Recurrence and risk factors of posterior communicating artery aneurysms after endovascular treatment

Min Jeoung Kim

Department of Medicine

The Graduate School, Yonsei University

Recurrence and risk factors of posterior communicating artery aneurysms after endovascular treatment

Directed by Professor Joonho Chung

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This certifies that the Master's Thesis of Min Jeoung Kim is approved.

Thesis Supervisor : Yong Bae Kim

Thesis Committee Member #1 : Joonho Chung

Thesis Committee Member #2 : Dong Joon Kim

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Yonsei University

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Thank you for my teachers of neurosurgery

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Key words : endovascular treatment; fetal-type posterior communicating artery; posterior communicating artery aneurysm; Raymond–Roy classification; recanalization; reinforcement

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Background: Endovascular treatment (EVT) of posterior communicating artery aneurysms (PcomA) is challenging because of the posterior communicating artery (Pcom) architecture. Additionally, these aneurysms have a high risk of recanalization compared with those located elsewhere.

Objective: To evaluate the incidence of recanalization and risk factors related to PcomAs after EVT.

Methods: The radiographic findings of 171 patients treated with EVT at two institutions were retrospectively reviewed. Univariate and multivariate analyses were performed, and subgroup analyses were performed based on the Pcom characteristics.

Results: Recanalization of PcomAs occurred in 53 patients (30.9%). Seven

patients (4.0%) were retreated (six endovascularly and one with microsurgical clipping). The mean follow-up duration was 27.7 months (range: 3.5–78.6). The maximum diameter (odds ratio [OR] 1.23, P=.006, 95% CI 1.07 - 1.44), a Raymond–Roy classification of grade II or III (OR 2.26, P=.03, 95% CI 1.08 - 4.82), and the presence of reinforcement (balloon or/and stent, OR 0.44, P=.03, 95% CI 0.20 - 0.91) were associated with recanalization using multivariate logistic regression. Significant differences were found in the maximum aneurysm diameter (P=.03) between the normal- and fetal-type Pcoms using analyses of variance.

Conclusions: The recanalization rate of PcomAs after EVT was 30.9%; the retreatment rate was 4.0%. The maximum diameter, Raymond–Roy classification, and presence of reinforcement were significantly associated with recanalization but not associated with a fetal-type Pcom. The aneurysm size was larger in patients with a fetal-type Pcom than in those with a normal Pcom. The size of the Pcom was unrelated to the recanalization rate.

Keywords: endovascular treatment; maximum aneurysm diameter; posterior communicating artery aneurysm; Raymond–Roy classification; recanalization; reinforcement

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I. INTRODUCTION

Recently, endovascular treatment (EVT) has emerged as a feasible and acceptable option for the treatment of aneurysms[1,2]; however, despite coil embolization proving effective, it has not showed promising results regarding recanalization rates. Posterior communicating artery aneurysms (PcomAs) are particularly susceptible to recanalization after coil embolization, and the occurrence is 30% higher than aneurysms located elsewhere (P=.03).[3,4] Additionally, the posterior communicating artery (Pcom) has unique features in terms of coil embolization. Posterior communicating artery aneurysms may be classified as either bifurcation or sidewall variants, depending on the caliber ratio of the Pcom and the P1 segment; therefore, treatment options vary accordingly.[5]

This study aimed to identify the risk factors and rates of recanalization that develop after coil embolization of a PcomA, with a special focus on the anatomic features of the Pcom and PcomA.

II. MATERIALS AND METHODS

Patient selection

The requirement for institutional review board approval and obtaining informed consent from patients was waived due to the retrospective nature of the study. The electronic medical records of patients with PcomAs treated with EVT at two neurovascular centers were reviewed. A total of 3 986 consecutive patients with ruptured and unruptured intracranial aneurysms were treated with microsurgical clipping or EVT at two tertiary hospitals between January 2013 and December 2018. Of these patients, 516 (13.0%) had a PcomA. The PcomAs were diagnosed using computed tomography angiography, magnetic resonance angiography (MRA), and digital subtraction angiography (DSA). Of these cases, we included only those where the Pcom was located at the internal carotid artery (ICA)–Pcom junction. Patients who underwent microsurgical clipping were excluded, resulting in a total of 235 patients with PcomAs. The following patients were excluded for the following reasons: 41 due to the lack of postoperative follow-up images, 16 who underwent repeated treatment, following their initial treatment that occurred before January 2013, 5 who underwent flowdiverter, 2 for having a pseudoaneurysm and 1 because of the presence of a dissecting aneurysm.

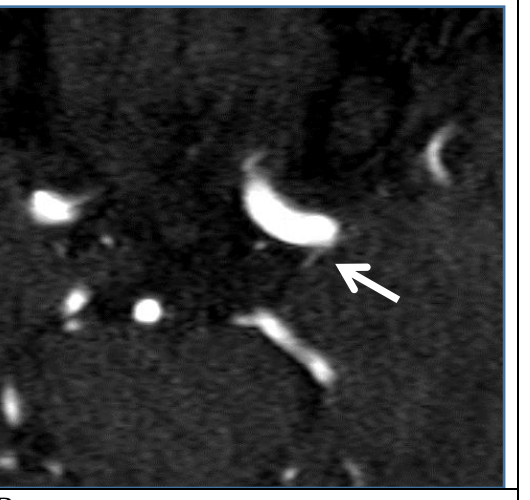
Data extraction

Demographic and clinical data were obtained from the patients' medical records; procedural details were collected from the procedural notes.

All patients had undergone prior cerebrovascular imaging using DSA. The 3D DSA angiograms were reviewed to identify the following PcomA characteristics: the aneurysm size (neck, depth, length, and width), maximum diameter, size ratio, relationship with the ICA, type of Pcom, and the occurrence of occlusion. Angiographic outcomes were classified using the Raymond–Roy classification system.[6]

All aneurysms were evaluated and classified as either fetal, hypoplastic, or normal Pcom. A Pcom was defined as fetal-type when it had a size larger than or equal to that of the ipsilateral P1 segment of the posterior cerebral artery (PCA), and when it supplied the majority of the blood flow to the PCA territory.[4] A Pcom was defined as hypoplastic-type when no vessel was found between the ophthalmic artery and the anterior choroidal artery. In these cases, the anterior choroidal artery was identified from the MRA source image. A Pcom was defined as normal-type when in had a size smaller than the ipsilateral P1 segment of the PCA (Figure 1).

A



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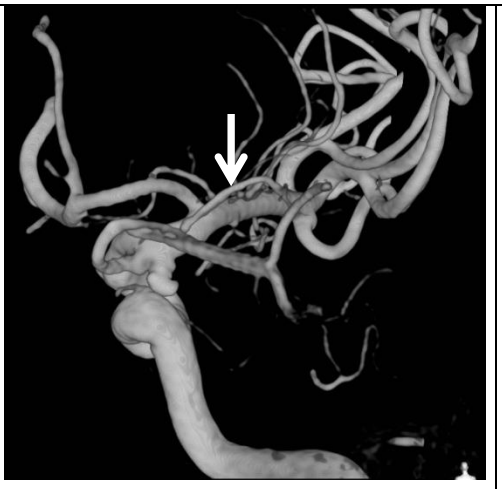

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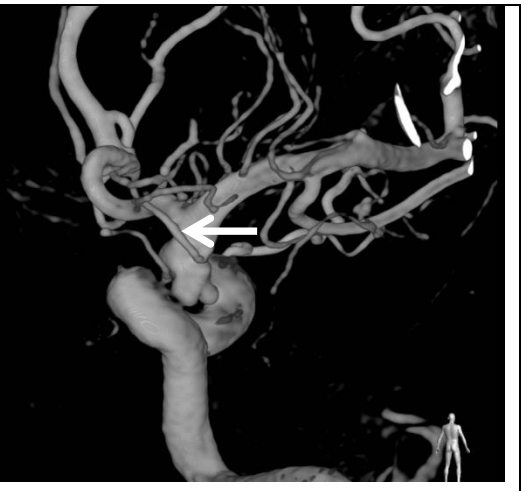


D

Figure 1. The type of posterior communicating artery (invisible/normal /fetal-type). We classified posterior communicating artery aneurysms according to the Pcom size. An invisible Pcom (A) was defined as no vessel found between the ophthalmic artery and the anterior choroidal artery. In these cases, the anterior choroidal artery (arrow) was identified from the MRA source image. (B) A fetal-type Pcom was defined as a Pcom larger than or equal in size to the ipsilateral P1 segment of the PCA. (C) A normal-type Pcom was defined as a Pcom smaller than the ipsilateral P1 segment of the PCA. (D). The white arrows indicate the anterior choroidal artery.
Pcom: posterior communicating artery; MRA: magnetic resonance angiography; PCA: posterior cerebral artery

Recanalization was defined as new or increased contrast filling of an aneurysm with or without aneurysm growth. Major recanalization was defined as contrast filling of the aneurysm dome, significant coil compaction, or aneurysmal regrowth.[7] Retreatment was recommended for all patients with major recanalization.

The direction of the angle between the projection line of the aneurysmal dome and the communicating segment of the ICA was measured using the lateral and

anteroposterior view. A superior direction was defined as an angle larger than 90 degrees, and an inferior direction as an angle smaller than 90 degrees.
Reinforcement included stent and/or balloon-assisted coiling.

Procedure

All patients with unruptured aneurysms received periprocedural antiplatelet therapy and platelet function testing as per the protocol of the relevant institution. Intraprocedural heparin was administered to achieve an activated clotting time of 2 to 3 times the baseline. Patients were treated by five interventionists with 5 to 20 years of experience. In all patients, aneurysm coiling was performed under general anesthesia using a biplane angiography unit.
After the initial coiling, routine imaging follow-up was conducted using 3.0 T MRA at 6, 18, 30, and 60 months. The follow-up MRA image was reviewed for recanalization of the PcomA; if recanalization was suspected, DSA was used for surveillance by the treating physician.

Statistical analyses

Univariate analysis was performed to determine the association of any occurrence of recanalization with factors and characteristics associated with the ruptured status. The chi-square test was used for categorical variables, and the logistic regression test for continuous numerical variables. Multivariate logistic regression analysis was performed for variables with an unadjusted effect, and a $P<.20$ in the univariate analysis was used to determine independent associations between the recurrence and characteristics of the ruptured status. The results of binary logistic regression were reported as odd ratios (ORs) with $P<.05$ for a 95% confidence interval (CI) considered as statistically significant. We compared the characteristics related to the Pcom size using chi-square tests and analyses of variance with a post-hoc analysis to determine associations between aneurysm characteristics. The program used for statistical analysis was SPSS (SPSS v19; IBM Corp, Armonk, New York, USA).

III. RESULTS

A total of 171 patients (female: 151, 88.3%; mean age: 61.9 years) with a PcomA underwent an EVT procedure. Among these patients, 85 (49.4%) had hypertension and 54 (31.4%) presented with a ruptured aneurysm. Regarding the aneurysmal factors, the mean maximum diameter was 6.12 mm (range 1.5–24.8), mean aspect ratio was 1.56 (range 0.7–5.6), and mean size ratio was 1.07 (range 0.4–2.0). Of the total patients, 17 (9.9%) showed superior dome projection, 75 (43.6 %) showed a fetal-type Pcom, and 37 (21.5%) showed a hypoplastic Pcom. A normal Pcom was isolated in 59 patients (34.3%).

All aneurysms were successfully treated without (n=102, 59.6%) or with (n=69, 40.4%) a balloon and/or stent, and the immediate post-procedural angiogram revealed 100 (58.1%) Raymond–Roy class I, 64 (37.4 %) class II, and 7 (4.0 %) class III aneurysms. Retreatment was performed in 7 (4.0%) patients; 1 patient was treated with microsurgical clipping, while the remaining patients underwent EVT.

Recanalization

Recanalization was noted in 53 patients (30.9%). A follow-up MRA was performed in all patients (mean months: 27.7; range 3.5–78.6). In the univariate analysis, significant risk factors for recurrence comprised a ruptured status (P=.04), the maximum diameter (P=.03), a Raymond–Roy classification of grade II or III (P=.02), and the presence of reinforcement in the form of a balloon or/and stent (P=.05). In the multivariate logistic regression analysis, the statistically significant factors included the maximum diameter (OR 1.23, 95% CI 1.07-1.44, P=.01), a Raymond–Roy classification of grade II or III (OR 2.26, 95% CI 1.08-4.82, P=.03) and reinforcement in the form of a balloon or/and stent (OR 0.44, 95% CI 0.20-0.91, P=.03). These results are presented in Table 1.

Table 1. Risk factors for recanalization after endovascular treatment of posterior communicating artery aneurysms

N=171				Univariate analysis	Multivariate analysis	
		Recanalization (n=53)	No recanalization (n=118)	P-value	OR (95% CI)	P-value
Patient-related factors	Age	61.2 ± 11.8	62.3 ± 10.6	.53		
	Female sex	50 (94.3%)	101 (85.6%)	.16		
	HTN	28 (52.8%)	57 (48.3%)	.70		
	DM	5 (9.4%)	15 (12.7%)	.71		
	Dyslipidemia	17 (32.1%)	49 (41.5%)	.31		
	Smoking	6 (11.3%)	18 (15.3%)	.65		
Aneurysm-related factors	Ruptured	23 (13.4%)	31 (26.3%)	**.04***	1.87 (0.88–4.02)	.10
	Multiple aneurysms	21 (39.6%)	54 (45.8%)	.56		
	Direction	6 (11.3%)	11 (9.3%)	.89		

	(superior)					
	Maximal diameter (mm)	7.3 ± 3.7	5.2 ± 2.2	**.003***	1.23 (1.07-1.44)	**.006***
	Size ratio	1.1 ± 0.4	1.0 ± 0.3	.24		
	Aspect ratio	1.7 ± 0.7	1.5 ± 0.5	.13		
	Fetal-type Pcom	27 (50.9%)	48 (40.7%)	.27		
Treatment-related factors	Raymond–Roy (grade II or III)	29 (54.7%)	42 (35.5%)	**.02***	2.26 (1.08-4.82)	**.03***
	Reinforcement (balloon/stent)	15 (28.3%)	54 (45.8%)	**.04***	0.44 (0.20-0.91)	**.03***

Bold font and * variables indicate a significant association with recurrence

OR: odds ratio; CI: confidence interval; HTN: hypertension; DM: diabetes mellitus; Pcom: posterior communicating artery

In the subgroup analysis based on the size of the Pcom, the maximum diameter of the group of patients with a fetal-type Pcom significantly differed from that of the group with a normal Pcom (6.8±3.5 vs 5.6±1.9 mm; P=.03); however, no significant difference was found regarding the ruptured status or the occurrence of recanalization (Table 2, Figure 2).

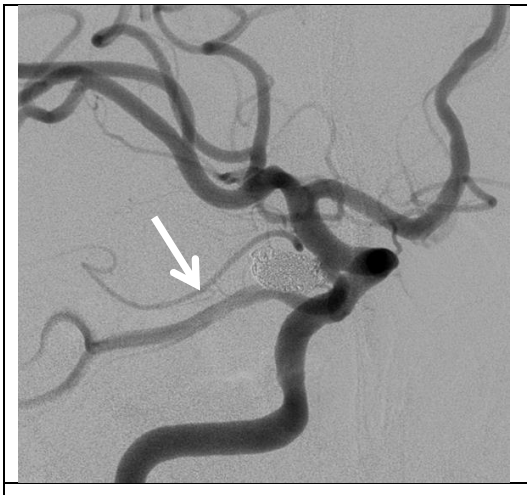
Table 2. Group characteristics based on the size of the posterior communicating artery along with the results of analysis of variance and post-hoc tests

		Invisible Pcom (n=37)	Normal Pcom (n=59)	Fetal Pcom (n=75)	P-value
Patient-related factors (%)	Female sex	31 (83.8%)	54 (91.5%)	66 (88.0%)	.51
	HTN	20 (54.1%)	27 (45.8%)	38 (50.7%)	.71
	DM	7 (18.9%)	4 (6.8%)	9 (12.0%)	.19
	Hyperlipidemia	16 (43.2%)	26 (44.1%)	24 (32.0%)	.29
	Smoking history	3 (8.1%)	8 (13.6%)	13 (17.3%)	.41
Aneurysm-related factors	Multiple	17 (45.9%)	28 (47.5%)	30 (40.0%)	.66
	Rupture	11 (29.7%)	14 (23.7)	29 (38.7%)	.17
	Direction (superior)	3 (8.1%)	8 (13.6%)	6 (8.0%)	.51
	Maximal diameter (mm)	5.8 ± 2.4	5.6 ± 1.9	6.8 ± 3.5*	**.03**
	Size ratio	1.1 ± 0.3	1.0 ± 0.3	1.1 ± 0.3	.44
	Aspect ratio	1.4 ± 0.4	1.5 ± 0.5	1.7 ± 0.7	.12
Treatment-related factors	Recanalization	10 (27.0%)	16 (27.1%)	27 (36.0%)	.46
	Reinforcement (balloon/stent)	19 (51.3%)	24 (40.6%)	26 (34.6%)	.24

Bold font variables indicate a significant difference

*Significantly different from the normal Pcom group (P=.04)

HTN: hypertension; DM: diabetes mellitus; Pcom: posterior communicating artery



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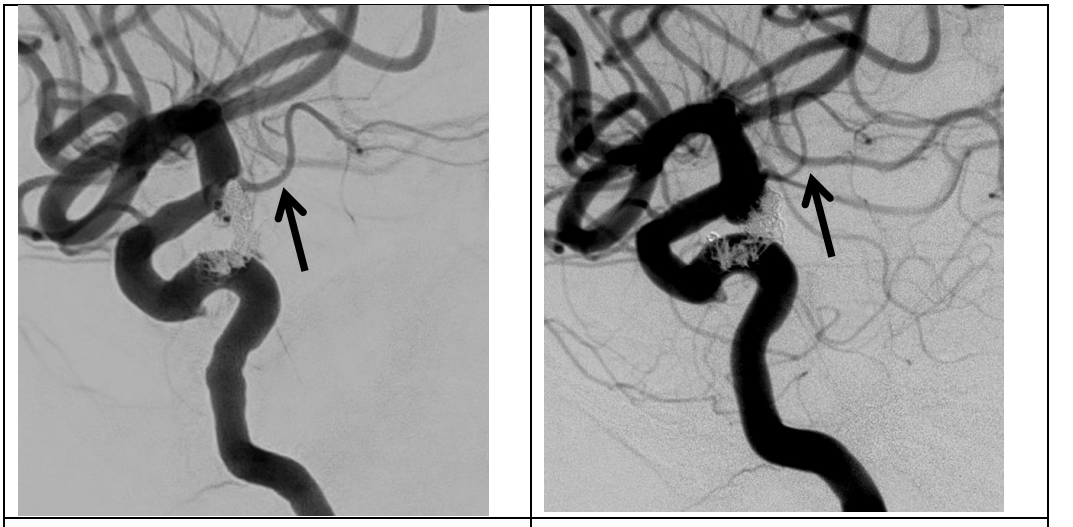

e. f.

Figure 2. Initial coil embolization and recanalization of fetal-type (a and b), invisible type (c and d), and normal-type (e and f) posterior communicating arteries. Characteristics of the Pcom were not associated with recanalization. The Raymond–Roy occlusion classification of three patients were grade II. Recanalization occurred after 1 year (b), 18 months (d), and 3 years (f), respectively. The white arrow indicates the anterior choroidal artery and the black arrow the Pcom.
Pcom: posterior communicating artery

IV. DISCUSSION

This study identified the incidence of and the risk factors for the recanalization of a PcomA after EVT. The novel finding is that the only independent factors predisposing the recanalization of a PcomA were the maximum diameter, a Raymond–Roy classification of grade II or III, and the presence of reinforcement. Furthermore, the anatomic characteristics of the Pcom were not associated with a ruptured status or recanalization after EVT.

A recent meta-analysis found a recanalization and retreatment rate of 20.8% and 10.3%

after EVT of cerebral aneurysms, respectively.[8] The International Subarachnoid Aneurysm Trial found that 17.4% of ruptured aneurysms recurred after EVT. Particularly, PcomAs are more susceptible to retreatment than aneurysms located at other sites (P=.03).[3] The current study found that recanalization of a PcomA after EVT occurs in 33.1% of cases.[4] Considering that PcomAs are subject to recurrence, we studied the recanalization of PcomAs after EVT. In this study, recanalization occurred in 53 of the 171 patients (30.9%), while 7 patients (4.0%) were retreated(6 endovascularly and 1 with surgical clipping).

The Pcom is a unique artery that connects the anterior and posterior cerebral circulation. If the embryonic Pcom fails to regress, the dominant blood supply to the occipital lobes originates from the ICA via the fetal-type Pcom instead of from the vertebrobasilar system.[9] Thiarawat et al found that the fetal-type Pcom may be implicated in the formation of an aneurysm, as it is associated with a higher risk of PcomAs (p<.001).[10]

In recent studies, the association between a ruptured PcomA and a fetal-type Pcom has been debated. It has been reported that circle of Willis anomalies are more commonly found in ruptured than in unruptured cerebral aneurysms.[11-13] Thiarawat et al found that the variant of the Pcom was not associated with the rupture status.[10] In out study, ruptured status was not the related with Pcom type. Choi et al has shown that the type of Pcom has no impact on the occurrence of recanalization.[4] In this study, the aneurysmal features were classified into three groups depending on the type of Pcom; the fetal, normal, or hypoplastic type. The size of the aneurysm was significantly larger in fetal-type than normal-type Pcoms. Moreover, fetal-type Pcoms experienced the largest number of PcomAs and ruptures, although this was not a statistically significant finding. In other words, the fetal-type Pcom was associated with the size of the aneurysm but not with the risk of rupture or recanalization. Therefore, in terms of recanalization, it can be concluded that a fetal-type Pcom with a PcomA can be treated using EVT.

The direction of of the aneurysm is determined by the direction of the parent artery. In

a hemodynamic study, the wall shear stress in the treated neck of a totally embolized aneurysm susceptible to future recanalization was markedly higher than that in the original aneurysm neck prior to embolization.[14,15] Therefore, we studied the relationship between the direction of the Pcom and the occurrence of recanalization. In this study, 100 patients (57.0%) had laterally-directed Pcoms, 4 (3.0%) had medially-directed Pcoms, and the remaining patients had neither laterally- nor medially-directed, but hypoplastic, Pcoms (37/67, 55.0%). This study concluded that the direction of the Pcom and the occurrence of recanalization is not related.

Many studies have investigated the risk factors involved in the recanalization of a PcomA. Jeon et al found that the deployment of a stent could prevent recanalization because of the reconstruction of the parent artery[16] and Son et al demonstrated that the recanalization rate was higher in larger aneurysms (>15 mm).[7] Similar to previous studies, this study found that the maximum diameter (7.3 ± 3.7 mm, P=.006) and the use of reinforcement such as a balloon and/or stent (P=.03) were significantly associated with the recanalization of a PcomA. Furthermore, the initial status of coil embolization was significantly correlated with the occurrence of recanalization. Therefore, patients with a Raymond–Roy classification of grade II or III, coil embolization without the use of a stent and/or balloon, and aneurysms larger than 5.2 ± 2.2 mm should be carefully followed up for recanalization.

Limitations

Limitations of this study include its retrospective nature. Additionally, this study includes specifically selected patients from two tertiary hospitals. A multicenter prospective study is necessary to increase the generalizability of the study results. In this study, the mean follow-up period was 27.7 months; therefore, the rate of recanalization could have been underestimated. In addition, a longer follow-up and observation period is necessary. Further, the complications of coil embolization, recanalization, and retreatment was not reviewed.

V. CONCLUSION

The recanalization rate of PcomAs after EVT was 30.9%. The maximal diameter, Raymond–Roy classification, and presence of reinforcement were significantly associated with the occurrence of recanalization; no association was found regarding a fetal-type Pcom. Therefore, the screening of treated PcomAs after EVT should be more carefully and sensitively in patient groups with the aforementioned risk factors.

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혈관내 치료를 한 후교통동맥류 재발의 위험 요인

지도교수 정준호

연세대학교 대학원 의학과

김민정

배경 : 후교통동맥류의 혈관내치료는 후교통동맥의 해부학적 구조로 인해서 치료하기 까다롭다. 또한, 다른 위치의 뇌동맥류에 비하여 이 위치의 동맥류는 재교통의 위험이 높다고 알려져 있다.

목적 : 혈관내 치료를 한 이후의 후교통동맥류의 재교통률과 위험요인을 분석한다.

방법 : 두기관에서 2013년에서 2018년까지 혈관내치료로 치료받은 환자의 영상학적 소견을 후향적으로 분석하였다. 단변량과 다변량 분석이 시행되었으며, 후교통동맥의 모양에 따라 그룹화하여 진행하였다.

결과 : 후교통동맥류의 재교통률은 53명의 환자에게서 일어났다(30.9%). 7명의 환자는 재치료 하였으며 (4.0%) 이중 6명은 혈관내치료로 1명은 외과적 클립결찰술을 시행하였다.평균 추적관찰 기간은 27.7 개월이었다. (3.5–78.6). 동맥류의 최대길이 (odds ratio [OR] 1.23, P=.006), a Raymond–Roy 분류의 2등급과 3등급 (OR 2.26, P=.03), 그리고 추가적 기구 사용 (풍선이나 스텐트, OR 0.44, P=.03) 가 다변량 기호 논리학 회귀에 의해 재교통에 연관관계가 있음을 밝혔다. 또한 동맥류의 최대 길이가 fetal-type 후교통동맥과 normal-type 후교통동맥 사이에서의 통계학적인 차이가 보임을 분석할 수 있었다.

결론 :혈관내치료 이후의 후교통동맥류의 재교통률은 30.9%, 재치료율은 4.0% 이다. 뇌동맥류의 최대 길이, Raymond–Roy 분류, 추가 기구의 사용은 재발률과 통계학적인 연관성이 있으나 fetal-type 후교통동맥류와는 보이지 않는다. 동맥류의 크기는 fetal-type 후교통 동맥류가 normal-type 후교통동맥류의 크기보다 더 큼을 알수 있었다. 또한 재교통률은 후교통 동맥류의 크기와는 관련이 없다.

핵심되는말 : 혈관내 치료, 후교통동맥류, Raymond-Roy 분류, 재교통, 풍선, 스텐트, fetal-type 후교통동맥