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Clinical Article

Size and Location of Ruptured Intracranial Aneurysms

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Objective : The aim of study was to review our patient population to determine whether there is a critical aneurysm size at which the incidence of rupture increases and whether there is a correlation between aneurysm size and location.

Methods : We reviewed charts and radiological findings (computed tomography (CT) scans, angiograms, CT angiography, magnetic resonance angiography) for all patients operated on for intracranial aneurysms in our hospital between September 2002 and May 2004. Of the 336 aneurysms that were reviewed, measurements were obtained from angiograms for 239 ruptured aneurysms by a neuroradiologist at the time of diagnosis in our hospital.

Results : There were 115 male and 221 female patients assessed in this study. The locations of aneurysms were the middle cerebral artery (MCA, 61), anterior communicating artery (ACoA, 66), posterior communicating artery (PCoA, 52), the top of the basilar artery (15), internal carotid artery (ICA) including the cavernous portion (13), anterior choroidal artery (AChA, 7), A1 segment of the anterior cerebral artery (3), A2 segment of the anterior cerebral artery (11), posterior inferior cerebellar artery (PICA, 8), superior cerebellar artery (SCA, 2), P2 segment of the posterior cerebral artery (1), and the vertebral artery (2). The mean diameter of aneurysms was 5.47±2.536 mm in anterior cerebral artery (ACA), 6.84±3.941 mm in ICA, 7.09±3.652 mm in MCA and 6.21±3.697 mm in vertebrobasilar artery. The ACA aneurysms were smaller than the MCA aneurysms. Aneurysms less than 6 mm in diameter included 37 (60.65%) in patients with aneurysms in the MCA, 43 (65.15%) in patients with aneurysms in the ACoA and 29 (55.76%) in patients with aneurysms in the PCoA.

Conclusion : Ruptured aneurysms in the ACA were smaller than those in the MCA. The most prevalent aneurysm size was 3-6 mm in the MCA (55.73%), 3-6 mm in the ACoA (57.57%) and 4-6 mm in the PCoA (42.30%). The more prevalent size of the aneurysm to treat may differ in accordance with the location of the aneurysm.

KEY WORDS : Size · Location · Aneurysm · Ruptured.

INTRODUCTION

The prevalence of unruptured intracranial aneurysms (UIAs) has been determined from postmortem studies, angiography, and magnetic resonance angiography (MRA). In Atkinson's study[2] of 9,295 angiograms, the prevalence of UIAs was around 1%. The prevalence of UIAs is higher in Finland[27] and in Japan[9] than in other countries. The size of intracranial aneurysm is an important indicator of risk of rupture[4,16,17,23,29,32] and outcome after treatment[20]. Other factors related to the rupture of aneurysms are shape[1,7,24,26], volume[5], and flow dynamics[14]. Knowing the critical size at which the incidence of rupture increases may help to identify the treatment for unruptured aneurysms. Reported critical diameters at which the incidence of aneurysm rupture increases are 4-10 mm[3,4,6,7,10,13,23,28,31,33,37,38]. Data from the International Study of Unruptured Intracranial Aneurysms (ISUIA) calculated a much lower risk of rupture (0% and 0.1%/year) in aneurysms less than 6 mm in diameter and 7-12 mm in diameter when the patient is asymptomatic. The limit of the size that could be safer has been revised from 9 mm to 6 mm in the ISUIA 2[10]. However, small aneurysms are more prevalent than large aneurysms in patients with ruptured aneurysms. The risk of hemorrhage associated with repair of UIAs may depend on the size and location of an aneurysm[34]. The study is still to come that can demonstrate that aneurysms below 6 mm in diameter are safe. We reviewed our patient population to determine

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the most common size of ruptured aneurysms and the critical size according to location in the cerebral vasculature.

MATERIALS AND METHODS

We reviewed charts and radiological findings of all patients operated on for intracranial aneurysms in our hospital from September 2002 to May 2004. Digital subtraction angiograms were conducted in our hospital and aneurysm sizes were measured by a neuroradiologist. The diameter of an angiocatheter in the internal carotid artery (ICA) in the angiographic view was used as the basis of the true size of arteries and aneurysms. The size of an aneurysm was the largest diameter measured by an angiographic program. In patients with multiple aneurysms, the ruptured aneurysm was confirmed in the operative findings. Patients with incidental aneurysms were excluded. Statistical analysis was performed for all aneurysms (diameter measured by catheter calibration) and their different locations (anterior cerebral artery (ACA), ICA, middle cerebral artery (MCA) and vertebrobasilar artery). To determine whether the size of the aneurysms differed among the different locations, ANOVA was done. Post hoc analysis was conducted using Scheffe's method. All analyses were performed using SAS statistical software (version 9.1; SAS Institute, Cary, NC) and $p<0.05$ was considered statistically significant.

Table 1. Age of patients

Age (years)	No. of patients
10-19	1
20-29	1
30-39	21
40-49	106
50-59	96
60-69	72
70-79	37
≥80	2

Table 2. Mean sizes and number of aneurysms according to location

Location	Mean size (mm)	No. of lesions
ACoA	6.67	66
MCA	7.09	61
PCoA	6.35	52
ICA (ophthalmic)	7.02	12
ICA (cavernous)	13.5	1
ICA (AChA)	7.5	7
A1	5.03	3
A2	4.8	11
Basilar top	6.5	13
SCA	4.2	2
PICA	46.8	8
P2	5.7	1
VA	11	2
Total		239

ACoA : anterior communicating artery, MCA : middle cerebral artery, ICA : internal carotid artery, PCoA : posterior communicating artery, AChA : anterior choroidal artery, A1, A2 : A1 and A2 segments of anterior cerebral artery, SCA : superior cerebellar artery, PICA : posterior inferior cerebellar artery, P2 : P2 segment of posterior cerebral artery, VA : vertebral artery

RESULTS

Of the 336 patients reviewed, definite measurements were obtained for 239 ruptured aneurysms. Multiple aneurysms occurred in 39 patients. Single incidental aneurysms occurred in five patients. All unruptured aneurysms were excluded from the study. Among the ruptured aneurysms, 199 were clipped, 8 were coated, and 32 were treated with Guglielmi detachable coil embolization.

Age and sex

The mean age of subjects in this study was 54±11.2 years (range 18-84 years). The most common age group was 40-49 years (Table 1). There were 115 male and 221 female patients. When the size of aneurysms was assessed in accordance with age using a t test, the mean size of aneurysms in patients below 65 years of age was 6.15±3.15 mm and the mean size of aneurysms in patients above 65 years of age was 7.62±4.19 mm. In the older age group (above 65 years), the size of aneurysms was larger than that of aneurysms in the younger age group (below 65 years), which was statistically significant (p=0.023).

Location of aneurysms

The mean size of aneurysms, their locations, and the number of lesions are summarized in Table 2. The mean size of aneurysms in the anterior communicating artery (ACoA) was 6.67 mm, for aneurysms in the MCA was 7.09 mm, for posterior communicating artery (PCoA) aneurysms was 6.35 mm, for ophthalmic segment aneurysms of ICA was 7.02 mm, for Basilar top aneurysms was 6.5 mm, and for A2 segment aneurysms of ACA was 4.8 mm (Table 2).

The most common sites for aneurysms were the ACoA (66 aneurysms), MCA (61 aneurysms), and PCoA (52 aneurysms). In ACoA aneurysms, the largest diameters of 3-4 mm, 4-5 mm, and 5-6 mm occurred in 13 patients (19.7%), 14 patients (21.2%), and 11 patients (16.7%), respectively. In MCA aneurysms, the largest diameters of 3-4 mm, 4-5 mm, and 5-6 mm occurred in 12 patients (19.6%), 10 patients (16.3%), and 12 patients (19.6%), respectively. In PCoA aneurysms, the largest diameters of 4-5 mm, 5-6 mm, and 7-8 mm occurred in 11 patients (21.1%), 11 patients (21.1%), and 8 patients (15.4%), respectively. The most prevalent aneurysm sizes in the MCA were 3-4 mm

and 5-6 mm and the next most prevalent size was 4-5 mm; in the ACoA the most prevalent sizes were 4-5 mm and 3-4 mm, in the PCoA 4-5 mm and 5-6 mm, and in the top of the basilar artery 5-6 mm (Table 3).

The locations of aneurysms were arranged into four categories : ACA, ICA, MCA, and vertebrobasilar artery aneurysms (Table 4). There were 80 aneurysms in the ACA, 72 in the ICA, 61 in the MCA, and 26 in the vertebrobasilar artery., The mean diameter of all aneurysms was 6.42±3.406 mm. The mean diameter of ACA aneurysms was 5.47±2.536 mm, the mean diameter of ICA aneurysms was 6.84±3.941 mm, the mean diameter of MCA aneurysms was 7.09±3.652 mm, and the mean diameter of vertebrobasilar artery aneurysms was 6.21±3.697 mm (Table 4). The diameters of aneurysms in the four areas differed significantly (p=0.012). There was a statistically significant difference between the diameters of aneurysms of the ACA and the MCA (p=0.025) (Fig. 1). ACA aneurysms were smaller than MCA aneurysms. The number of aneurysms below 6 mm in diameter in the MCA was 37 (60.65%), 43 (65.15%) in the ACoA, and 29 (55.76%) in the PCoA.

Table 3. Summary of aneurysm sizes and locations

Location size (mm)	MCA	ACoA	PCoA	Basilar top	ICA (opht + AChA)	Total (%)
2-3	3	5	6		3	17 (7.9)
3-4	12	13	1	2		28 (13)
4-5	10	14	11	1	3	39 (18.2)
5-6	12	11	11	3	1	38 (17.7)
6-7	4	5	4	2	4	19 (8.8)
7-8	2	6	8	1	4	21 (9.8)
8-9	5	4	3	2	1	15 (7)
9-10	3	5	2	1		11 (5.1)
10-12	4	3	4	1		12 (5.6)
12-14	5				2	7 (3.2)
14-16	3		1			4 (1.8)
16-18	1					1 (0.4)
20			1		1	2 (0.9)
Total	61	66	52	11	19	214

Opht : ophthalmic segment of ICA

Table 4. Mean sizes of aneurysms in four categorized locations

Location	Number	Mean	Standard Deviation
ACA	80	5.47	2.54
ICA	72	6.84	3.94
MCA	61	7.09	3.65
Vertebrobasilar	26	6.21	3.70
Total	239	6.42	3.41

ACA : anterior cerebral artery, Vertebrobasilar : vertebrobasilar artery

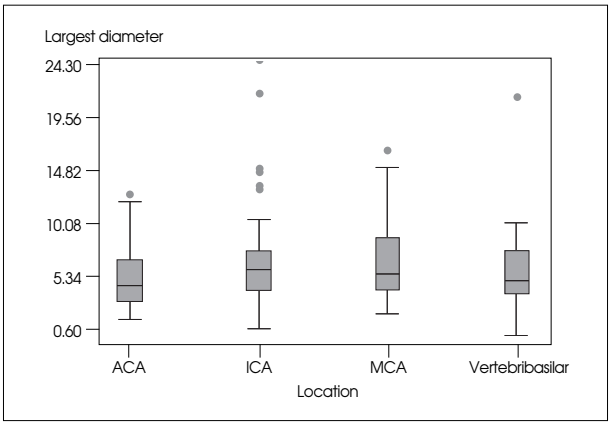

Fig. 1. Comparison of aneurysm size by locations.

DISCUSSION

The incidence of subarachnoid hemorrhage (SAH) in Japan is 17 to 96 per 100,000 population per year[14], which is higher than in other developed countries. The general incidence of SAH in developed countries is 10 per 100,000 population per year[33]. If the prevalence of UIAs is taken to be 1%, the risk of SAH for an individual with a UIA may be calculated as 1% per year[28].

Recent studies have indicated that intracranial aneurysm size may be a primary determinant of rupture probability[15] and many earlier series have implicated size as an important factor in aneurysm rupture.

Reported critical sizes at which the incidence of rupture increases for aneurysms are from 4 to 10 mm. Zacks et al.[38] stated that unruptured aneurysms <10 mm have a good prognosis without surgical treatment. Wiebers[33] and others from the Mayo clinic claim that there is a critical diameter of 10 mm below which aneurysms rarely rupture. The recommendations of the American Heart Association recommendations show there is an apparent low risk of hemorrhage from incidental small (<10 mm) aneurysms[3]. In the ISUIA 2 study[10], the rupture rate of aneurysms <7 mm in diameter in the anterior circulation was 0% per year in patients with no prior SAH, 0.3% per year in patients with previous SAH, and aneurysms 7-12 mm in diameter had a rupture rate of 0.5% per year in both groups. Mitchell et al. reported that incidentally discovered aneurysms in the anterior circulation less than 7 mm in size in individuals with no personal history or family history of SAH should be left untreated.

However, Yonekura[36] observed the natural history of small unruptured aneurysms (<5 mm in diameter) without surgical treatment and found that the annual rupture rate was 0.8% for 380 aneurysms followed up for a mean of 13.8 months. Asari and Ohmoto1 followed up 54 patients with 72 unruptured intracranial aneurysms for about 44 months and found that 11 patients (20.4%) experienced

the rupture and the annual bleeding rate was 1.92%. They concluded that shape, location, and presence of hypertension were the most important factors for predicting the rupture of an aneurysm. Juvela et al.[11,12] reported that 142 patients harboring 181 aneurysms followed over a 20-year period showed a 1.3% annual risk of rupture in previously unruptured aneurysms. Their findings support our opinion that aneurysms smaller than 10 mm are not benign and warrant treatment.

Rosenorn and colleagues[28] studied 1,076 patients with intracranial ruptured aneurysms in the Danish Aneurysm Study. They recommended that unruptured aneurysms with a size of 10 mm or less should be seriously considered for operation. Orz and colleagues[23] reported that small aneurysms <6 mm in diameter were hazardous and not innocuous, and found that 475 (38%) of the ruptured aneurysms they studied were small in size with a maximum diameter <6 mm. Kassel and Tonner13 found that 13% of the ruptured aneurysms they studied were less than 5 mm in diameter and 57% were between 5 and 10 mm in diameter. They concluded that operations should be considered for lesions more than 5 mm in diameter. The Japanese Society for Detection of Asymptomatic Brain Diseases[37] studied at more than 400 Japanese institutes in 1995. They recommend basic criteria for the surgical treatment of unruptured aneurysms larger than 5 mm in diameter. Several authors emphasized the risk of rupture of small aneurysms of a diameter even less than 5 mm[30,35]. Crompton[4] found that the critical size for the risk of rupture in an unruptured aneurysm was a maximum external diameter of 4 mm. Suzuki[31] reported that the risk for rupture increases as the diameter of an aneurysm increases beyond 4 mm. In a report by Forget et al.[8], 94.4% of ruptured aneurysms in the ACoA were smaller than 10 mm and 44% were smaller than 5 mm.

In our patients, 60.65% of aneurysms below 6 mm were in the MCA, 65.15% were in the ACoA, and 55.76% were in the PCoA. The most prevalent sizes for aneurysms in the MCA were 3-4 mm and 5-6 mm and the second most prevalent size was 4-5 mm. In the ACoA, aneurysm sizes were 4-5 mm, 3-4 mm, and 5-6 mm, in order of prevalence. In the PCoA, the prevalent aneurysm sizes were 4-5 and 5-6 mm, and 7-8 mm in order of prevalence. Aneurysm rupture occurred more often in aneurysms of small size. Therefore, we cannot consider that aneurysms below 6 mm are safe, as stated in the ISUIA report.

In the Cooperative Study of Intracranial Aneurysms, Kassel and Torner[13] reported that, in 1,092 patients with SAH, aneurysms located in the MCA tended to be larger than aneurysms located at other sites. Ferguson[7] and Ebina et al.[6] also suggest that certain aspects of MCA morphology predispose this arterial location to the formation of large aneurysms. Qureshi et al. and Forget et al. reported MCA aneurysms were larger than aneurysms at other locations. Ohasi et al.[21] reported that ruptured ACA aneurysms were significantly smaller (6.6 mm) than ICA or MCA aneurysms (8.5 mm and 8 mm). Mizoi et al.[19] reported that for more than 1000 aneurysms the average size of ruptured ACA aneurysms was 7.6±2.9 and the average size of ruptured MCA aneurysms was 8.3±3.6 mm. There seems to be a tendency for ACA aneurysms to rupture at a relatively small size. Okuyama et al.[22] also reported that the incidence rate for rupture of ACA aneurysms of 3 mm size was 55-60%.

In our patients, the mean diameter of ACA aneurysms was 5.47±2.536 mm, ICA aneurysms 6.84±3.941 mm, MCA aneurysms 7.09±3.652 mm, and vertebrobasilar artery aneurysms 6.21±3.3697 mm. The diameter differences were significant when aneurysms of the four locations were compared (p=0.012). In particular, ACA aneurysms were smaller than MCA aneurysms (p=0.025).

Dickey and Kailasnath[5] reported that the probability of aneurysm rupture varied as the third power of aneurysm diameter. Rupture occurs at sites of focal wall thinning. The probability of aneurysm rupture is proportional to the cube of the aneurysm diameter. They recommended that clinicians consider every unruptured intracranial aneurysm as a potentially lethal lesion and individualize all treatment decisions.

CONCLUSION

The size of aneurysms in the older age group in this study was larger than that of the younger age group. Ruptured aneurysms in the ACA were smaller than those in the MCA. The most prevalent aneurysm size was 3-6 mm in the MCA (55.73%), 3-6 mm in the ACoA (57.57%), and 4-6 mm in the PCoA (42.30%). The more prevalent size of the aneurysm to treat may differ in accordance with the location of the aneurysm.

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