Analysis of morphology of the basilar-superior cerebellar artery aneurysms

Shigeyuki Sakamoto, MD
Department of Neurosurgery, Hiroshima University
Graduate School of Biomedical Sciences
Hiroshima, Japan

Shinji Ohba, MD
Department of Neurosurgery, Hiroshima University
Graduate School of Biomedical Sciences
Hiroshima, Japan

Masaaki Shibukawa, MD
Department of Neurosurgery, Hiroshima University
Graduate School of Biomedical Sciences
Hiroshima, Japan

Yoshihiro Kiura, MD
Department of Neurosurgery, Hiroshima University
Graduate School of Biomedical Sciences
Hiroshima, Japan

Takahito Okazaki, MD
Department of Neurosurgery, Hiroshima University
Graduate School of Biomedical Sciences
Hiroshima, Japan

Toshinoru Matsushige, MD
Department of Neurosurgery, Hiroshima University
Graduate School of Biomedical Sciences
Hiroshima, Japan

Kaoru Kurisu, MD
Department of Neurosurgery, Hiroshima University
Graduate School of Biomedical Sciences
Hiroshima, Japan

Address for correspondence:
Shigeyuki Sakamoto, MD
Department of Neurosurgery, Hiroshima University
Graduate School of Biomedical Sciences
Hiroshima, Japan
E-mail: sakamoto@hiroshima-u.ac.jp

Morphological information of aneurysms is important for performing surgical clipping or endovascular coiling. Basilar-superior cerebellar artery (BA-SCA) aneurysms are rare types of intracranial aneurysms.

There have been few studies of the morphological features of BA-SCA aneurysms. In this study, we retrospectively analyzed the morphology of 24 BA-SCA aneurysms from 24 patients. Various dimensions of aneurysm including width (W), height (H) and neck (N) of the aneurysms; H/N, W/N and W/H ratios and the angles formed between the posterior cerebral artery (PCA) and SCA were measured. BA-SCA aneurysms were classified according to the location of the aneurysm neck. Aneurysm size, ratios, angle and type were compared between ruptured and unruptured aneurysms. The average measurements of the BA-SCA aneurysm domes were as follows: height = 4.7 mm; width = 5.1 mm; and neck = 2.9 mm. The average size ratios of the BA-SCA aneurysms were: H/N =1.56; W/N = 1.74; and W/H = 1.15. The average PCA-SCA angle of the aneurysms was 111.9 degrees. Approximately 70% of the necks of the BA-SCA aneurysms were partially located on the SCA.

There was not a significant difference between ruptured and unruptured BA-SCA aneurysms, in size, angle, and neck location. Regardless of ruptured or unruptured status, BA-SCA aneurysms tended to have width more than height with the neck partially located on the SCA.

Key Words: basilar artery, cerebral aneurysm, morphology, superior cerebellar artery

Saccular intracranial aneurysms commonly occur at arterial bifurcations since bifurcations are the site of maximum hemodynamic stress.[5,8] However, a recent report found that the aneurysmal neck does not necessarily always exist at the bifurcation but may deviate to the daughter artery.[8] Thus, preoperative understanding of the morphology of the aneurysm is important when performing surgical clipping or endovascular coiling. Vertebrobasilar aneurysms represent approximately 10% of all intracranial aneurysms.[10] Among vertebrobasilar aneurysms, saccular aneurysms of the upper basilar artery (BA) arising at the bifurcation of the origin of the superior cerebellar artery (SCA) and posterior cerebral artery (PCA) are called BA-SCA aneurysms. BA-SCA aneurysms are rare and there are few studies on the morphological features of these aneurysms.[4, 10] In this study we analyzed the

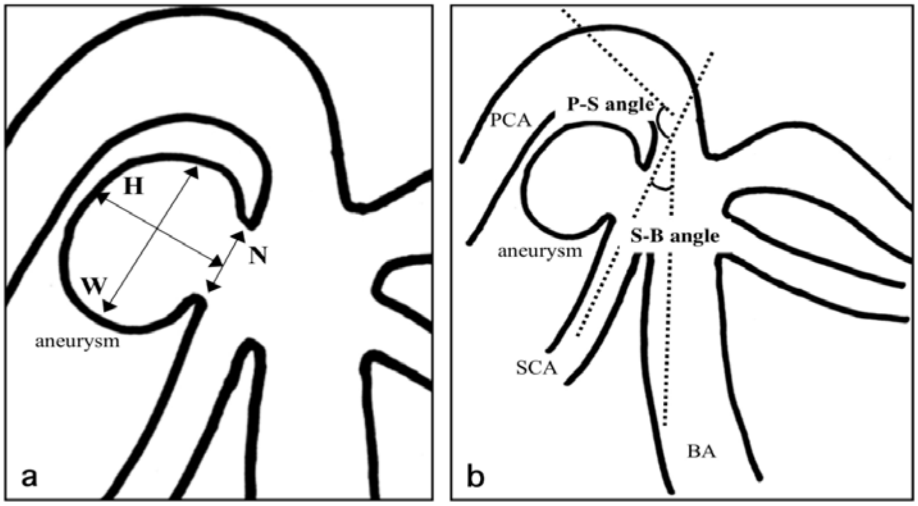

Figure 1. a) schematic diagram of a BA-SCA aneurysm. The size of the aneurysm was defined by measuring the aneurysm height (H), aneurysm width (W) and neck width (N). b) schematic diagram of the basilar artery with the BA-SCA aneurysm. The angle between the PCA and the SCA on the aneurysm side was defined as the P-S angle. The angle between the SCA and the BA was defined as the S-B angle.

morphology of 24 BA-SCA aneurysms to better understand the anatomical features contributing to successful treatment, especially for endovascular coiling.

Materials and methods

Between January 1998 and August 2006, there were 24 patients with a BA-SCA aneurysm in our institution and affiliated hospitals **(Table 1)**. The patients included 12 females and 12 males ranging in age from 37 to 80 years with an average of 62.8 years. Of 24 aneurysms, 16 were ruptured and eight were unruptured, with 12 located on the right side and 12 on the left side. All eight patients with unruptured aneurysms initially presented with nonspecific symptoms such as headache, vertigo, or tinnitus. The unruptured aneurysms were detected in magnetic resonance angiography (MRA) or computed tomographic angiography (CTA). Preoperative digital subtraction angiography (DSA) was performed in all 24 patients, in addition to MRA and/or CTA. All patients underwent endovascular treatment.

Morphological features of aneurysm were examined by measuring size of dome in terms of height (H), width (W) and neck width (N) in DSA images **(Figure 1a)**, and the following ratios were calculated: aneurysm height/neck (H/N), width/neck (W/N) and width/height (W/H).

The angle between PCA and SCA on the aneurysm side was defined as P-S angle. Similarly, the angle between SCA and BA was defined as S-B angle **(Figure 1b)**. The P-S and S-B angles were measured using a DSA image that showed precise position of the aneurysm neck, and MRA and/or CTA images were also reviewed as necessary **(Figure 2)**. The aneurysm size was measured on DSA films in micrometers and corrected according to the scale on the film.

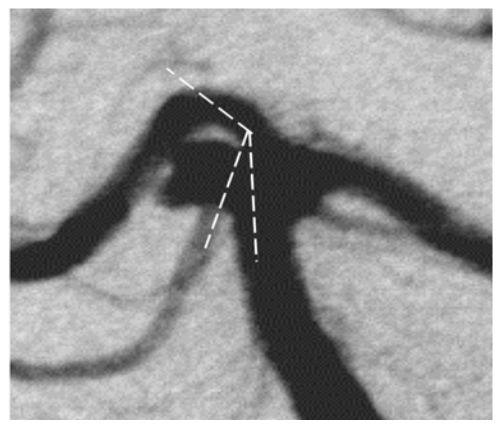

Figure 2. Patient No.18: A patient with an unruptured BA-SCA aneurysm on the right side. The P-S angle was 119 degree and the S-B angle was 21 degree.

We classified the BA-SCA aneurysms into 3 types according to the location of aneurysm neck. When the aneurysm neck was completely located on SCA, the aneurysm was defined as type S **(Figure 3a)**. When the aneurysm neck was partially located on SCA and partially on BA i.e. proximal neck on SCA and distal neck on BA, the aneurysm was defined as type BS **(Figure 3b and 4)**. When the aneurysm neck was located completely on BA, the aneurysm was defined as type B **(Figure 3c and 5)**.

The ruptured and unruptured groups were compared by using Mann-Whitney U test in terms of aneurysm size (H, W and N), size ratio (H/N, W/N and W/H), angle (P-S and S-B) and type (B, BS and S). Differences of $p<0.05$ were regarded as statistically significant.

				Size (mm)						Angle			
Patient	Age / Sex	Symptom	Side	H	W	N	H/N	W/N	W/H	P-S	S-B	Type	Treatment
1	56 / F	Ruptured	R	7.1	5.0	3.0	2.37	1.67	0.71	78	45	B	Coiling
2	49 / F	Ruptured	L	2.3	3.1	1.0	2.3	3.10	1.35	108	49	BS	Coiling
3	37 / M	Ruptured	R	2.0	2.2	2.2	0.91	1.00	1.10	91	68	BS	Coiling
4	66 / M	Ruptured	L	11.8	12.0	5.4	2.19	2.22	1.02	108	29	BS	Coiling
5	71 / M	Ruptured	L	6.5	12.4	3.7	1.76	3.35	1.91	35	108	BS	Coiling
6	54 / M	Ruptured	R	4.6	4.0	3.0	1.53	1.33	0.87	132	35	BS	Coiling
7	62 / F	Ruptured	L	7.8	4.7	3.2	1.66	1.47	0.60	99	35	B	Coiling
8	77 / F	Ruptured	L	5.0	5.2	3.7	1.35	1.41	1.04	119	35	BS	Coiling
9	67 / M	Ruptured	L	10.2	6.2	2.9	3.52	2.14	0.61	100	77	B	Coiling
10	63 / M	Ruptured	R	4.3	7.4	3.4	1.26	2.18	1.72	131	9	B	Coiling
11	78 / M	Ruptured	R	1.6	2.0	1.6	1	1.25	1.25	142	40	BS	Coiling
12	54 / F	Ruptured	L	3.1	3.9	2.0	1.55	1.95	1.26	114	42	BS	Coiling
13	61 / F	Ruptured	R	3.9	4.4	2.4	1.63	1.83	1.13	125	38	BS	Coiling
14	80 / F	Ruptured	L	3.7	5.0	4.0	0.925	1.25	1.35	127	32	BS	Coiling
15	67 / F	Ruptured	R	3.0	3.1	2.1	1.43	1.48	1.03	102	40	BS	Coiling
16	52 / F	Ruptured	R	2.5	2.2	1.8	1.39	1.22	0.88	93	52	BS	Coiling
17	60 / M	Unruptured	L	3.2	3.4	2.3	1.39	1.48	1.06	114	57	B	Coiling
18	60 / F	Unruptured	R	3.4	4.2	2.3	1.48	1.83	1.24	119	21	BS	Coiling
19	75 / M	Unruptured	R	2.7	3.4	3.4	0.79	1.00	1.26	155	5	B	Coiling
20	51 / M	Unruptured	L	2.9	3.4	3.2	0.91	1.06	1.17	124	7	BS	Coiling
21	70 / M	Unruptured	R	3.0	4.5	3.0	1	1.50	1.50	111	35	B	Coiling
22	56 / F	Unruptured	L	3.2	3.9	2.2	1.45	1.77	1.22	126	47	BS	Coiling
23	67 / F	Unruptured	R	7.7	9.6	4.0	1.93	2.40	1.25	125	60	BS	Coiling
24	75 / M	Unruptured	L	6.2	6.5	3.7	1.68	1.76	1.05	108	52	BS	Coiling

Table 1. Summary of 24 patients with BA-SCA aneurysms; H, height; W, width; N, neck width; P-S, posterior cerebral artery-superior cerebellar artery; S-B, superior cerebellar artery-basilar artery

H	4.7 ± 2.7 mm
W	5.1 ± 2.8 mm
N	2.9 ± 0.96 mm
H/N	1.56 ± 0.60
W/N	1.74 ± 0.60
W/H	1.15 ± 0.31
P-S	111.9 ± 23.7 degrees
S-B	42.4 ± 22.6 degrees

Table 2. Summary of geometry of 24 BA-SCA aneurysms (mean ± SD) H, aneurysm height; W, aneurysm width; N, neck width; P-S, posterior cerebral artery-superior cerebellar artery; S-B, superior cerebellar artery-basilar artery

Results

The average size of 24 BA-SCA aneurysms were as follows: H = 4.7 ± 2.7 mm (range 1.6 - 11.8 mm), W = 5.1 ± 2.8 mm (range 2.0 - 12.4 mm) and N = 2.9 ± 0.96 mm (range 1.0 - 5.4 mm) **(Table 1 and 2)**. The average size of ruptured aneurysms were as follows: H = 5.0 ± 3.0 mm (range 1.6 - 11.8 mm), W = 5.2 ± 3.1 mm (range 2.0 - 12.4 mm) and N = 2.8 ± 1.1 mm (range 1.0 - 5.4 mm) **(Table 1 and 3)**. The average size of unruptured aneurysms were as follows: H = 4.0 ± 1.9 mm (range 2.7 - 7.7 mm), W = 4.9 ± 2.2 mm (range 3.4 - 9.6 mm) and N = 3.0 ± 0.69 mm (range 2.2 - 4.0 mm) **(Table 1 and 3)**. The average size ratio of 24 BA-SCA aneurysms were H/N 1.56 ± 0.60 (range 0.79 - 3.52), W/N 1.74 ± 0.60 (range 1.00 - 3.35) and W/H 1.15 ± 0.31 (range 0.60 - 3.35) **(Table 1 and 2)**. The average size ratios of the ruptured aneurysms were H/N 1.67 ± 0.66 (range 0.91 - 3.52), W/N 1.80 ± 0.67

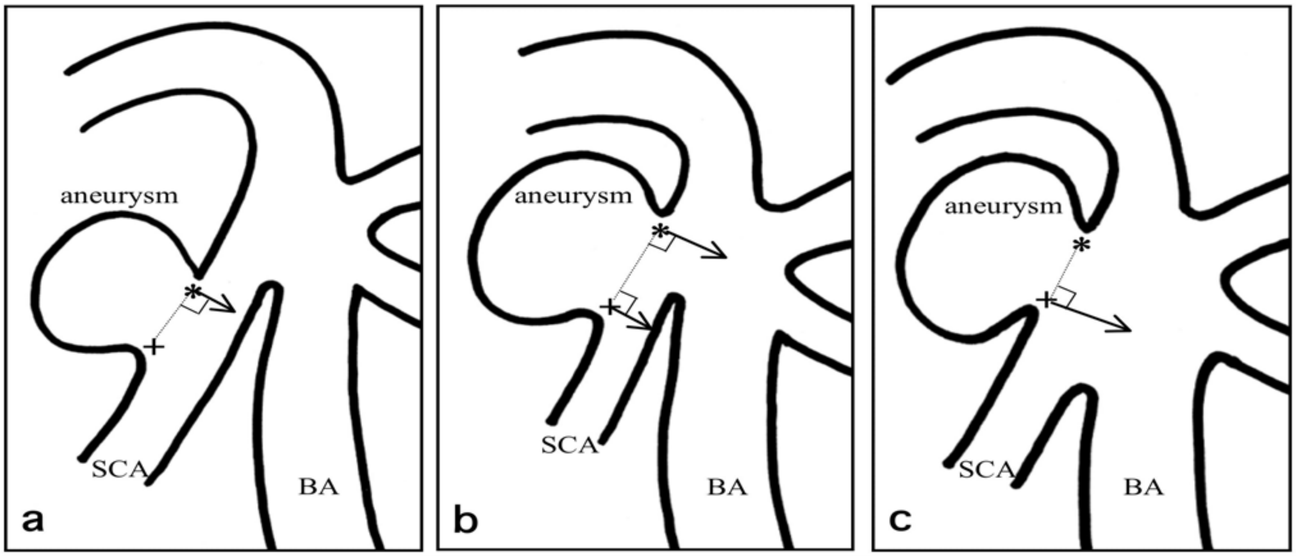

Figure 3. *Schematic diagram of different types of BA-SCA aneurysms classified by position of the aneurysm neck. a) The aneurysm was defined as type S when a line extending from the proximal origin (*) of the aneurysm neck was located on the SCA. b)The aneurysms was defined as type BS when a line extending from the distal origin (+) of the aneurysm neck was located on the SCA and a line extending from the proximal origin (*) of the aneurysm neck was located on the BA. c) The aneurysm was defined as type B when a line extending from the distal origin (+) of the aneurysm neck was located on the BA.*

	Ruptured (mean ± SD)	Unruptured (mean ± SD)
H	5.0 ± 3.0 mm	4.0 ± 1.9 mm
W	5.2 ± 3.1 mm	4.9 ± 2.2 mm
N	2.8 ± 1.1 mm	3.0 ± 0.69 mm
H/N	1.67 ± 0.66	1.33 ± 0.40
W/N	1.80 ± 0.67	1.60 ± 0.45
W/H	1.11 ± 0.36	1.22 ± 0.14
P-S	106.5 ± 25.8 degrees	122.8 ± 14.7 degrees
S-B	45.9 ± 22.7 degrees	35.5 ± 22.1 degrees

Table 3. Ruptured versus unruptured BA-SCA aneurysmsH, aneurysm height; W, aneurysm width; N, neck width; P-S, posterior cerebral artery-superior cerebellar artery; S-B, superior cerebellar artery-basilar artery

(range 1.00 - 3.35) and W/H 1.11 ± 0.36 (range 0.60 - 1.91) **(Table 1 and 3)**. The average size ratios of the unruptured aneurysms were H/N 1.33 ± 0.40 (range 0.79 - 1.93), W/N 1.60 ± 0.45 (range 1.00 - 2.40) and W/H 1.22 ± 0.14 (range 1.05 - 1.50) **(Table 1 and 3)**.

In 24 BA-SCA aneurysms, the average P-S angles were 111.9 ± 23.7 degrees (range 35 - 155 degrees) and the average S-B angles were 42.4 ± 22.6 degrees (range 5 - 108 degrees) **(Table 1 and 2)**. In ruptured aneurysms, the average P-S angles were 106.5 ± 25.8 degrees (range 35 - 142 degrees) and the average S-B angles were 45.9 ± 22.7 degrees (range 9 - 108 degrees) **(Table 1 and 3)**. In unruptured aneurysms, the average P-S angles were 122.8 ± 14.7 degrees (range 108 - 155 degrees) and the average S-B angles were 35.5 ± 22.1 degrees (range 5 - 60 degrees) **(Table 1 and 3)**.

Regarding type of aneurysm, in 24 BA-SCA aneurysms, 7 were type B (29.2%) and 17 were type BS (70.8%) **(Table 1)**. In the 16 ruptured aneurysms, 4 were type B (25%) and 12 were type BS (75%), while in the 8 unruptured aneurysms, 3 were type B (37.5%) and 5 were type BS (62.5%).

There were no significant differences in aneurysm size (H, W and N), size ratio (H/N, W/N and W/H), angle (P-S and S-B), or type (B and BS) between the ruptured and unruptured aneurysms.

Discussion

Vertebrobasilar artery aneurysms represent approximately 10% of all intracranial aneurysms.[3] BA-SCA aneurysms appear to be rarer among vertebrobasilar artery aneurysms.[4, 10] Yasargil reported a 5% incidence of BA-SCA aneurysms in his series [10] and Drake reported a 14%

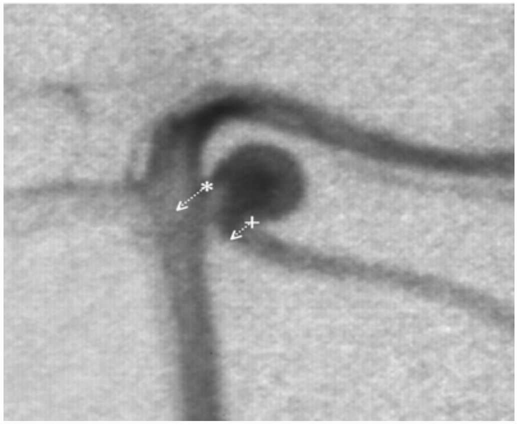

Figure 4. *Patient 22: A patient with an unruptured BA-SCA aneurysm on the left side. The aneurysm was classified as type BS because the line extending from the distal origin (+) of the aneurysm neck was located on the left SCA and the line extending from the proximal origin (*) of the aneurysm neck was located on the BA.*

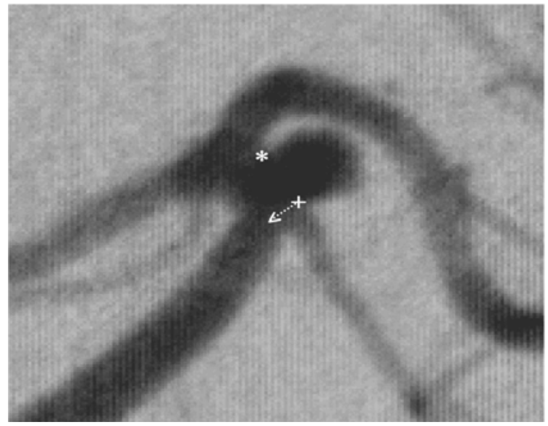

Figure 5. *Patient 17: A patient with an unruptured BA-SCA aneurysm on the left side. The aneurysm was classified as type B because the line extending from the distal origin (+) of the aneurysm neck was located on the BA.*

incidence of BA-SCA aneurysms[4)] In Drake's series, the BA-SCA aneurysm occurred more often on the left side (66%), and in female patients (75%). With regard to size, the incidence rates for small (<12mm), large (12-25mm), and giant (>25mm) aneurysms were 58%, 22%, and 20%, respectively. The localizing clinical feature of rupture or enlargement of the BA-SCA aneurysm is an ipsilateral third nerve paresis. Third nerve paresis was unusual with small aneurysms (13%), but more common with large aneurysms (35%), and frequently seen with giant aneurysms (61%). In our study, 22 out of 24 aneurysms were small. This high incidence of small aneurysms differed from previous reports [4], however, our study included more ruptured aneurysms (16 of 24), and unruptured aneurysms were detected incidentally without cranial nerve palsy.

Preoperative understanding of aneurysm morphology is important when performing surgical clipping or endovascular coiling. The W/N ratio is especially important in endovascular coiling. [1, 3, 9] To the best of our knowledge, although there has been a report of dome size in BA-SCA aneurysms [4], there are no reports of aneurysm size ratio. A ratio of less than 1 suggests surgery as the best method of treatment, whereas a ratio of greater than 1 would favor embolization. Particularly for wide-neck aneurysms, this ratio is important in predicting whether coils can be placed in a stable position within the aneurysm dome. [1, 3, 9] Furthermore, the percentage of immediate complete angiographic occlusion was related to the density of coil packing, which in turn was strongly dependent on the geometry of the aneurysm, including the dome-to-neck ratio and neck size. [3] Additionally, it is important to evaluate the arteries branching from the aneurysm for treatment planning. In Drake's series, the SCA tended to emerge from the inferior origin of the neck of the aneurysm rather than from the BA[4]. In our study, approximately 70% (type BS) of the necks were partially located on the SCA, with an obtuse angle between the PCA and SCA on the aneurysm side. In a study of aneurysm formation at bifurcation, Brown reported that the transmural pressure in the smaller daughter branch is greater than or equal to that in the larger daughter branch, and that the larger daughter branch makes a smaller angle with the direction of the parent artery. [2] Ingebrigtsen et al. reported that the odds ratio for the presence of an aneurysm was 3.46 when comparing the lowest and highest tertile of the observed angle between the parent vessel and the largest branch. [6] The corresponding odds ratio for the smallest branch was 48.06. For these reasons, intracranial aneurysms, including BA-SCA aneurysms, do not appear to occur at just the bifurcation, but also deviate to the smallest daughter artery. [4, 6-8, 10] In our study, the mean ratios of the BA-SCA aneurysms were W/N =1.74 and H/N =1.56. These results suggested that coils could be placed in a relatively stable position within the aneurysm dome [1], however most of the aneurysm necks were partially located on the SCA. It is therefore important to preserve the SCA in endovascular coiling.

In our study, most of the BA-SCA aneurysms were small in size. The geometry of the BA-SCA aneurysms displayed an aneurysm width that was a little larger than the aneurysm height, with most of the necks of BA-SCA aneurysm partially located on the SCA. We found no significant differences between ruptured and unruptured BA-SCA aneurysms in size, size ratio, angle or type of aneurysm. Our study suggests that BA-SCA aneurysms might rupture even when the aneurysms are small, and unruptured BA-SCA aneurysms might exist when the P-S angle was obtuse. Preoperative understanding of these anatomical features may contribute to more successful treatment of BA-SCA aneurysms, especially in cases using endovascular coiling.

References

1. Bavinzski G, Richling B, Gruber A, et al: Endosaccular occlusion of basilar artery bifurcation aneurysms using electrically detachable coils. **Acta Neurochir (Wien) 134:** 184-189, 1995
2. Brown N: A mathematical model for the formation of cerebral aneurysms. **Stroke 22:** 619-625, 1991
3. Debrun GM, Aletich VA, Kehrli P, et al: Selection of cerebral aneurysms for treatment using Guglielmi detachable coils: the preliminary University of Illinois at Chicago experience. **Neurosurgery 43:** 1281-1295, 1998
4. **Drake CG:** Non-Giant (Small and Large) Basilar Superior Cerebellar Artery Aneurysms. **Surgery of Vertebrobasilar Aneurysms: London, Ontario Experience on 1767 Patients.** Springer Verlag, New York, 1996, pp95-118
5. Hademenos GJ and Massoud TF: Biophysical mechanisms of stroke. **Stroke 28:** 2067-2077, 1997
6. Ingebrigtsen T, Morgan MK, Faulder K, et al: Bifurcation geometry and the presence of cerebral artery aneurysms. **J Neurosurg 101:** 108-113, 2004
7. Parlea L, Fahrig R, Holdsworth DW, et al: An analysis of the geometry of saccular intracranial aneurysms. **AJNR Am J Neuroradiol 20:** 1079-1089, 1999
8. Sakamoto S, Ohba S, Shibukawa M, et al: Characteristics of aneurysms of the internal carotid artery bifurcation. **Acta Neurochir (Wien) 148:** 139-143, 2006
9. Vinuela F, Duckwiler G, Mawad M: Guglielmi detachable coil embolization of acute intracranial aneurysm: perioperative anatomical and clinical outcome in 403 patients. **J Neurosurg 86:** 475-482, 1997
10. **Yasargil MG:** Upper Basilar Artery Trunk Aneurysms. **Microsurgery II.** Georg Thieme Verlag, New York, 1984, pp257-259