by endovascular coiling at a single center from May 2003 to February 2014. They underwent follow-up digital subtraction angiography or magnetic resonance angiography ≥ 1 year.

Results: Recanalization developed in 47 cases (26.7%). Among them, 7 recanalized aneurysms presented with rupture. Risk factors for the recanalization were ruptured aneurysm at initial presentation ($p = 0.043$; odds ratio [OR] 2.158, confidence interval [CI] 1.023–4.550), size larger than 10 mm ($p = 0.001$; OR 16.682, CI 3.292–84.541), and longer follow-up duration (longer than 48 months; $p = 0.002$; OR = 3.105, CI 1.187–5.231) in multivariate analysis. Angiographically, all of the ruptured recanalized aneurysms showed sac regrowth ($p = 0.009$). The deviated direction of the recanalized part was significantly related with rupture of the recanalized aneurysm ($p = 0.019$; OR 14.250, CI 1.808–112.323).

Conclusions: The recanalization risk factors of PcomA aneurysm after coil embolization were ruptured aneurysm at initial admission, aneurysm size

larger than 10 mm, and follow-up duration longer than 48 months. Aneurysmal sac regrowth and deviated direction of the recanalized aneurysm were significantly related with rupture of the recanalized aneurysm after PcomA coil embolization.

Keywords: Posterior communicating artery aneurysm, Embolization, Coil,

Student number: 2013-21745

CONTENTS

LIST OF TABLES AND FIGURES

LIST OF ABBREVIATIONS

PcomA = Posterior communicating artery

OR = Odds ratio

CI = Confidence interval

MRA = Magnetic resonance angiography

DSA = Digital subtraction angiography

D/N = Dome-to-neck

HTN = Hypertension

DM = Diabetes mellitus

AcomA = Anterior communicating artery

MCAB = Middle cerebral artery bifurcation

INTRODUCTION

Posterior communicating artery (PcomA) aneurysms comprise 20–25% of all intracranial aneurysms[5,16]. They make up 25% of the ruptured intracranial aneurysms following anterior communicating aneurysms (45.4%)[12].

As coiling is accepted as a major modality for cerebral aneurysm treatment, PcomA aneurysms have been actively treated by endovascular methods. However, with the increased number of coil treatments, one of the major shortcomings–recanalization has also been an issue. PcomA aneurysms seem to represent a risky location for aneurysm recanalization. One report showed the second highest recurrence rate (37.2% Raymond et al.'s series) following basilar artery bifurcation aneurysm[17]. A study on major recurrence in the ISAT(International Subarachnoid Aneurysm Trial) trial showed that coiled aneurysms in the PcomA location had a significantly higher risk of recurrence requiring re-embolization[3].

The clinical importance of recanalization is obviously the risk of bleeding. The reason why we care for recanalization of the coiled aneurysms is to prevent rupture from the recurrence. Reportedly, the risk of rupture in recanalized aneurysms after coil embolization is 0.9–3.1%[2,10,14,18,22]. However, there are few reports on the rupture risk of PcomA aneurysms after coil embolization. Analysis on the rupture risk factors in recanalized PcomA aneurysms is limited[2,6,9,10,14,17,20,21]. In this article, we analyze the factors related to recanalization of PcomA aneurysms after coil embolization and the rupture of recanalized PcomA aneurysms.

METHODS

A retrospective study was conducted on patients who underwent endovascular coil embolization for PcomA aneurysm in a single center. From May 2003 to February 2014, a total of 254 PcomA aneurysms in 246 patients were treated using endovascular coil embolization. Among them, this study included 176 PcomA aneurysms in 169 patients who underwent minimum clinical and radiological follow-up for 1 year. Radiological follow-up included magnetic resonance angiography (MRA) or digital subtraction angiography (DSA). Seventy-eight PcomA aneurysms did not met the minimum clinical and radiological follow-up duration of 1 year with MRA or DSA and were excluded from the study.

For aneurysm coiling, patients with unruptured aneurysms were medicated for at least 5 days before the procedure with aspirin 100 mg and clopidogrel 75 mg, and patients with ruptured aneurysm were not prescribed an antiplatelet agent. All aneurysm coilings were performed under general anesthesia using an biplane angiographic unit, Integris Allura systems (Phillips Medical Systems, Best, Netherlands). Systemic heparinization was administered after the femoral artery puncture. Rotational angiography, followed by three-dimensional image reconstruction by volume rendering, was performed before embolization in all patients using the Integris 3D-RA software package (release 3.2, Philips Medical Systems). Based on the images generated using rotational acquisition, at least two working projections that provided the best achievable view of the aneurysm neck were defined. A microcatheter was navigated into the parent artery with the target aneurysm

using a guidewire. Once the microcatheter was placed stably in the aneurysmal neck, coils were inserted until sufficient occlusion was achieved. As required, the stent was delivered across the aneurysm neck. Aneurysms were occluded using detachable platinum coils. The final postembolization angiography was performed at the working projection to detect any residual contrast filling, thrombus formation, or parent artery compromise. After coil embolization without a stent, patients stopped taking aspirin and clopidogrel. However, patients who were treated with stent-assisted coil embolization were maintained on aspirin and clopidogrel at least for 6 months.

Baseline data, such as age, sex, and past medical history, were obtained retrospectively from medical records. The preoperative radiological investigations included DSA. The postoperative MRA or DSA was performed in the immediate postoperative period, 6 months, 12 months after initial coil embolization, and annually during the later follow-up period. The size of each aneurysm was measured in three-dimensional (3D) angiographic images using the angiography unit software.

Characteristics of aneurysms were recorded; the presence of bilateral PcomA aneurysms, multiple aneurysms and fetal-type PcomA on the same side as the aneurysms, and aneurysm size (maximum dimension) and dome-to-neck (D/N) ratio in 2D DSA were measured. The postoperative angiographic state of occlusion was evaluated using the Raymond–Roy classification[19]. In addition, Raymond–Roy classification class II was subdivided into the proximal neck remnant, distal neck remnant, and entire neck remnant (Figure 1).

If recanalization was found in follow-up MRA or DSA, angiographic findings were also analyzed and recorded, including the maximum dimension at the recanalization site. Recanalization was strictly defined as any interval change in aneurysm opacification[11,15]. Recanalization was classified as follows: major (if it was judged to require retreatment) or minor (if retreatment was not required)[1]. Recanalized aneurysms were classified as "neck filling (compaction only)," "sac filling (compaction only)," and "aneurysmal sac regrowth." The direction of recanalization against the parent artery was sorted into the proximal direction, distal direction, and entire direction.

The definition of neck filling is coil compaction without sac regrowth. The definition of sac filling is coil compaction without sac regrowth. Compaction could occur mainly in the proximal part (proximal neck part filling or proximal sac part filling), distal part (distal neck part filling or distal sac part filling), or not deviated part (entire neck part filling or not-deviated sac part filling). Aneurysmal sac regrowth was defined as an increase in size in one or more dimensions. This could also occur in the proximal part (proximal sac part regrowth), distal part (distal sac part regrowth), and entire part (sac part regrowth; Figure 2). In the recanalized aneurysm, "deviated direction" was defined as opacification of the neck or sac deviated to the proximal or distal direction against the parent artery.

Data were expressed as mean ± standard deviation in continuous variation or as the number of patients with the percentage in categorical variation. The existence of bilateral PcomA aneurysms, multiple aneurysm,

fetal-type PcomA on the aneurysm side, aneurysm size (small: < 10 mm, large: ≥ 10 mm), D/N ratio, postoperative occlusion state (immediate, follow-up duration), recanalization type (neck filling, sac filling, or aneurysmal sac regrowth), the direction of the recanalized aneurysm (proximal, distal, or entire), and size of the recanalization part were analyzed using the Chi-square test, Fisher's exact test, or Mann–Whitney test. A p-value < 0.05 was considered significant. A multivariate logistic regression analysis was used to find the risk factors of the recanalization of PcomA aneurysms after coil embolization. All statistical analyses were performed using the SPSS version 21.0 (IBM Corporation, Armonk, NY, USA).

RESULTS

A total of 176 aneurysms in 169 patients were analyzed (Table 1). They comprised 26 men and 143 women with an average age of 58.5 years (range, 30–83). Ruptured aneurysms at initial admission were 61 (34.7%) and unruptured aneurysms were 113 (65.3%). All of the aneurysms were of the saccular shape. The mean follow-up duration was 45.1 months (range, 12-128). Recanalization developed in 47 cases (26.7%). The mean time of first detection of recanalization was 25.9 months (range, 2–127). Major recanalization was observed in 24 cases (13.6%) during the follow-up period. In recanalized aneurysms, 23 cases were neck filling (13.1%) and all of those were in the not deviated direction. Twenty-four cases of recanalized aneurysms involved aneurysmal sac regrowth (13.6%); 5 of these cases were deviated and 19 were not deviated. There were zero cases of sac filling. Among recanalized aneurysms, 7 (4%) were ruptured. The timing of rupture varied from 26 to 155 months (mean duration, 76.9 months).

Recanalization after coil embolization in PcomA aneurysms

In analyzing risk factors for recanalization, univariate analysis showed that ruptured aneurysm at initial presentation ($p = 0.016$), size larger than 10 mm ($p < 0.001$), follow-up period longer than 48 months ($p = 0.008$), and Raymond–Roy classification II ($p = 0.035$) were associated with recanalization. Age, gender, and medical history, including hypertension (HTN), diabetes mellitus (DM), smoking, alcohol consumption, previous

stroke history, multiple aneurysms, fetal-type PcomA, D/N ratio, and stent use were not significantly different between the recanalized and non-recanalized aneurysms (Table 2). In multivariate analysis with the logistic regression test, ruptured aneurysm at initial presentation (p = 0.043; odds ratio [OR] 2.158, confidence interval [CI] 1.023–4.550), size larger than 10 mm (p = 0.001; OR 16.682, CI 3.292–84.541), and follow-up duration longer than 48 months (p = 0.002; OR = 3.105, CI 1.187–5.231) were identified as the recanalization risk factors (Table 3).

Correlation between the direction of residual remnants in the immediate postoperative occlusion state after coil embolization and the direction of recanalized aneurysm

There were 31 aneurysms with incomplete occlusion (Raymond–Roy classification II) after coil embolization of PcomA aneurysms. Two of 3 aneurysms (66.7%) with proximal neck remnants, 5 of 17 (29.4%) with distal neck remnant, and 6 of 11 (54.5%) with entire neck remnants were recanalized (Table 4). Table 4 shows that there was no direct correlation between the initial remnant location and recanalization pattern.

Rupture from recanalized aneurysms

In the ruptured recanalization group, the total number was 7 (4.0%), the mean age was 56.4 years (range, 46–68), and the average size of the recanalized part was 7.4 mm (range, 1.7–13.2; Table 5). In the unruptured recanalization group, the total number was 40 (22.7%), the mean age was 56.7

years (range, 33–79), and the average size of the recanalized part was 4.9 mm (range, 1.5–20.3). Age, gender, HTN, DM, smoking, alcohol consumption, previous stroke history, ruptured aneurysm at initial presentation, and coiling technique including stent use were not significantly different between the two groups. The presence of multiple aneurysms and fetal-type PcomA on the aneurysm side, aneurysm size, D/N ratio, initial occlusion state (Raymond–Roy classification), and size of the recanalized part were not significantly different between the ruptured and unruptured recanalization groups. The follow-up time was longer in the ruptured recanalization group than in the unruptured recanalization group (71.7 [range, 28 – 128] months vs. 52.6 [range, 13–106] months, $p = 0.296$). The size of the recanalized part was not significantly different between the two groups (7.4 [1.7–13.2] mm vs. 4.9 [1.5 – 20.3) mm, $p = 0.126$). The aneurysmal sac regrowth was significantly different between the two groups (7 [100%] vs. 17 [42.5%], $p = 0.009$). In the direction of the recanalized part, the deviated direction (proximal recanalization or distal recanalization) was also significantly different between two groups (3 [42.9%] vs. 2 [5%], $p = 0.019$) and was significantly related to the ruptured recanalization group (OR 14.250, CI 1.808–112.323).

Analysis of the ruptured recanalization group

In the ruptured recanalization group, the number of complete occlusion states (Raymond–Roy class I) was four, and three cases were Raymond–Roy class II in the immediate postoperative period (Table 6). In case 6, the immediate postoperative occlusion state involved a proximal neck

remnant. However, the direction of recanalized aneurysm at the time of rupture was proximal. There was no definite relation between the immediate postocclusion state and the direction of recanalized aneurysm at the time of rupture.

At the time of rupture after coil embolization, all cases involved aneurysmal sac regrowth, and three cases were deviated. The presentation of first recanalization as rupture was observed in five cases.

The rupture time after coil embolization varied from 26 months to 155 months (mean duration, 76.9 months). The angiographic images performed before the rupture showed minor recanalization in two cases. However, in these cases, the appearance of recanalization was not associated with the shape of the aneurysm after rupture. The time gap between the last image and rupture varied from 1 month to 94 months. The time gap between last image and rupture was ≥ 1 year in four cases and < 1 year in three cases.

Table 1. Baseline clinical and radiological characteristics of posterior communicating artery aneurysms.

Parameters	Number
Total number	176
Gender	
Female	150 (85.2%)
Male	26 (14.8%)
Age (years)	58.4 (30-83)
Hypertension	95 (54.0%)
Diabetes mellitus	18 (10.2%)
Previous stroke	15 (8.5%)
Smoking	27 (15.3%)
Alcohol consumption	31 (17.6%)
Ruptured aneurysm (initial presentation)	61 (34.7%)
Bilateral PcomA aneurysms	25 (14.2%)
Multiple aneurysms	78 (44.3%)
Fetal-type PcomA (aneurysm side)	85 (48.3%)
Aneurysm size (mm)	6.3 (2.4-18.2)
D/N ratio	1.4 (0.4-4.2)

Stent apply	29 (16.5%)
Immediate postoperative occlusion state with Raymond-Roy classification	145 (82.4%)
Class I	31 (17.6%)
Class II	0 (0%)
Class III	
Recanalization	47 (26.7%)
Major	24(13.6%)
Minor	23(13.1%)
Neck filling	23(13.1%)
Sac filing	0(0%)
Aneurysmal sac regrowth	24(13.6%)
Proximal	2(4.2%)
Distal	3(6.4%)
Entire	42(89.4%)
1st detected time of recanalization (month)	25.9 (2-127)
Size of recanalized part (mm)	5.3 (1.5-20.3)
Ruptured aneurysm after coil embolization	7 (4%)
Follow-up duration (month)	45.1 (12-128)

Numbers in parentheses represent percentages or range unless otherwise indicated.
PcomA, posterior communicating artery

Table 2. Comparison of clinical and radiological characteristics of posterior communicating artery aneurysms according to non-recanalized aneurysm and recanalized aneurysm after coil embolization.

Parameters	Non-recanalized aneurysm	Recanalized aneurysm	p-value
Total number	129	47	
Gender			0.612
Female	111	39	
Male	18	8	
Age (years)	59.0 (33-79)	56.7 (33-83)	0.174
Hypertension	68	27	0.577
Diabetes mellitus	13	5	1.000
Previous stroke	10	5	0.549
Smoking	19	8	0.709
Alcohol consumption	23	8	0.901
Ruptured aneurysm (initial presentation)	38	23	0.016
Bilateral PcomA aneurysms	16	9	0.257
Multiple aneurysms	56	22	0.688

Fetal-type PcomA (aneurysm side)	64	21	0.562
Aneurysm size (≥ 10mm)	2	9	0.000
D/N ratio	1.4 (0.5-3.9)	1.6 (0.4-3.2)	0.070
Stent apply	24	5	0.208
Immediate postoperative occlusion state with Raymond-Roy classification			0.035
Class I	111	34	
Class II	18	13	
Follow-up duration (month)			
Mean	41.3 (12-125)	55.4 (13-128)	0.008
≥ 48 months	38 (29.5%)	25 (53.2%)	0.004

Numbers in parentheses represent range unless otherwise indicated.
PcomA, posterior communicating artery; D/N, Dome/Neck

Table 3. The uni- and multivariate analysis of risk factors about recanalization of PcomA aneurysm after coil embolization

Factors	Risk factor of recanalization in PcomA aneurysm after coil embolization		
	Univariate	Multivariate	OR (95% CI)
Ruptured aneurysm (initial presentation)	**0.016**	**0.043**	**2.158(1.023-4.550))**
Aneurysm size (≥10mm)	**0.000**	**0.001**	**16.682(3.292-84.541)**
Follow-up duration (≥ 48months)	**0.002**	**0.002**	**3.105(1.187-5.231)**
Immediate postoperative occlusion state with Raymond-Roy classification Class II	0.035		

PcomA, posterior communicating artery; OR, odds ratio; CI, confidence interval

Table 4. The direction of recanalized aneurysm

Immediate postoperative occlusion state with Raymond-Roy classification		Recanalized aneurysm (N=47)	The direction of recanalized aneurysm		
			Distal recanalization	Proximal recanalization	Entire recanalization
Class I	145	34	1	2	31
Class II					
Proximal neck remnant	3	2	0	0	2
Distal neck remnant	17	5	1	0	4
Entire neck remnant	11	6	1	0	5

Table 5. Comparison of clinical and radiological characteristics of posterior communicating artery aneurysm according to recanalized aneurysm without rupture and ruptured aneurysm after coil embolization.

Parameters	Unruptured recanalization group	Ruptured recanalization group	p-value
Total number	40	7	
Gender			1.000
Female	7	1	
Male	33	6	
Age (years)	56.7 (33-79)	56.4 (46-68)	0.942
Hypertension	25	2	0.119
Diabetes mellitus	5	0	1.000
Previous stroke	4	1	0.571
Smoking	7	1	1.000
Alcohol	5	3	0.084
Ruptured aneurysm (initial presentation)	19	4	0.701
Bilateral PcomA aneurysms	8	1	1.000
Multiple aneurysms	19	3	1.000
Fetal-type PcomA (aneurysm side)	17	4	0.684

Aneurysm size (≥ 10mm)	8	1	1.000
D/N ratio	1.6 (0.4-4.2)	1.3 (0.7-2.3)	0.134
Stent apply	5	0	1.000
Immediate postoperative occlusion state with Raymond-Roy classification Class II	10	3	0.377
Size of recanalized part (mm)	4.9 (1.5-20.3)	7.4 (1.7-13.2)	0.126
Follow-up duration (month)	52.6 (13-106)	71.7 (28-128)	0.296
Recanalization type			0.009
Neck filling	23	0	
Aneurysmal sac regrowth	17	7	
Direction of recanalized aneurysm			0.019
Deviated (proximal or distal)	2	3	
Not deviated	38	4	

Numbers in parentheses represent range unless otherwise indicated.
PcomA, posterior communicating artery; D/N, Dome/Neck

Table 6. Characteristics of the ruptured aneurysms after coil embolization of posterior communicating artery aneurysm

Case	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
Immediate postoperative occlusion state with Raymond-Roy classification	I	II (Entire neck remnant)	II (Entire neck remnant)	I	I	II (Proximal neck remnant)	I
1st detected time of recanalization (months)	127	26	47	35	120	50	11
Aneurysmal sac regrowth at the time of rupture	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Direction of recanalized aneurysm at the time of rupture	Entire	Entire	Distal	Distal	Entire	Entire	Proximal
The time of rupture after coil embolization (months)	127	26	47	35	155	109	39
The time gap between last image and rupture (months)	94	1	21	11	4	38	27
Follow-up images in detail	33 month : no recanalization	12month :no recanalization 25month :no recanalization	26 month : no recanalization	24 month : no recanalization 63month :minor recanalization	121 & 136 month : reembolization due to major recanalization 151month : no recanalization	22 month : no recanalization 50 month : minor recanalization 71 month: no change	12 month : minor recanalization 62 month : minor recanalization

Figure 1. shows subclassification of Raymond-Roy classification II; proximal neck remnant, distal neck remnant and entire neck remnant after immediately posterior communicating artery aneurysm coil embolization.

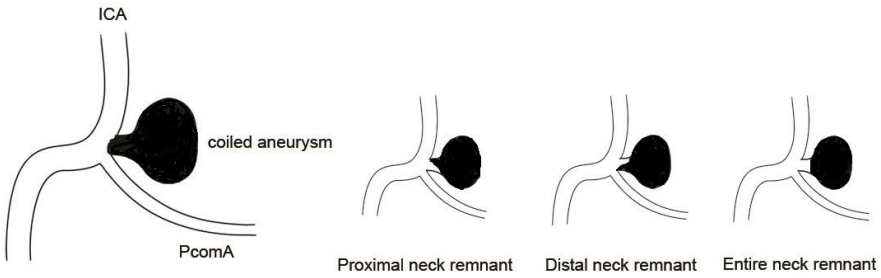
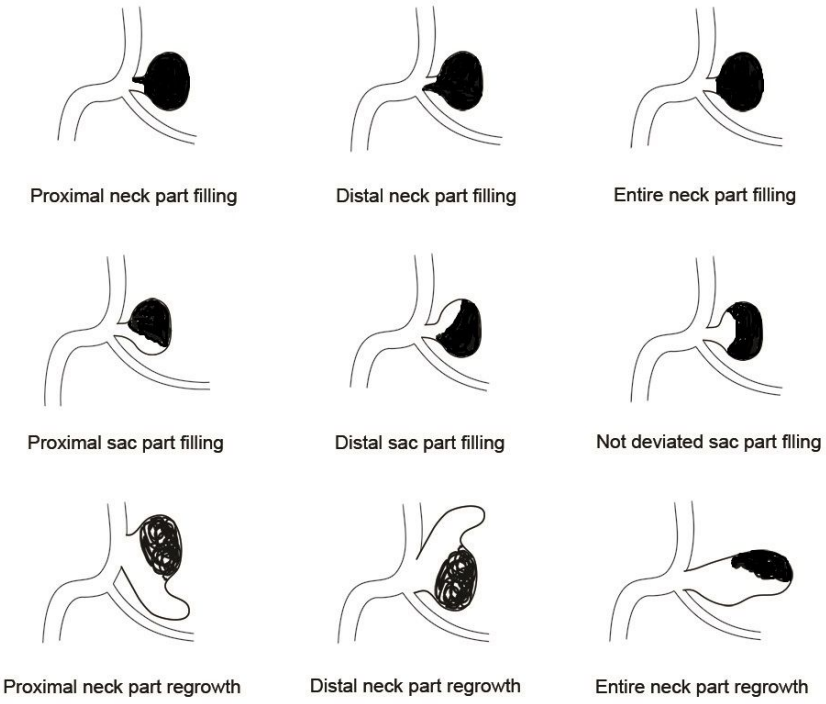


Figure 2. shows proximal neck part filling, distal neck part filling, entire neck part filling, proximal sac part filling, distal sac part filling, not deviated sac filling, proximal part regrowth, distal part regrowth and entire part regrowth in the posterior communicating artery aneurysm.



DISCUSSION

During the period of investigation, at Seoul National University Bundang Hospital, bleeding after coil embolization occurred in 0 of 339 cases (0%) in anterior communicating artery (AcomA) aneurysms and in 2 of 205 cases (0.9%) in middle cerebral artery bifurcation (MCAB) aneurysms. As reported in this article, the rupture rate of PcomA aneurysms after coiling occurred in 7 of 176 aneurysms; therefore, the rupture rate was 4%—much higher than those observed in the other types of aneurism. All of these were associated with recanalization and regrowth of the coiled aneurysms.

The recanalization risk factors in our study were ruptured aneurysm at initial presentation, aneurysm size larger than 10 mm, and follow-up duration longer than 48 months. Raymond et al.[17] reported that ruptured aneurysm is one of risk factors for recurrence ($p = 0.007$; relative risk = 1.96), while Cognard et al.[4] reported that recurrence is more frequent after coil embolization of ruptured aneurysms (17%) than of unruptured aneurysm (7%). Our analysis also showed that ruptured aneurysm at initial admission is one of the recanalization risk factors. A hypothesis to explain this result is that lysis of the clot occluding the rupture site may induce the coils to compact the back of aneurysm[4]. It is well known that the larger aneurysm size, the more frequently recanalization of aneurysm after coil embolization occurs[8,18]. Our results also showed that large PcomA aneurysms are recanalized more often. The follow-up duration longer than 48 months as a

recanalization risk factor means that the recanalization rate is proportional to follow-up duration. In our study, 26 cases (53.2%) of recanalized aneurysms and 38 cases (29.5%) of non-recanalized aneurysms had a follow-up duration of more than 48 months.

Mortimer et al.[13] and Geyik et al.[7] reported that recanalization more frequently occurs at 6 months after coil-embolization, but the late recanalization rate is very low. This indicates that once coiled aneurysms have not recanalized in the early period, they can be considered to be stabilized later. These two articles included various locations of aneurysms. However, the results were different from ours on PcomA aneurysms. In our study, the average time of recanalization was 24.8 months (2–127 months). In addition, multivariate analysis showed that the longer the follow-up, the more often recanalization was found. It is clear coiled PcomA aneurysms are recanalized more often when they are ruptured at initial presentation and of a size ≥ 10 mm in late period.

We suggest that in immediate postoperative angiography, the direction of the residual remnant could affect the directions of recanalized and ruptured aneurysms. However, there was a tendency whereby almost all recanalized aneurysms were not deviated, regardless of the direction of the residual remnant (Table 5). Table 6 shows that the direction of the recanalized aneurysm was distal in one case and proximal in two cases, and this was not related with the direction of residual remnant after coil embolization. In conclusion, the direction of the residual remnant of the aneurysm in immediate postoperative angiography did not seem to influence the direction of the recanalized aneurysm or ruptured aneurysm in follow-up images.

Our analysis shows that many factors are not related to rupture in PcomA recanalized aneurysms. These factors include patient factors (age, gender, past medical history, social history), preoperative aneurysm (before 1st coil embolization) characteristics (size, bilateral PcomA aneurysms, multiple aneurysms, fetal-type PcomA at the aneurysm side), and the immediate postoperative occlusion state. Therefore, before 1st coil embolization, we cannot predict the possibility of rupture of PcomA aneurysm after coil embolization.

All aneurysms in the ruptured recanalization group showed aneurysmal sac regrowth, and the deviated direction in the recanalized aneurysm was significantly related with the rupture of the recanalized aneurysm after PcomA coil embolization. One may consider that aneurysmal sac regrowth is the result of rupture. However, all of the regrowths were relatively large and eccentric. Follow-up MRA or DSA was performed at regular intervals (6 months or 1 year or more according to the follow-up protocol); we may not know the exact aneurysm shape and size on the verge of rupture. Therefore, if there is a change in aneurysmal sac regrowth or deviated direction of aneurysm on the radiologic images, immediate re-embolization or close follow-up will be needed.

The rupture of PcomA aneurysm after coil embolization occurred even after 155 months from initial coil embolization, even though the aneurysm state in the MRA or DSA did not change from the immediate postoperative radiological data until 71 months. The time gap between the last images and rupture was ≥ 12 months in the four cases in the ruptured recanalization group. However, although the last images showed non-recanalization, the time gap between the last images

and rupture was < 12 months in three cases in the ruptured recanalization group. A definite follow-up duration of MRA or DSA after PcomA aneurysm coil embolization cannot be suggested. Therefore, radiological follow-up may be needed periodically throughout the lifespan. Furthermore, we must pay attention to morphological changes of aneurysms over a long period.

It is unclear why PcomA aneurysms rupture after coil embolization more frequently than aneurysms in other locations. As a result, it is necessary to perform comparative analysis between PcomA aneurysms and aneurysms in other locations in relation to patient factors, aneurysm characteristics, and morphological changes of aneurysm as time goes by. In addition, there seems to be a need for research about hemodynamic differences between aneurysms in other locations and PcomA.

CONCLUSION

Aneurysmal sac regrowth and deviated direction of recanalized aneurysms were significantly related with the rupture of recanalized aneurysms after PcomA coil embolization. As time progresses, morphological change in PcomA aneurysms after coil embolization can occur. Therefore, it is necessary to carry out periodic follow-up with radiological imaging modalities, such as DSA or MRA, throughout the patient's lifetime after coil embolization of PcomA aneurysms.

REFERENCES

1. Bandeira A, Raphaeli G, Balériaux D, Bruneau M, De Witte O, Lubicz B: Selective embolization of unruptured intracranial aneurysms is associated with low retreatment rate. **Neuroradiology 52:** 141-146, 2010
2. Byrne JV, Sohn M-J, Molyneux AJ: Five-year experience in using coil embolization for ruptured intracranial aneurysms: outcomes and incidence of late rebleeding. **Journal of neurosurgery 90:** 656-663, 1999
3. Campi A, Ramzi N, Molyneux AJ, Summers PE, Kerr RS, Sneade M, et al.: Retreatment of ruptured cerebral aneurysms in patients randomized by coiling or clipping in the International Subarachnoid Aneurysm Trial (ISAT). **Stroke 38:** 1538-1544, 2007
4. Cognard C, Weill A, Spelle L, Piotin M, Castaings L, Rey A, et al.: Long-term Angiographic Follow-up of 169 Intracranial Berry Aneurysms Occluded with Detachable Coils 1. **Radiology 212:** 348-356, 1999
5. Fein JM, Flamm ES: **Cerebrovascular surgery**. Springer-Verlag, 1985, pp841-860
6. Gallas S, Pasco A, Cottier J-P, Gabrillargues J, Drouineau J, Cognard C, et al.: A multicenter study of 705 ruptured intracranial aneurysms treated with Guglielmi detachable coils. **American journal of neuroradiology 26:** 1723-1731, 2005
7. Geyik S, Yavuz K, Yurttutan N, Saatci I, Cekirge H: Stent-assisted coiling in endovascular treatment of 500 consecutive cerebral aneurysms with long-

term follow-up. **American Journal of Neuroradiology 34:** 2157-2162, 2013

8. Hayakawa M, Murayama Y, Duckwiler GR, Gobin YP, Guglielmi G, Viñuela F: Natural history of the neck remnant of a cerebral aneurysm treated with the Guglielmi detachable coil system. **Journal of neurosurgery 93:** 561-568, 2000

9. Investigators C: Rates of delayed rebleeding from intracranial aneurysms are low after surgical and endovascular treatment. **Stroke; a journal of cerebral circulation 37:** 1437, 2006

10. Kang H-S, Han MH, Kwon BJ, Kwon O-K, Kim SH: Repeat endovascular treatment in post-embolization recurrent intracranial aneurysms. **Neurosurgery 58:** 60-70, 2006

11. Kang H-S, Han MH, Kwon BJ, Kwon O-K, Kim SH, Choi SH, et al.: Short-term outcome of intracranial aneurysms treated with polyglycolic acid/lactide copolymer–coated coils compared to historical controls treated with bare platinum coils: a single-center experience. **American journal of neuroradiology 26:** 1921-1928, 2005

12. Molyneux A: International Subarachnoid Aneurysm Trial (ISAT) of neurosurgical clipping versus endovascular coiling in 2143 patients with ruptured intracranial aneurysms: a randomised trial. **The Lancet 360:** 1267-1274, 2002

13. Mortimer AM, Marsh H, Klimczak K, Joshi D, Barton H, Nelson RJ, et al.: Is long-term follow-up of adequately coil-occluded ruptured cerebral

aneurysms always necessary? A single-center study of recurrences after endovascular treatment. **Journal of neurointerventional surgery** neurintsurg-2014-011152, 2014

14. Murayama Y, Nien YL, Duckwiler G, Gobin YP, Jahan R, Frazee J, et al.: Guglielmi detachable coil embolization of cerebral aneurysms: 11 years' experience. **Journal of neurosurgery 98:** 959-966, 2003
15. Niimi Y, Song J, Madrid M, Berenstein A: Endosaccular treatment of intracranial aneurysms using matrix coils early experience and midterm follow-up. **Stroke 37:** 1028-1032, 2006
16. Ojemann RG, Heros RC, Crowell RM: **Surgical management of cerebrovascular disease**. Williams & Wilkins, 1988,
17. Raymond J, Guilbert F, Weill A, Georganos SA, Juravsky L, Lambert A, et al.: Long-term angiographic recurrences after selective endovascular treatment of aneurysms with detachable coils. **Stroke 34:** 1398-1403, 2003
18. Ries T, Siemonsen S, Thomalla G, Grzyska U, Zeumer H, Fiehler J: Long-term follow-up of cerebral aneurysms after endovascular therapy–prediction and outcome of retreatment. **American Journal of Neuroradiology 28:** 1755-1761, 2007
19. Roy D, Milot G, Raymond J: Endovascular treatment of unruptured aneurysms. **Stroke 32:** 1998-2004, 2001
20. Sluzewski M, van Rooij WJ, Beute GN, Nijssen PC: Late rebleeding of ruptured intracranial aneurysms treated with detachable coils. **American journal of neuroradiology 26:** 2542-2549, 2005

21. Thornton J, Debrun GM, Aletich VA, Bashir Q, Charbel FT, Ausman J: Follow-up angiography of intracranial aneurysms treated with endovascular placement of Guglielmi detachable coils. **Neurosurgery 50:** 239-250, 2002

22. Uda K, Murayama Y, Gobin YP, Duckwiler GR, Viñuela F: Endovascular treatment with Guglielmi detachable coils for basilar artery trunk aneurysms: clinical experience with 41 aneurysms in 39 patients. **Journal of Neurosurgery 95:** 624-632, 2001

국문 초록

서론: 본 연구는 코일 색전술 후에 후교통동맥 동맥류의 재관류(recanalization)에 대해 임상적 방사선학적 결과를 연구한 것이다. 코일 색전술후에 후교통동맥 동맥류의 재관류 (recanalization) 및 파열(rupture)에 관련된 요인을 알아보기 위해 비교 연구를 하였다.

방법: 단일 연구기관에서 2003 년 5 월부터 2014 년 2 월까지 코일 색전술을 시행한 후교통동맥중에서 관찰기간 동안 디지탈 감산 혈관조영술 (digital subtraction angiography)이나 자기공명혈관조영법 (magnetic resonance angiography)을 1 년이상 시행한 동맥류를 대상으로 하였고 총 169 명의 환자 중에서 176 개의 동맥류가 이 연구에 포함되었다.

결과: 47 (26.7%)개의 동맥류가 재관류 (recanalization)되었고 이중에서 7 개의 동맥류가 코일 색전술후에 터졌다. 다변량 분석시에 재관류 (recanalization) 의 위험요인으로는 처음 증상 발현이 뇌동맥류 파열인 경우 (p = 0.043; 교차비(Odds ratio) [OR] 2.158, 신뢰구간(Confidence interval) [CI] 1.023-4.550), 동맥류의 크기가 10mm 이상인 경우 (p = 0.001; OR 16.682, CI 3.292-84.541) 와 동맥류 코일 색전술 후에 관찰기관이 48 개월 이상인 경우 (p = 0.002; OR = 3.105, CI 1.187-5.231)였다.

혈관조영술상에서 모든 파열된 재관류 동맥류 (ruptured recanalized aneurysm)들은 동맥류의 재성장 (sac regrowth)를 보였다 (p = 0.009). 재관류된 부분(recanalized part)이 편위되어 있는 것은 파열된 재관류 동맥류 (ruptured recanalized aneurysm)와 상당히 연관이 있었다 (p= 0.019; [OR] 14.250, [CI] 1.808-112.323).

결론: 코일 색전술 후에 후교통동맥의 재관류 (recanalization)의 위험요인은 처음 증상 발현이 뇌동맥류 파열인 경우, 맥류의 크기가 10mm 이상인 경우와 동맥류 코일 색전술 후에 관찰기관이 48 개월 이상인 경우이다. 동맥류의 재성장 (aneurysamal sac regrowth)과 재관류된 부분 (recanalized part)의 편위는 파열된 재관류 동맥류 (ruptured recanalized aneurysm) 상당히 연관이 있다.

주요어 : 후교통동맥, 색전술, 코일

학 번 : 2013-21745