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The Incidence and Characteristics of Patients with Small Ruptured Aneurysms (<5 mm) in Subarachnoid Hemorrhage

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Objective : Small unruptured aneurysms (<5 mm) are known for their very low risk of rupture, and are recommended to be treated conservatively. However, we encounter many patients with small ruptured aneurysms in the clinical practice. We aimed to investigate the incidence and characteristics of patients with small ruptured aneurysms.

Methods : We reviewed all patients admitted to our hospital with subarachnoid hemorrhage from January 2005 to December 2015. The patients were divided into two groups : those with aneurysms <5 mm (group S) and those with aneurysms ≥5 mm (group L). The patient's age and sex, size and location of aneurysms, and risk factors such as hypertension, diabetes, alcohol use, and smoking were compared between the two groups.

Results : Eight-hundred eleven patients were diagnosed with ruptured aneurysms, and 337 (41.6%) were included in group S. The mean size of all aneurysms was 6.10±2.99 mm (range, 0.7–37.7); aneurysms with a diameter of 4–5 mm accounted for the largest subgroup of all aneurysms. Female sex was significantly associated with the incidence of small ruptured aneurysms (odds ratio [OR] 1.50, 95% confidence intervals [CI] 1.02–2.19, p=0.037). Despite female predominance in the incidence of small ruptured aneurysms, the proportion of small ruptured aneurysms in young (<50 years) men was high. In men, there were no significant differences regarding the location of the aneurysms between group S and group L (p=0.267), with the most frequent location being the anterior communicating artery (ACoA) in both group S (50.9%) and group L (51.4%). However, in women, there were significant differences regarding the location of the aneurysms between group S and group L (p=0.023), with the most frequent locations being the ACoA (33.0%) in group S, and the posterior communicating artery (30.6%) in group L. In women, two locations were significantly associated with small (<5 mm) ruptured aneurysms: the ACoA (OR 2.14, 95% CI 1.01–4.54, p=0.047) and anterior cerebral artery (OR 3.54, 95% CI 1.19–10.54, p=0.023). Multiplicity and smoking were significantly associated with large (≥5 mm) ruptured aneurysms in women. The use of alcohol was related to small ruptured aneurysms in men over 50 years of age (OR 2.23, 95% CI 1.03–4.84, p=0.042).

Conclusion : In this study, small (<5 mm) ruptured aneurysms exhibited different incidences by age, sex, location, and risk factors such as multiplicity, smoking, and alcohol use.

Key Words : Subarachnoid hemorrhage · Intracranial aneurysm · Rupture · Risk factors.

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INTRODUCTION

Intracranial aneurysms are relatively common lesions, with a prevalence of approximately 5%[23]. Recently, unruptured aneurysms are increasingly detected due to the increased availability and improved sensitivity of noninvasive imaging techniques[14]. The most common presentation of intracranial aneurysm is rupture, which leads to subarachnoid hemorrhage (SAH). Previous studies reported that overall mortality rates of aneurysmal SAH range between 32% and 67%, and about 30% of survivors exhibit moderate to severe disability[5]. The size of the intracranial aneurysm is an important risk factor for rupture, and the International Study of Unruptured Intracranial Aneurysms (ISUIA) reported much lower 5-year cumulative rupture rates for small aneurysms[7]. It is currently recommended that small, incidental aneurysms measuring less than 5 mm in diameter be managed conservatively[8,9,15,28]. However, we encounter many cases of the rupture of small aneurysms measuring less than 5 mm in clinical practice. Therefore, the main purpose of this study was to investigate the incidence and characteristics of patients with small (<5 mm) ruptured aneurysms.

MATERIALS AND METHODS

Nine hundred six patients were admitted at our hospital with SAH between January 2005 and December 2015. A total of 811 patients were included in this study (Table 1), after excluding 95 cases of 21 patients with a dissecting aneurysm, 47 patients with SAH of unknown origin, and 27 patients for whom no angiographic data were available. Various factors retrieved from medical records and radiological findings were analyzed, including the size and location of aneurysms, as well as associated risk factors including hypertension, diabetes mellitus, aneurysm multiplicity, alcohol use, and smoking. Multiplicity of aneurysm was defined in this study as the occurrence of more than two aneurysms. Alcohol use was defined as having up to 15 drinks or more per week and smoking was defined as current smokers and ex-smokers.

Digital subtraction angiography was used for measuring the size of aneurysms. We defined the size of an aneurysm as the largest diameter measured based on the long axis of the aneurysm. In multiple aneurysms, the ruptured aneurysm was confirmed by the hemorrhage distribution on computed tomography scan, size, and morphology. The aneurysm sizes were divided into two groups: those smaller than 5 mm in diameter (group S) and those larger than or equal to 5 mm (group L). The location of the aneurysm was classified as follows : 1) anterior communicating artery (ACoA), 2) posterior communicating artery (PCoA), 3) internal carotid artery (ICA), 4) middle cerebral artery (MCA), 5) anterior cerebral artery (ACA), and 6) posterior circulation, including the posterior cerebral artery, basilar artery, and vertebral artery.

Statistical analysis was performed using SPSS software (SPSS version 21.0; SPSS Inc., Chicago, IL, USA). The chi-square test and t-test were used for comparisons between group S and group L, as appropriate. Odds ratio (OR) for comparison of the two groups were summarized with 95% confidence intervals (CI) and p values using logistic regression analysis. p values lower than 0.05 were considered statistically significant.

RESULTS

Distribution of ruptured aneurysms according to age and sex

The mean age of all patients was 60.33±12.73 years (range, 26–96). The mean age of men (54.59±11.13) was significantly lower than that of women (63.47±12.46; p<0.001). The mean age of patients in group S (59.01±12.73) was lower than that of patients in group L (61.27±12.66, p=0.013). Regarding the mean age of women, a statistically significant difference was observed between the two groups (group S, 61.91±11.96 years; group L, 64.67±12.73 years; p=0.012). In men, ruptured aneurysms showed the highest incidence in the 40s and 50s in group S, while they had the highest incidence in the 50s and 60s in group L (p=0.052) (Fig. 1A). In women, ruptured aneurysms showed the highest incidence in their 50s and 60s for group S, while they had the highest incidence in their 50s and 70s in group L (p=0.044) (Fig. 1B). Small ruptured aneurysms were more prevalent among those with young age (<50 years) in both men and women, and especially those with young age (<40 years) in male patients. Five hundred twenty-four patients were women (64.6%) and 287 were men (35.4%). The proportion of women in group S (67.4%) was larger than that in group L (62.7%). Table 2 shows that female sex is signifi-

Table 1. Patient information and clinical characteristics

	Total				Male patients			Female patients		
	Size			*p*-value	Size		*p*-value	Size		*p*-value
	Total	Small (<5 mm)	Large (≥5 mm)		Small (<5 mm)	Large (≥5 mm)		Small (<5 mm)	Large (≥5 mm)	
Total	811	337 (41.6)	474 (58.4)		110 (38.3)	177 (61.7)		227 (43.3)	297 (56.7)	
Sex										
Male	287 (35.4)	110 (32.6)	177 (37.3)	0.168						
Female	524 (64.6)	227 (67.4)	297 (62.7)							
Age (yrs)										
Mean±SD	60.33±12.73	59.01±12.73	61.27±12.66	0.013	53.04±12.23	55.56±10.30	0.062	61.91±11.96	64.67±12.73	0.012
≤39	36 (4.4)	20 (5.9)	16 (3.4)	0.032	16 (14.5)	9 (5.1)	0.052	4 (1.8)	7 (2.4)	0.044
40–49	123 (15.2)	61 (18.1)	62 (13.1)		27 (24.5)	35 (19.8)		34 (15.0)	27 (9.1)	
50–59	258 (31.8)	102 (30.3)	156 (32.9)		35 (31.8)	75 (42.4)		67 (29.5)	81 (27.3)	
60–69	184 (22.7)	81 (24.0)	103 (21.7)		24 (21.8)	42 (23.7)		57 (25.1)	61 (20.5)	
70–79	148 (18.2)	48 (14.2)	100 (21.1)		5 (4.5)	13 (7.3)		43 (18.9)	87 (29.3)	
≥80	62 (7.6)	25 (7.4)	37 (7.8)		3 (2.7)	3 (1.7)		22 (9.7)	34 (11.4)	
Location										
ACoA	291 (35.9)	131 (38.9)	160 (33.8)	0.193	56 (50.9)	91 (51.4)	0.267	75 (33.0)	69 (23.2)	0.023
PCoA	166 (20.5)	59 (17.5)	107 (22.6)		11 (10.0)	16 (9.0)		48 (21.1)	91 (30.6)	
ICA	59 (7.3)	22 (6.5)	37 (7.8)		8 (7.3)	9 (5.1)		14 (6.2)	28 (9.4)	
MCA	219 (27.0)	87 (25.8)	132 (27.8)		24 (21.8)	53 (29.9)		63 (27.8)	79 (26.6)	
ACA	31 (3.8)	17 (5.0)	14 (3.0)		3 (2.7)	4 (2.3)		14 (6.2)	10 (3.4)	
PC	45 (5.5)	21 (6.2)	24 (5.1)		8 (7.3)	4 (2.3)		13 (5.7)	20 (6.7)	
Multiplicity										
No	608 (76.8)	268 (81.0)	340 (73.8)	0.018	92 (86.0)	139 (80.3)	0.228	176 (78.6)	201 (69.8)	0.025
Yes	184 (23.2)	63 (19.0)	121 (26.2)		15 (14.0)	34 (19.7)		48 (21.4)	87 (30.2)	
Hypertension										
No	503 (62.0)	215 (63.8)	288 (60.8)	0.380	77 (70.0)	122 (68.9)	0.848	138 (60.8)	166 (55.9)	0.260
Yes	308 (38.0)	122 (36.2)	186 (39.2)		33 (30.0)	55 (31.1)		89 (39.2)	131 (44.1)	
Diabetes mellitus										
No	759 (93.6)	313 (92.9)	446 (94.1)	0.487	104 (94.5)	169 (95.5)	0.721	209 (92.1)	277 (93.3)	0.601
Yes	52 (6.4)	24 (7.1)	28 (5.9)		6 (5.5)	8 (4.5)		18 (7.9)	20 (6.7)	
Alcohol										
No	565 (69.8)	232 (69.0)	333 (70.4)	0.679	40 (36.7)	78 (44.3)	0.204	192 (84.6)	255 (85.9)	0.682
Yes	244 (30.2)	104 (31.0)	140 (29.6)		69 (63.3)	98 (55.7)		35 (15.4)	42 (14.1)	
Smoking										
No	588 (72.6)	258 (76.8)	330 (69.6)	0.024	47 (43.1)	77 (43.5)	0.949	211 (93.0)	253 (85.2)	0.006
Yes	222 (27.4)	78 (23.2)	144 (30.4)		62 (56.9)	100 (56.5)			44 (14.8)	

SD : standard deviation, ACoA : anterior communicating artery, PCoA : posterior communicating artery, ICA : internal carotid artery, MCA : middle cerebral artery, ACA : anterior cerebral artery, PC : posterior circulation

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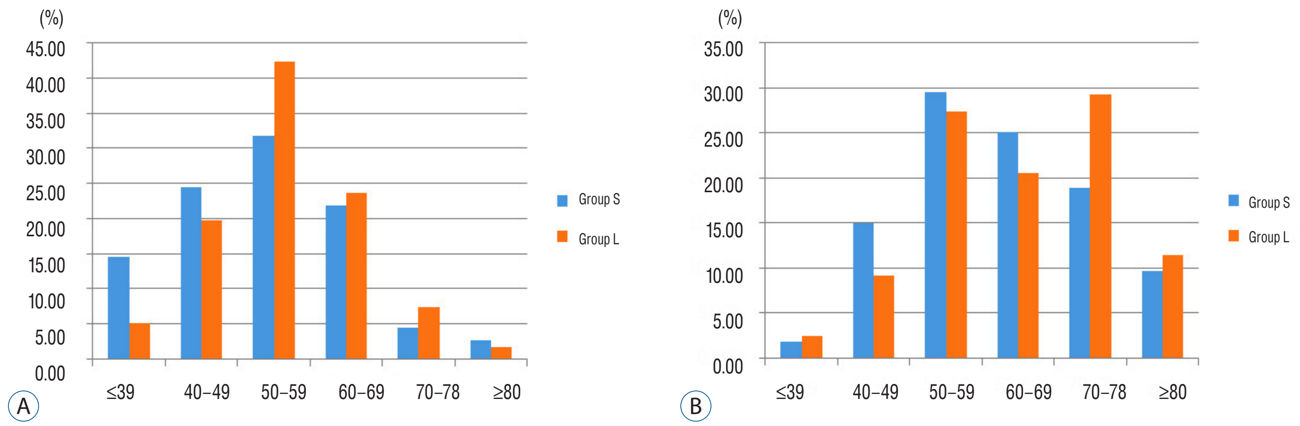

Fig. 1. Distribution of patients with ruptured aneurysms stratified by age and gender. A : Male patients. B : Female patients.

cantly associated with the incidence of small (<5 mm) ruptured aneurysms (OR 1.50, 95% CI 1.02–2.19, p=0.037).

Distribution of ruptured aneurysms according to size and location

Three hundred thirty-seven (41.6%) patients were included in group S. The mean size of all aneurysms was 6.10±2.99 mm (range, 0.7–37.7). After categorizing aneurysms by differences of 1 mm in diameter, aneurysms with a diameter of 4–5 mm accounted for the largest subgroup of aneurysms (Fig. 2). After comparing by sex, women most commonly exhibited ruptured aneurysms with a diameter of 4–5 mm, and men most commonly exhibited ruptured aneurysms with a diameter of 5–6 mm (p=0.187). The most frequent location of aneurysms of all size was the ACoA (35.9%), followed by the MCA (27.0%), and then the PCoA (20.5%). In men, there were no significant differences regarding the location of aneurysms between group S and group L (p=0.267), with the most frequent location being the ACoA in both group S (50.9%) and group L (51.4%). However, in women, there were significant differences regarding the location of aneurysms between group S and group L (p=0.023), with the most frequent locations being the ACoA (33.0%) in group S and the PCoA (30.6%) in group L. Two locations in women that were significantly associated with small (<5 mm) ruptured aneurysms (Table 2); ACoA (OR 2.14, 95% CI 1.01–4.54, p=0.047) and ACA (OR 3.54, 95% CI 1.19–10.54, p=0.023).

Risk factors for rupture of aneurysms

Several risk factors including multiplicity of the aneurysms, hypertension, diabetes mellitus, smoking, and alcohol use were evaluated. After evaluating the risk factors, the presence of hypertension or diabetes was not mean to be statistically significant between group S and group L. Multiplicity of the aneurysms and smoking were more frequent in group L than group S. The risk factors of multiplicity of the aneurysms (OR 0.65, 95% CI 0.46–0.93, p=0.019) and smoking (OR 0.32, 95% CI 0.17–0.64, p=0.001) were statistically significant only in women, as seen in Table 2. The use of alcohol was likely related to small (<5 mm) ruptured aneurysms (OR 1.78, 95% CI 0.96–3.30, p=0.066) only in male patients. In patients with small ruptured aneurysms (group S), the use of alcohol was more prevalent in those over 50 years old (66.7%) than in patients under 50 years old (58.1%). In young (<50 years) men, young age was a stronger factor related with small (<5 mm) ruptured aneurysms (OR 2.03, 95% CI 1.21–3.40, p=0.007) than the use of alcohol (OR 1.39, 95% CI 0.85–2.28, p=0.193) on multivariate analysis (Table 3). Among men over 50 years old, the use of alcohol was significantly related to small ruptured aneurysms (OR 2.23, 95% CI 1.03–4.84, p=0.042) (Table 4).

DISCUSSION

The size of an intracranial aneurysm is one of the most important criterion when deciding on the treatment for unruptured aneurysms. Aneurysm size, as a criterion influencing treatment decision-making, was decreased from 10 mm in the first ISUIA trial to 7 mm in the second ISUIA trial[7,31], and recent guidelines suggest that unruptured aneurysms less than 5 mm in diameter should be managed conservatively[8,9,15,28]. Both ISUIA trials revealed that unruptured aneurysms had a much lower risk of rupture than expected; according to the first ISUIA results, the risk of rupture for unruptured aneurysms with less than 10 mm in diameter was only 0.05% per year in patients with no SAH history[7]; the second ISUIA study revealed that the risk of rupture for aneurysms with less than 7 mm in diameter was 0.15% per year in patients with no SAH history[31]. However, the extremely low risk of rupture associated with unruptured aneurysms in both ISUIA studies

Table 2. Logistic regression analysis of independent contributions of variables for small (<5 mm) ruptured aneurysms

	Total		Male patients		Female patients	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Sex						
Male	1.00 (reference)					
Female	1.50 (1.02–2.19)	0.037				
Age (yrs)						
≤39	1.00 (reference)		1.00 (reference)		1.00 (reference)	
40–49	0.65 (0.30–1.43)	0.288	0.37 (0.13–1.03)	0.058	2.09 (0.53–8.26)	0.295
50–59	0.40 (0.19–0.84)	0.015	0.21 (0.08–0.56)	0.002	1.36 (0.37–5.05)	0.643
60–69	0.47 (0.22–1.01)	0.054	0.27 (0.10–0.77)	0.014	1.52 (0.40–5.78)	0.543
70–79	0.31 (0.14–0.69)	0.004	0.21 (0.05–0.85)	0.028	0.94 (0.24–3.64)	0.931
≥80	0.43 (0.18–1.05)	0.065	0.49 (0.07–3.26)	0.457	1.25 (0.31–5.13)	0.754
Location						
ACoA	1.45 (0.79–2.66)	0.228	0.50 (0.17–1.53)	0.226	2.14 (1.01–4.54)	0.047
PCoA	0.93 (0.49–1.77)	0.814	0.61 (0.16–2.27)	0.461	1.06 (0.49–2.28)	0.885
ICA	1.00 (reference)		1.00 (reference)		1.00 (reference)	
MCA	1.18 (0.63–2.19)	0.611	0.40 (0.12–1.29)	0.126	1.66 (0.78–3.56)	0.191
ACA	2.23 (0.90–5.55)	0.083	0.61 (0.09–4.10)	0.610	3.54 (1.19–10.54)	0.023
PC	1.44 (0.63–3.28)	0.386	1.59 (0.31–8.12)	0.577	1.26 (0.46–3.44)	0.648
Multiplicity						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	0.65 (0.46–0.93)	0.019	0.63 (0.30–1.30)	0.208	0.64 (0.42–0.98)	0.040
Hypertension						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	0.86 (0.62–1.17)	0.336	0.79 (0.44–1.40)	0.414	0.86 (0.58–1.27)	0.453
Diabetes mellitus						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	1.43 (0.79–2.61)	0.237	1.72 (0.54–5.52)	0.361	1.44 (0.70–2.95)	0.318
Alcohol						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	1.39 (0.94–2.07)	0.101	1.78 (0.96–3.30)	0.066	1.38 (0.78–2.42)	0.270
Smoking						
No	1.00 (reference)		1.00 (reference)		1.00 (reference)	
Yes	0.57 (0.38–0.86)	0.008	0.70 (0.38–1.29)	0.250	0.32 (0.16–0.62)	0.001

OR : odds ratio, CI : confidence interval, ACoA : anterior communicating artery, PCoA : posterior communicating artery, ICA : internal carotid artery, MCA : middle cerebral artery, ACA : anterior cerebral artery, PC : posterior circulation

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was widely criticized for selection bias, crossover due to switching of therapeutic intervention, and incomplete follow-up. Furthermore, a large portion of the ruptured aneurysms encountered in clinical practice are small in size[1,3,10,16,29]. In this study, 41.6% of patients had ruptured aneurysms less than 5 mm, and the largest proportion of aneurysms were between 4 and 5 mm among all aneurysms.

Why many patients with SAH and small-sized aneurysms are seen in clinical practice although the rupture rate of small unruptured aneurysms is reported very low? Some authors suggested that the size of the aneurysms may decrease after rupture[32]. However, Rahman et al.[22] studied whether cerebral aneurysms shrink with rupture by comparing pre- and post-rupture images of 9 patients with cerebral aneurysms, and they reported that aneurysms do not shrink after rupture. The small unruptured intracranial aneurysm verification study

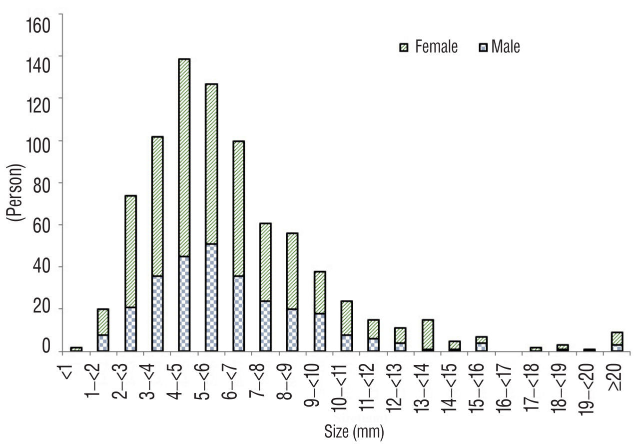

Fig. 2. Distribution of patients with ruptured aneurysms, stratified by size of the aneurysm.

(SUAVe study) also found no shrinkage of aneurysms after rupture in their data[25]. Kataoka et al.[13] investigated histological findings for both unruptured and ruptured aneurysms, and found no histological evidence to support the shrinkage of aneurysms after rupture.

Yonekura[33] demonstrated that the growth process of an aneurysm from its occurrence can be classified into one of four patterns : type 1, the aneurysm ruptures within a time span as short as a few days to a few weeks after its formation; type 2, the aneurysm grows slowly for a few years after its formation, and then ruptures during this process; type 3, the formed aneurysm continues growing slowly for a few years without rupture; and type 4, the aneurysm grows to a certain size and remains unchanged thereafter. We believe that, in certain patients, cerebral aneurysms rupture easily even when they are small in size and within a relatively shorter period after formation (corresponding to type 1 aneurysms), and this is usually observed as a SAH in clinical practice. On the other hand, most unruptured aneurysms diagnosed incidentally have already passed into the safe period and have a low risk of rupture (corresponding to type 4 aneurysms). These concepts may explain the discrepancy between the very low risk of rupture associated with small unruptured aneurysms and the small size of many ruptured aneurysms.

The characteristics of patients with small ruptured aneurysms (corresponding to type 1 aneurysms) may be different from those of patients with large ruptured aneurysms (corresponding to type 2 aneurysms). In this study, small (<5 mm) ruptured aneurysms were significantly associated with female sex (Table 2). Female sex is a recognized risk factor for the rupture of cerebral aneurysms[27], and aneurysm formation es-

Table 3. Multivariate analysis of independent contributions of variables for small (<5 mm) ruptured aneurysms in young (<50 years) patients : young age (<50 years) vs. the use of alcohol

	Male patients		Female patients	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Alcohol				
No	1.00 (reference)		1.00 (reference)	
Yes	1.39 (0.85–2.28)	0.193	1.03 (0.63–1.69)	0.899
Age				
Old (≥50)	1.00 (reference)		1.00 (reference)	
Young (<50)	2.03 (1.21–3.40)	0.007	1.55 (0.93–2.57)	0.091

OR : odds ratio, CI : confidence interval

Table 4. Logistic regression analysis of independent contributions of variables for small (<5 mm) ruptured aneurysms in male patients over 50 years

	OR (95% CI)	*p*-value
Age		
50–59	1.00 (reference)	
60–69	1.22 (0.6–2.47)	0.581
70–79	1.13 (0.35–3.68)	0.842
≥80	3.09 (0.52–18.55)	0.217
Location		
ACoA	0.45 (0.1–1.94)	0.285
PCoA	1.32 (0.25–6.98)	0.746
ICA	1.00 (reference)	
MCA	0.55 (0.12–2.48)	0.435
ACA	1.11 (0.13–9.75)	0.925
PC	1.72 (0.17–17.48)	0.646
Multiplicity		
No	1.00 (reference)	
Yes	0.44 (0.17–1.16)	0.097
HTN		
No	1.00 (reference)	
Yes	0.84 (0.41–1.72)	0.637
DM		
No	1.00 (reference)	
Yes	2.23 (0.65–7.67)	0.204
Alcohol		
No	1.00 (reference)	
Yes	2.23 (1.03–4.84)	0.042
Smoking		
No	1.00 (reference)	
Yes	0.66 (0.31–1.4)	0.285

OR : odds ratio, CI : confidence interval, ACoA : anterior communicating artery, PCoA : posterior communicating artery, ICA : internal carotid artery, MCA : middle cerebral artery, ACA : anterior cerebral artery, PC : posterior circulation, HTN : Hypertension, DM : diabetes mellitus

pecially in postmenopausal women, where estrogen deficiency has an important impact on the pathophysiology of formation and rupture of cerebral aneurysms[26]. This study also revealed the association of small ruptured aneurysms with young male patients, showing a higher incidence between 30 and 40 years of age (Fig. 1A). Despite a female predominance in small ruptured aneurysms, it was interesting that the incidence of small ruptured aneurysm was high in young men, especially in those aged <40 years. Heavy drinking is more frequently observed among men with SAH than women with SAH[11], and alcohol use is known to increase the risk of SAH[17]. In this study, the use of alcohol was significantly related to small ruptured aneurysms in patients over 50 years old. In young (<50 years) men, the statistical analysis revealed that young age was more significantly related with small (<5 mm) ruptured aneurysms than the use of alcohol.

In this study, the ACoA was the most common aneurysm site in men, accounting for approximately 50% of both small and large aneurysms. However, in women, small aneurysms were more likely to occur in the ACoA, but large aneurysms were more likely to occur in the PCoA. Silva Neto et al.[24] suggested that the higher frequency of fetal-type PCoA and the smaller angle of the carotid artery might be responsible for the higher prevalence of PCoA aneurysms in women. We found that small and large aneurysms exhibited a similar pattern of location in men. However, there was a different pattern in the location of small and large aneurysms in women; small ruptured aneurysms were significantly associated with the location of the ACoA and ACA. Previous studies found that ruptured aneurysms located in the ACoA and ACA were smaller than those located at other sites[19,30]. The size of an aneurysm at the time of rupture may be partly determined by the thickness and diameter of the parent artery[18]. Since the diameter of the ACoA and ACA is smaller than that of the MCA and ICA[2], aneurysms located in the ACoA and ACA can rupture before they reach a larger size. With regards to the differences of aneurysm location by sex, anatomical differences in the circle of Willis may cause different hemodynamic stress and thus result in different pathways and mechanism of aneurysm formation[24].

In previous papers, it was reported that larger ruptured aneurysms exhibit multiplicity more frequently[6,18,21]. We also found that multiplicity was significantly more common in patients with aneurysms larger than 5 mm. Inagawa[6] proposed a hypothesis that may explain our results. When considering the time interval from new development of aneurysms to rupture, in patients with large ruptured aneurysms, newly developed aneurysms do not easily rupture when they are small. Furthermore, the longer the interval from development to rupture, the higher the possibility that an additional aneurysm will develop, resulting in multiple aneurysms, and that the size of the aneurysms will increase[6]. In this study, smok-

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ing was also significantly more common in the group with aneurysms larger than 5 mm. Smoking has been known to be strongly associated with the growth of cerebral aneurysms[4,12]. Smoking was more common in patients with larger aneurysms in a multicenter research trial[21], and Qureshi et al.[20] reported that smoking was associated with multiple aneurysms. These were consistent with our results that multiplicity and smoking were more prevalent in patients with larger aneurysms.

The main limitation of our study is its retrospective nature. Smoking and multiplicity were associated with large ruptured aneurysms in this study, which does not indicate that such risk factors are not relevant for the future rupture of small unruptured aneurysms. Prospective studies are warranted to investigate the impact of such risk factors on the rupture of small unruptured aneurysms. However, we believe that the following results are clinically meaningful for identifying the characteristics of patients with small ruptured aneurysms: female sex, younger (<50 years) age in men, ACoA or ACA aneurysm location in women, and the use of alcohol in men over 50 years were significantly associated with small ruptured aneurysms. Another limitation of this study is that we did not include the aneurysm shape like a daughter sac, which is also known as a risk factor for aneurysm rupture. The optimal way to study the natural history and risk factors for the rupture of unruptured small aneurysms is simply to observe without treatment. However, such an approach is risky and practically impossible. Further research regarding the factors associated with the rupture of small aneurysms is warranted to gather information to assist in guiding the decision-making process with respect to the best treatment strategy of incidentally identified small aneurysms.

CONCLUSION

In this study, small ruptured aneurysms <5 mm were found in a large portion of about 40% of all SAH patients, and revealed a different distribution among variables including age, sex, location, and risk factors such as multiplicity, alcohol use, and smoking, compared with ruptured aneurysms ≥5 mm. Female sex, young (<50 years) age in men, ACoA and ACA locations in female patients, and the use of alcohol in men over 50 years old were associated with small (<5 mm) ruptured aneurysms. Although aneurysms size is important in the prediction of aneurysm rupture, other various factors should be considered when deciding on the treatment for incidentally identified small aneurysms.

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