Morphological Study of Aneurysms at the Junction of the Superior Cerebellar Artery

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Summary

Superior cerebellar artery (SCA) aneurysms sometimes involve the origin of the SCA making treatment difficult. We focused on the morphological characteristics of SCA aneurysms and adjacent vascular structures to apply clinical decision-making for the treatment strategy. Sixty-nine SCA aneurysms, including 34 ruptured and 35 unruptured ones, had been treated for over 12 years. Multiple aneurysms were associated in 30 patients. The pattern of the neck position of aneurysms was classified into three types: Type A: no SCA-involved type; Type B: half involved type with SCA originating from the aneurysmal neck; Type C: pure SCA aneurysm with all the neck mounting on SCA. Morphological and clinical analysis was done between ruptured and unruptured aneurysms and among the three types.

There was no difference in patient profile between ruptured and unruptured aneurysms. The angle formed by the posterior cerebral artery and SCA on the aneurysm side was obtuse in 62 (90%) patients. From the morphological point of view the SCA-involved type (types B + C) was significantly more prevalent in ruptured aneurysms (77%). Bleb formation was particular in ruptured aneurysms. As for the treatment, the risk of SCA occlusion and incomplete and attempted operation was particularly high in cases with SCA-involved type.

Although SCA aneurysms may grow due to the hemodynamic stress at the opened bifurcation between the PCA and SCA, the neck shifting to the origin of SCA, particularly in ruptured lesions, may suggest some other etiological mechanism. SCA-involved type aneurysms had a high treatment risk of SCA occlusion and tended to incomplete treatment to avoid such ischemic complications.

Introduction

Cerebral aneurysms are broadly divided into lateral and terminal type by adjacent branching pattern. According to this concept, the aneurysms at the junction of the basilar artery (BA) and superior cerebellar artery (SCA) look like the lateral type protruding from the BA trunk. However some aneurysms appear to be a terminal type between the posterior cerebral artery (PCA) and SCA. This variation may influence the treatment strategy and results, particularly in the case of embolization [1,2]. We studied the specific morphology of SCA aneurysms and the adjacent vascular complex to clarify the characteristics of ruptured lesions and address the treatment risk by the location of the neck including a review in the literature.

Methods

Profile of patients

We treated 69 patients with BA-SCA aneurysms at Nagoya University hospital and our facilities over a twelve-year period from 1995 to 2006. We retrospectively reviewed the medical

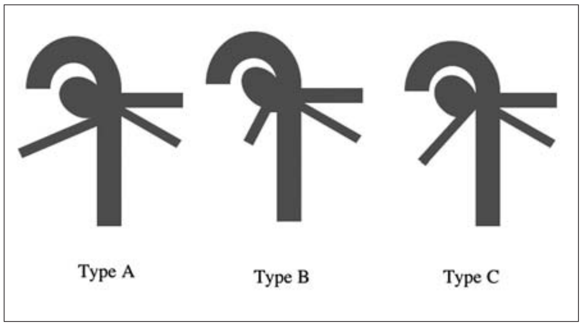

Figure 1 The pattern of the neck position of aneurysms. Type A: no SCA-involved type; Type B: half involved type with SCA originating from the aneurysmal neck; Type C: pure SCA aneurysm with all the neck mounting on SCA.

Table 1 **Summary of the cases.**

	ruptured	unruptured	total
case number	34	35	69
patient profile			
male	13	9	22
female	21	26	47
age	61	62,7	61,9
H&H grade 0	–	35	35
H&H grade I	5	–	5
H&H grade II	14	–	14
H&H grade III	9	–	9
H&H grade IV	6	–	6
aneurysm profile			
side right	18	18	36
side left	16	17	33
size <4 mm	16	13	29
size 4 - 6 mm	12	13	25
size 7 - 9 mm	6	7	13
size ≥10 mm	2	2	4
leb formation	10	2	12
another aneurysms	9	22	31
anterior circulation	5	19	24
ICA	2	8	10
MCA	0	9	9
AcomA	3	2	5
posterior circulation	4	3	7
BA-tip	2	1	3
AICA	1	0	1
PICA	2	2	4
branching profile			
open angled ipsialteral PCA-SCA junction	31	31	62
neck involvement to SCA			
type A	8	16	24
type B	16	15	31
type C	10	4	14
treatment method			
clipping, wrapping	7	3	10
coil embolization	27	21	48
attempt	1	5	6
observation	0	6	6

ICA: internal carotid artery, MCA: middle cerebral artery; AcomA: anterior communicating artery, BA: basilar artery; AICA: anterior inferior cerebellar artery, PICA: posterior inferior cerebellar artery; PCA: posterior cerebral artery, SCA: superior cerebellar artery.

records, radiographic studies and operation records of the patients (Table 1). Forty-seven patients were female (68%) and 22 were male. Their ages ranged from 44 to 77 years (mean 61.9±8.6 SD years). Thirty-four patients had ruptured aneurysms and 35 had unruptured lesions. Hunt & Hess grade of the patients with ruptured aneurysms was Grade I in 5, II in 14, III in 9, IV in 6, respectively. Thirty patients had 31 multiple aneurysms in other locations, including the anterior circulation in 24 and posterior circulation in seven. The definition of ruptured aneurysm among the multiple aneurysms was based on the distribution of subarachnoid hemorrhage and clinical manifestations. Ten aneurysms were clipped, 47 were embolized with detachable coils. The choice of the treatment methods was based on the operator's decision-making and the patient's wishes. Five patients with failed clipping underwent embolization and two patients with failed embolization were clipped. Six patients with tiny unruptured aneurysms were observed because of the anatomical difficulty or patients declined treatments. Treatment was only attempted in six aneurysms because of failure of access or the high risk of procedural complications (Table 1).

Analysis of images

Digital subtraction angiography (DSA) and three dimensional CT angiography were used as a reference to examine the morphology of aneurysms including laterality, size, shape (the existence of bleb), the location of the neck based on the relation with the SCA, as well as the pattern of the adjacent vascular complex including the angle between SCA and PCA, and the existence of other aneurysms. The

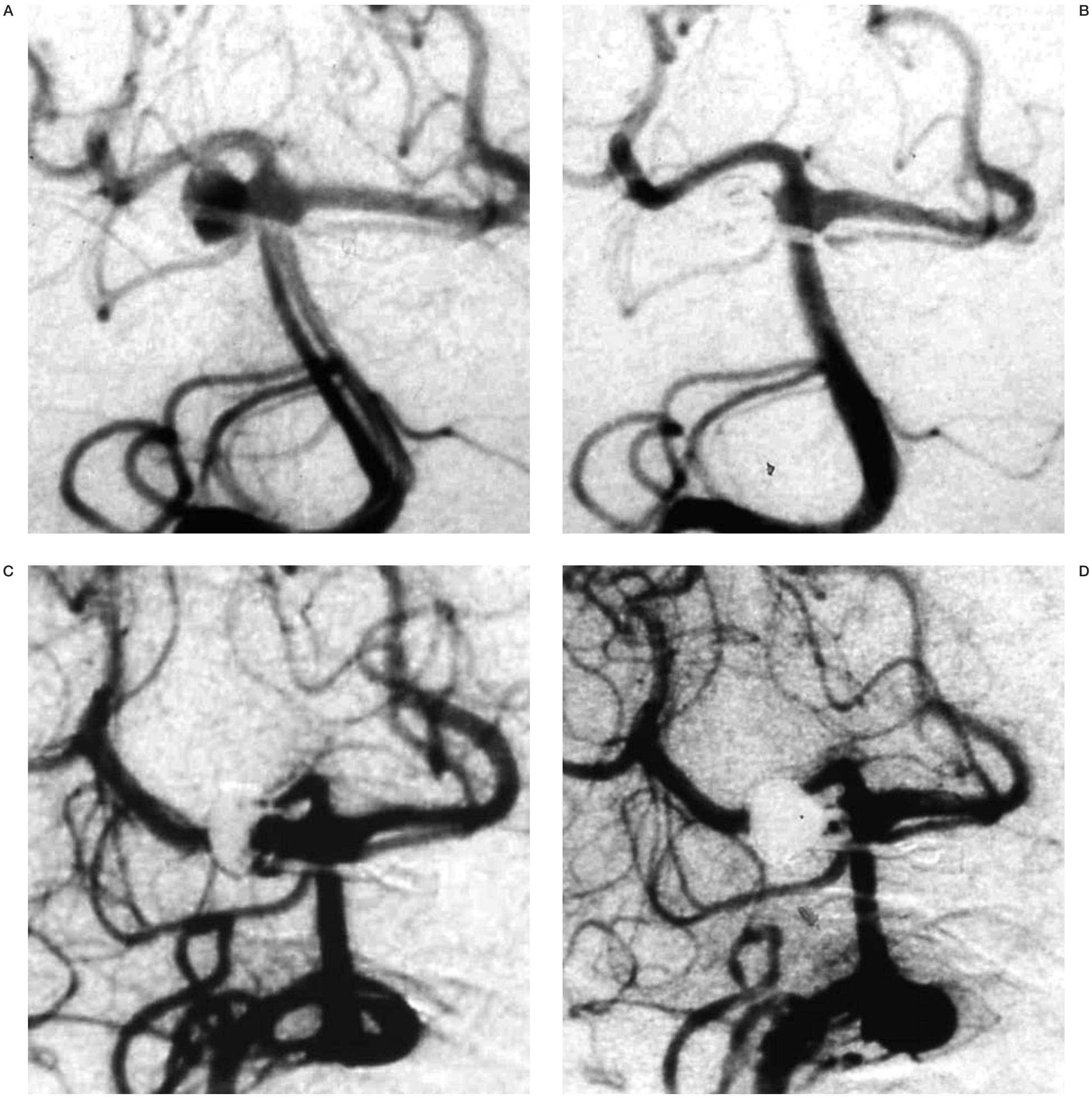

Figure 2 A case of Type A: before (A) and after (B) embolization. Recurrent aneurysm 3 years after the initial treatment (C) was re-embolized with coils (D). Note the counterclockwise inclination to the right of BA course and the obtuse angle between posterior cerebral artery and SCA.

longest diameter in the three dimensional views was adopted as the size of the aneurysm. The angle between the SCA and PCA was calculated in the most opened angle among the anteroposterior and various oblique views of 3D-CT angiography or 3D-DSA. The location of the neck was classified based on the degree of involvement of the SCA into the following three types: Type A: no SCA-involved type; SCA directly originates from BA and the neck locates on the junction of BA and SCA; Type B: half involved type; most part of the neck is shifted to SCA and SCA originates from the lateral side of the aneurysmal neck; Type C: pure SCA aneurysm; all the neck mounts on the first segment of the SCA (Figure 1). Two

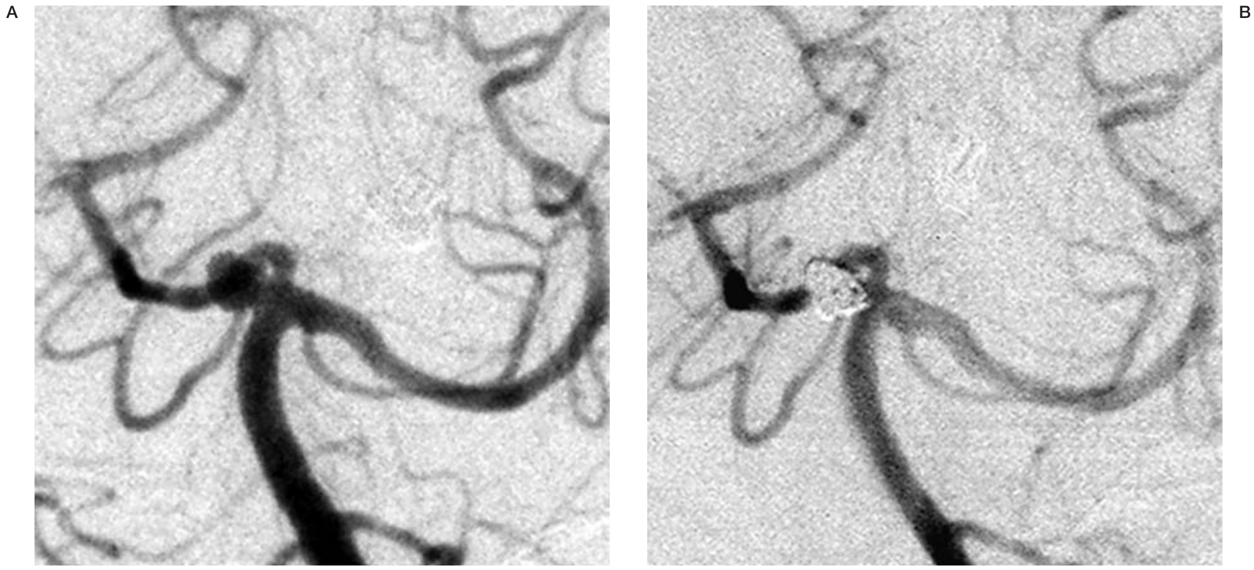

Figure 3 A case of Type B: before (A) and after (B) embolization.

neurosurgeons and neuroradiologists examined and judged the images. We analyzed the data to clarify the relation between the morphological pattern and the rupture or treatment difficulties. Statistical evaluation was done by $\chi 2$ test.

Results

Differences between ruptured and unruptured aneurysms

There was no significant difference as to the patient age and sex between the two groups with ruptured and unruptured aneurysms (Table 1). Female dominance was found in patients with unruptured aneurysms; 62% in ruptured cases and 74% in unruptured cases.

As for the aneurysm profile, there was no statistical difference in the size of aneurysms, however the rate of very small aneurysms (<4 mm) was higher in the ruptured ones (47% versus 37%). The laterality of the aneurysms was slightly shifted to the right (52%). Bleb formation was frequently found in ruptured aneurysms (10/34; 29%) significantly different from that of unruptured lesions (2/35; 6%) ($p=0.038$).

The branching pattern of the BA-tip in cases with aneurysms was left-right asymmetry in all cases. In the A-P view in DSA, 62 cases (90%) displayed an obtuse angle between the PCA and SCA on the aneurysm side (Figure 1). This particular finding was similar in both groups.

As for the relation between the aneurysmal neck and SCA, Type A in 24 cases (35%), Type B in 31 cases (45%), and Type C in 14 cases (20%). In cases of ruptured aneurysms, it was Type A in eight cases (24%), Type B in 16 cases (47%), and Type C in ten cases (29%). While in cases of unruptured lesions, it was Type A in 16 cases (46%), Type B in 15 cases (42%), and Type C in four cases (11%) (Table 2). Overall, the SCA involved type (Types B and C) accounted for 76% of cases of ruptured aneurysms and 53% of the unruptured lesions. The distribution of Type A and Type C was significantly different between ruptures and unruptured aneurysms ($p<0.05$).

Relationship between the laterality of the aneurysm and the inclination of the BA

Among 37 patients who had the aneurysm on the right side 19 patients showed the course of the BA trunk shifted with a counterclockwise inclination in the anteroposterior view of the angiography. In contrast, 17 out of 33 patients who had the SCA aneurysms on the left side showed a clockwise rotation of the BA. Thirty patients showed a vertical positioned BA, in whom16 aneurysms were located on the right side and 14 were on the left. In other words, 19 out of 21 BA of counterclockwise inclination to the right formed aneurysms on the inclined side, and 17 out of 19 of clockwise inclination to the left showed the same tendency (Table 3).

Results and treatment complications

Complete occlusion of the aneurysms was achieved in 43 patients (62%). According to the analysis by type of aneurysms, there was no relation among the distribution of the aneurysms, size, and side with types. However, SCA involved type (Types B and C) had a relatively higher tendency to fail the complete treatments. The rate of neck remnant was 12% in Type A, 35% in Type B and 31% in Type C (Table 2).

As for the clinical results, there was no treatment-related mortality. Treatment-related morbidity was 4.3%. The patients with permanent deficits (more than mRS 3) included two patients with intraoperative rupture of other aneurysms and one patient with cerebellar infarction due to the SCA occlusion. Four patients died from the initial damage of subarachnoid hemorrhage in three and rerupture of the aneuryrm in one.

In our endovascular treatment there were six technical complications. Extravasation occurred in one patient without neurological deficits. SCA occlusion or embolism occurred in five patients: three of them were successfully recanalized with local fibrinolytic therapy, another two patients in whom SCA occlusion occurred several hours after the embolization were managed with medical therapy. All the patients except one with a large cerebellar infarction recovered well with or without mild cerebellar symptoms. All thrombotic complications of SCA occurred in the SCA involved type (Table 2).

Recurrence of aneurysms occurred in four cases. The recurrent style was coil sinking and regrowth after incomplete clipping in two small ruptured aneurysms, and coil compaction with persistent growth in two unruptured aneurysms. With regard to coil compaction and regrowth, additional coil embolization was needed for three patients and clipping was performed in one.

Discussion

Generally aneurysms form at the junction of arteries[3,4], and hemodynamic stress serves to enlarge them[3,5,6]. In particular, the hemodynamic stress exerted on the bifurcation may be one of the factors generating terminal type aneurysms. Thus, aneurysms of the BA-tip may be readily formed by hemodynamic stress. Tanaka et Al.[1] indicated with regard to nine cases of SCA aneurysms that the angle between the PCA and SCA on the side of an aneurysm was obtuse in an anteroposterior view in DSA, while that on the opposite side was acute. In other words, the fact that the angle between the PCA and SCA is obtuse may be one of the mechanisms of aneurysm formation at the BA-SCA junction. According to our results, three out of four recurrent cases were Type A aneurysms. Type A

Figure 4 A case of Type C: 3D-DSA (A) before (B) and after (C) embolization.

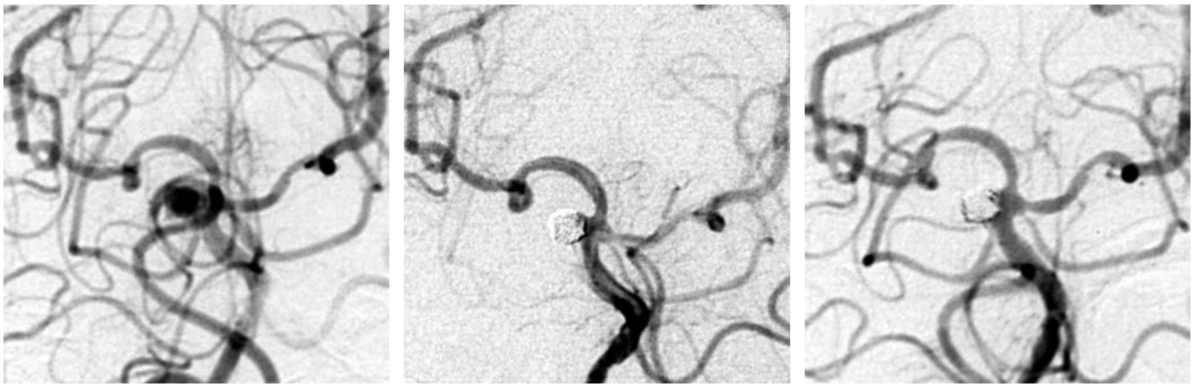

Figure 5 A case of intraoperative branch occlusion: Pre-embolization of Type B unruptured aneurysm (A). SCA was occluded after the THIRD coil insertion (B). Successful recanalization with local fibrinolytic therapy (C).

Table 2 **Characteristics by type of neck involvement to SCA.**

	type A	type B	type C	total
Clinical manifestations				
rupture	9	16	9	34
unrupture	16	15	4	35
Aneurysm side				
right	12 (5)	16 (7)	8 (6)	36 (18)
left	13 (4)	15 (9)	5 (3)	33 (16)
Aneurysm size				
<4 mm	10	8	4	22
4 - 6 mm	10	14	7	31
7 - 9 mm	2	6	2	10
≥10 mm	2	2	0	4
bleb formation	5	3	4	12
Treatment method				
clipping	2	6	2	10
coiling				
attempt	1	4 [1]	1	6
observation	5	1	0	6
angiographic result				
total occlusion	19	15	9	43
body filing	3	5	1	9
neck remnant	3 [1]	11 [1]	4	17 [2]
complications				
extravasation	0	1	0	1
SCA occlusion	0	4	1	5
recurrence	3	1 [1]	0	4 [1]

( ): number of the ruptured cases [ ]: number of the clipping cases

aneurysm has the orifice directly opening to the BA, therefore they might be exposed by higher hemodynamic stress than other branch-oriented types (Types B and C). Obvious distribution of the laterality of the aneurysms by BA inclination may also suggest participation of the hemodynamic effect. It is well known that aneurysms with blebs tend to rupture [7-9]. Our study showing that bleb formation was particularly seen in the ruptured aneurysms confirms previous evidence. As for our case, there was no significant difference in type, but Type B aneurysms had a tendency to less bleb formation. It is unclear whether this fact may be correlated with the hemodynamic stress.

In our series, 58% of the aneurysms belonged to the SCA involved type (Types B and C) rather than the BA-originated type (Type A). Type C aneurysms were relatively found particularly in ruptured aneurysms, in contrast about half of the unruptured aneurysm were Type A. This difference was statistically significant ($p<0.05$). The reason for this difference was unclear, but we speculate that the fragility of the aneurysm wall may be caused by the thinner structure of the branches rather than the main trunk. We cannot address the monistic explanation that the extension of the aneurysm to the branches may cause enlargement and rupture.

With regard to the size of the aneurysm, several reports disclosed that larger aneurysms (especially more than 10 mm) tend to rupture more easily [10]. The International Study of Unruptured Intracranial Aneurysms Investigators (ISUIA) [11] reported in 2003 that aneurysms more than 13 mm in size tend to rupture. According to our initial speculation, the larger the aneurysms become, the more frequently the SCA should have been involved in the aneurysm, and should have ruptured, but our study failed to prove this hypothesis. There was no correlation among size, type and rupture (Tables 1 and 2). This may suggest that aneurysms may enlarge as concentric circles just from their origin and may not have an alternative direction to extend the orifice.

According to a review of 22 studies on the incidence of technical complications in aneurysm embolization, Park et Al [12] found that 23% occurred in cases of rupture and 8% in cases without rupture. Robert et Al [13] reported one case with an embolized BA-SCA aneurysm in which the shape of coils changed, and the SCA was occluded at the two year follow-up. Albayram et Al [14] indicated that in cases of BA-SCA aneurysms thrombotic complications occurred in three out of five cases and one case occluded the SCA completely. In the present study, technical complications such as SCA occlusion and ischemic complications occurred in 8.7%, which is comparable to that in other reports [2]. However, the rate of ischemic complication (7.2%) due to the branch occlusion was much higher than that of aneurysms in other locations, mean 2.4% in our 625 experiences. In our series, all five cases where the SCA was completely occluded belonged to SCA-involved type. Lubics et Al [15] addressed the difficulty of endovascular treatment for aneurysms with a branch arising from the sac. They had no experiences of branch occlusion, but complete occlusion of the aneurysm was achieved in only 22% of cases. Therefore we have to make the utmost effort to preserve the SCA using various adjunctive techniques for these high-risk aneurysms. In other words, we must evaluate small, asymptomatic SCA-involved type aneurysms based on the risk-benefit assessment including the choice of observation, and this discreet tendency was expressed in the recent negative inclination to embolize these aneurysms (Table 1). Attempted rate (8.7%) was slightly higher than that of the report of the International Subarachnoid Aneurysm Trial (ISAT) [16].

In our series, coil compaction occurred in 19% of embolized aneurysms. One of the reasons is the incomplete packing in several former cases using the mechanical detachable coils, which have a poor size line-up to achieve suitable coil embolization. Further, a terminal type of aneurysm with a wide neck readily affected by hemodynamic stress may result in coil compaction and regrowth, as proven in experimental studies [17]. Hope et Al [18] reviewed 63

Table 3 **The relationship between the laterality of the aneurysm and the inclination of basilar artery.**

	BA inlination*		
aneurysm side	**counterclockwize (right)**	**clockwize (right)**	**vertical (left)**
right	18	2	16
left	2	17	14
total	20	19	30

: see Fig. 1

aneurysm cases after seven months follow-up and showed 28% had coil compaction and 11% had aneurysmal growth. They stressed that the major cause of recurrence was wide-neck size. It is known that rough packing of a large aneurysm frequently causes coil compaction[14,19-21]. Thus, caution is especially needed in cases with a terminal type of relatively large SCA aneurysms and an obtuse angle of the branching pattern of the BA-tip because of possible post-embolization coil compaction and recurrence.

Conclusions

BA-SCA aneurysms particularly tended to originate closer to the SCA and were significantly frequent in cases of ruptured aneurysm. Although SCA aneurysms may grow due to the hemodynamic stress at the opened bifurcation between the PCA and SCA, the right side dominance and the neck shifting to the origin of SCA, particularly in ruptured aneurysms, may suggest some other etiological mechanism. SCA-involved type aneurysms had a high treatment risk of SCA occlusion and tend to incomplete treatment to avoid ischemic complications. When embolizing SCA aneurysms, particularly those in cases with a broad neck, either a balloon catheter or some other microcatheters should be used to preserve the SCA and should be packed tightly to avoid later recanalization. Further perioperative management focusing on antiplatelet agents may be important to avoid ischemic complications.

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