online © ML Comm
www.jkns.or.kr 10.3340/jkns.2009.45.2.85
Print ISSN 2005-3711 On-line ISSN 1598-7876
J Korean Neurosurg Soc 45 : 85-89, 2009

Clinical Article

What Is the Significance of a Large Number of Ruptured Aneurysms Smaller than 7 mm in Diameter?

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Objective : The International Study of Unruptured Intracranial Aneurysms (ISUIA) reported that the 5-year cumulative rupture rate of small unruptured aneurysms less than 7 mm in diameter is very low depending on the aneurysm's location. However, we have seen a large number of ruptured aneurysms less than 7 mm in clinical practice. The purpose of this study was to review our experience and to measure the size and location at which aneurysms ruptured in our patient population.
Methods : We reviewed the characteristics of aneurysms, such as size and location, from the original angiograms of patients who were admitted to our hospital between January 2004 and December 2007. All aneurysms were treated surgically or through endovascular procedures.
Results : Interventional or surgical treatment was given to a total of 889 patients, including 568 females and 321 males. At the time of our study, 627 cases were ruptured aneurysms and 262 cases were unruptured aneurysms. Of the ruptured cases, the mean diameter of the aneurysm was 6.28 mm. We found that 71.8% of ruptured aneurysms were smaller than 7 mm in diameter, and 87.9%, were smaller than 10 mm. Based on location, the data show that anterior communicating artery aneurysms most often presented with rupture sizes less than 7 mm (76.8%) and 10 mm (92.1%) in diameter. Most ruptured aneurysms were less than 7 mm in size, although recent studies have noted that small aneurysms are less likely to rupture.
Conclusion : Although the natural history of unruptured intracranial aneurysms remains controversial, the aneurysm size and location play a signigicant role in determining the risk of rupture. Larger sample sizes and a long term study are needed to reveal the natural history and the rupture risk of unruptured intracranial aneurysms because the size of most ruptured aneurysms was less than 7 mm in diameter in our series.

KEY WORDS : Size · Location · Age · Intracranial aneurysm · Rupture.

INTRODUCTION

Intracranial aneurysms are relatively common[13,19]. The overall frequency in the general population ranges from 0.2% to 9% (mean frequency, about 5%) in autopsy studies[7,8]. However, the likelihood of detection of unruptured aneurysms has increased with improved imaging techniques, such as 3D computed tomography angiography and magnetic resonance angiography[6,11,12].

The effect of rupture of an intracranial aneurysms are devastating, and surgical morbidity and mortality remain as high as 60%[16] despite recent advances in the intensive management of patients with subarachnoid hemorrhage (SAH)[5]. Therefore, many neurosurgeons agree on the need to treat unruptured aneurysms before rupture, but the management of unruptured aneurysms remains controversial[2,18]. This is partly because the natural history and the risks associated with repair of unruptured aneurysms are not understood.

Although there are many factors that can contribute to the rupture of unruptured aneurysms, size is thought to be the best predictor of future rupture and surgical decision. Many studies have shown that the risk of rupture of unruptured aneurysms ranges from 0.5% to 2.5% per year[4,9,10,21,26,27]. In particular, data from retrospective International Study of Unruptured Intracranial Aneurysms (ISUIA) study represented a low risk of rupture (0.05%/year) of aneurysms smaller than 10 mm in asymptomatic patients[22]. Data from prospective ISUIA study showed a risk of rupture of 0.52% for aneurysms 7 to 12 mm in diameter of the anterior circulation and 2.9% for aneurysms located posterior circulation in same size category[25]. In

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contrast, we have found that small aneurysms smaller than 7 mm in diameter were most likely to rupture. We reviewed our clinical data to analyze the distribution of ruptured and unruptured aneurysms, especially those smaller than 7 mm in diameter, according to their location and patient's age.

MATERIALS AND METHODS

We reviewed the medical records and angiograms of all patients who were diagnosed with ruptured or unruptured aneurysms and treated by surgical or endovascular procedures. All patients admitted to our hospital from January 2004 to December 2007 underwent digital subtraction angiograms. The aneurysm measurement was performed using the largest diameter measurement based on the long or perpendicular axis of the aneurysm.

In multiple aneurysms, ruptured aneurysms were confirmed by the distribution of blood on computed tomography (CT), aneurysm morphology, and finally intraoperative findings. The aneurysm sizes were divided into two categories : Those smaller than 7 mm in diameter and those samller than 10 mm in diameter. The locations of the aneurysms were classified as follows : (1) All of the internal carotid artery except for the posterior communicating artery (ICA); (2) the anterior communicating artery or the anterior cerebral artery (ACoA); (3) the posterior communicating artery (PCoA); (4) the middle cerebral artery (MCA); and (5) the vertebrobasilar system (VB). And the patients' age groups were divided into the following categories : (1) 40 years or younger; (2) between 41 to 59 years; and (3) older than 60 years. The correlation between aneurysm size and location was evaluated by a one-way analysis of variance (ANOVA). All statistical analyses were performed using the Chi-square test. A $p<0.05$ was considered significant.

RESULTS

Surgical or interventional treatment was implemented in 889 intracranial aneurysms. Among these, 627 cases were ruptured aneurysms and 262 cases were unruptured. The mean age of patients was 54.7±11.5 years. Five-hundred-sixty-seven patients were female (63.8%) and 322 were male (36.2%). The mean diameter of all ruptured and unruptured aneurysms was 6.04±4.67 mm, and that of ruptured aneurysms was 6.28±5.08 mm (Table 1).

Table 1. Mean diameter of ruptured and unruptured aneurysms (n=889) along with patients' ages and sexes

Parameter		Ruptured	Unruptured	All aneurysms
Location	ICA	6.44 mm (n=70)	5.57 mm (n=61)	6.04 mm (n=131)
	ACoA	5.75 mm (n=228)	4.83 mm (n=56)	5.57 mm (n=284)
	MCA	6.15 mm (n=172)	5.56 mm (n=86)	5.96 mm (n=258)
	PCoA	6.79 mm (n=117)	4.97 mm (n=35)	6.37 mm (n=152)
	VB	8.08 mm (n=40)	7.13 mm (n=24)	7.72 mm (n=64)
	Total	6.28 mm (n=627)	5.47 mm (n=262)	6.04 mm (n=889)
Mean Age		54.3±12.0 years	55.7±10.2 years	54.7±11.5 years
Male		241 patients	81 patients	322 patients
Female		386 patients	181 patients	567 patients

ACoA : anterior communicating or anterior cerebral artery, ICA : internal cerebral artery, MCA : middle cerebral artery, PCoA : posterior communicating artery, VB : vertebrobasilar system, n : number of cases

Table 2. Numbers of aneurysms according to size and location

Parameter	Smaller than 7 mm	Smaller than 10 mm
	Ruptured (n=450, 71.8%)	Ruptured (n=551, 87.9%)
ICA	54 (12%)	58 (10.5%)
ACoA	175 (38.9%)*	210 (38.1%)*
MCA	122 (27.1%)	152 (27.1%)
PCoA	76 (16.9%)	99 (18%)
VB	23 (5.1%)	32 (5.8%)
Unruptured (n=262)	202 (77.1%)	233 (88.9%)

*statistically significant ($p<0.05$), ACoA : anterior communicating or anterior cerebral artery, ICA : internal cerebral artery, MCA : middle cerebral artery, PCoA : posterior communicating artery, VB : vertebrobasilar system, n : number of cases

Size and location of aneurysms

The incidence of all aneurysms smaller than 7 mm in diameter and smaller than 10 mm in diameter are indicated in Table 2. There were 450 cases of ruptured aneurysms smaller than 7 mm in diameter, and 551 cases of ruptured aneurysms smaller than 10 mm in diameter. For unruptured aneurysms, 202 cases were smaller than 7 mm in diameter, and 233 cases were smaller than 10 mm in diameter. The mean sizes of ruptured aneurysms were as follows : (1) ICA, 6.44 mm; (2) ACoA, 5.75 mm; (3) MCA, 6.15 mm; (4) PCoA, 6.79 mm and (5) VB, 8.08 mm. Additionally, the average sizes of unruptured aneurysms were : (1) ICA, 5.57 mm; (2) ACoA, 4.83 mm; (3) MCA, 5.56 mm; (4) PCoA, 4.97 mm and (5) VB, 7.13 mm (Table 1). The mean size of ruptures at the ACoA was smaller than ruptures at all other sites, but this difference was not significant ($p=0.062$). However, of ruptured aneurysms smaller than 7 mm in diameter, aneurysms of the ACoA were most frequent and this was statistically significant ($p<0.0001$). The same result was also seen in aneurysms smaller than 10 mm in dia-

meter (p<0.0001) (Table 2).

Size and age of aneurysms

The total number of ruptured/unruptured aneurysms in the three age groups (40 years or younger, 41-59 years, and 60 years and older) was 62/16, 350/147 and 215/99 cases, respectively. The mean diameter of all aneurysms according to aneurysm location and patients' age group is presented in Table 3. In the patients younger than 40 years and those from 41 to 59 years of age, the mean size of ICA aneruysms was smaller (4.89 mm and 5.66 mm, respectively) than the other sites, but the difference was not statistically significant. However, in the group 60 years of age and older, ACoA aneurysms were smaller (5.06 mm) than those at the other sites, the difference was statistically significant (p=0.001).

Table 3. Mean diameter of aneurysms according to the patient's age group (mm, (n))

Location	<40 years		40-59 years		≥60 years	
	Ruptured	Unruptured	Ruptured	Unruptured	Ruptured	Unruptured
ICA	4.89 (7)	3.36 (3)	5.66 (45)	4.86 (32)	8.89 (18)	6.68 (26)
ACoA	5.62 (20)	3.85 (4)	6.17 (131)	4.40 (25)	5.06 (77)*	5.37 (27)
MCA	5.59 (22)	11.65 (4)	6.08 (98)	5.14 (54)	6.53 (52)	5.51 (28)
PCoA	8.40 (9)	3.45 (4)	6.10 (51)	4.71 (18)	7.15 (57)	5.78 (13)
VB	7.31 (4)	10.8 (1)	7.77 (25)	7.18 (18)	9.05 (11)	6.22 (5)
Total	6.04 (62)	6.09 (16)	6.18 (350)	5.15 (147)	6.50 (215)	5.85 (99)

*statistically significant (p<0.05), ACoA : anterior communicating or anterior cerebral artery, ICA : internal cerebral artery, MCA : middle cerebral artery, PCoA : posterior communicating artery, VB : vertebrobasilar system, n : number of cases

DISCUSSION

Intracranial aneurysms are relatively common, and the overall frequency ranges from 0.2% to 9% in the general population. Of these, unruptured intracranial aneurysms affect up to 2-5%[3]. Because the effects of subarachnoid hemorrhage are grave despite the improvement in its management, it is important to decide whether to treat unruptured aneurysms or not. We believe that size is one of the most important determinants for future rupture and surgical decision.

According to retrospective ISUIA data[22], the rate of rupture of aneurysms less than 10 mm in diameter was less than 0.05% per year in patients with no SAH history and 0.5% per year in patients with previous history of SAH. Additionally, in prospective ISUIA results[25], the annual rupture rates for patients without a history of SAH with aneurysms located in the anterior circulation were 0% for aneurysms less than 7 mm and 0.5% for those ranging from 7-12 mm in diameter. They reported that the annual rate for posterior circulation were 0.5% and 2.9% for the same size categories. These results suggest that small aneurysms are relatively safe and not likely to rupture easily.

Many other studies have also reported rupture rate of unruptured intracranial aneurysms. Juvela et al.[9,10] recently reported their experience with 181 aneurysms followed over a 20-year period. They found a 1.3% annual risk of rupture for unruptured aneurysms. Another study[20] reported the natural course of 181 unruptured aneurysms followed-up over a period of 3,862 person-months. These results indicated a rupture rate of 3.42% per year. Morita et al.[14] investigated the data from 13 reports in Japan. The 13 studies included in their analyses 922 patients with unruptured aneurysms who were followed-up for a total of 3,081 patient-years. They reported that the annual rupture rate was 2.7%. These results represented a relatively high rupture rate as well known, especially in comparison with ISUIA.

Yasuhiro et al.[15] analyzed 280 patients with ruptured aneurysms and found that 208 (74.3%) aneurysms were smaller than 10 mm in diameter, and 73 (26.1%) were smaller than 5 mm in diameter. Forget et al.[3] reviewed 362 cases, and definite measurements of ruptured aneurysms were obtained in 245. Their data showed that 85.6% of the aneurysms were less than 10 mm in diameter regardless of their location on the circle of Willis.

In our study, ruptured aneurysms made up 627 of our total cases. Among these, aneurysms located in the ACoA (including the anterior cerebral artery and the anterior communicating artery) were most frequent (228 cases, 36.4%) as compared to other sites. MCA aneurysms were the second most common (172 cases, 27.4%). Of ruptured aneurysms, 450 cases (71.8%) were smaller than 7 mm in diameter and 551 cases (87.9%) were smaller than 10 mm in diameter. ACoA aneurysms were much more common than aneurysms at all other sites for those smaller than 7 mm in diameter as well as those 10 mm in size or smaller.

The mean sizes of ruptured aneurysms according to their location were 5.75 mm in the ACoA, 6.15 mm in the MCA, 6.44 mm in the ICA, 6.79 mm in the PCoA and 8.08 mm in the vertebrobasilar system. The mean size of ACoA was the smallest as compared with the other sites. These results contradict the ISUIA results that small aneurysms are safe and tend not to rupture easily.

Earlier studies reported that aneurysms located in the anterior circulation are smaller than those identified at other sites[17,23]. Forget et al.[3] in their study noted that 94.4% of ruptured aneurysms of the anterior communicating artery were small, and 44% were less than 5 mm in diam-

eter. The diameter of the anterior communicating artery and the distal ACA is smaller than that of the MCA and ICA. Therefore, aneurysms located in the anterior circulation may bleed before they reach a large size[15].

Size is assumed to be one of the most important determinants for future rupture. However, there are many differences in size determinations among studies and investigators. One study[1] reported a mean height of 6.7 mm and an average width of 6.1 mm for ruptured aneurysms when measured with advanced 3-dimensional rotational angiography. These results indicate that the size of ruptured aneurysms are smaller than those of previous studies, but they are similar to our results.

Some authors have suggested that aneurysms shrink after rupture. Wiebers et al.[25] noted aneurysmal shrinkage after rupture, so the calculated size of ruptured aneurysms dose not truly reflect their sizes before rupture. Recently, Kataoka et al.[24] carried out a study to investigate this problem. They analyzed histologic findings for both ruptured and unruptured aneurysms and concluded that there was no histological evidence to suggest that aneurysms shrink after rupture. These findings support our results that even small aneurysms can rupture.

Contrary to previous studies, our study implies that many ruptured aneurysms are small. Also, the location of the aneurysms, especially for the ACoA, is thought to be important factor for aneurysmal rupture. However, the size of the aneurysm at the time of rupture may in part be determined by the original thickness and diameter of the parent arteries. The diameter of the ACoA and the distal ACA is smaller than that of the MCA and the ICA[15]. Therefore, aneurysms located in the ACoA and the distal ACA may bleed before they reach a larger size. Because size and location cannot be considered the only factors to determine future rupture and treatment recommendations, other factors, such as the patient's age, the morphology of the aneurysm, the patient's smoking habits, and the patient's medical condition, should be considered.

CONCLUSION

Contrary to previous thought, our study demonstrates that small aneurysms smaller than 7 mm in diameter can rupture. The majority of aneurysms rupture before reaching 7 mm (71.8%) and 10 mm (87.9%) in diameter, and the most frequent site of ruptured aneurysms is ACoA. The natural history of unruptured intracranial aneurysms is still unclear. Although the aneurysm size is a key factor in determining the risk of rupture, other factors, such as the aneurysmal location and the patient's age, should be considered. For treatment strategies of unruptured intracranial aneurysms, we should keep in mind that small aneurysms are not safe and must be considered to warrant treatment.

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