Comparison of Rates of Growth between Unruptured and Ruptured Aneurysms Using Magnetic Resonance Angiography

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Background and Purpose: Growth is a key risk factor for rupture of unruptured cerebral aneurysms. There are few reports of investigations into the actual growth of ruptured intracranial aneurysms. The aim of the present study was to ascertain the risk of rupture of aneurysms based on the growth of unruptured and ruptured aneurysms. *Methods:* Changes in size on magnetic resonance angiography (MRA) were examined in 50 patients with ruptured cerebral aneurysms. Images obtained before and after subarachnoid hemorrhage were used. Moreover, changes in aneurysm size were retrospectively examined in 73 patients with 100 unruptured cerebral aneurysms that were followed serially with MRA that was performed using a 1.5-T or 3-T system. The size of the aneurysm was determined by measuring the maximum diameter on maximum intensity projection MRA images. Based on these data, the annual growth rates (mm growth/year) of unruptured and ruptured aneurysms were calculated and compared. *Results:* The median annual growth rate of ruptured aneurysms was significantly greater than that of unruptured aneurysms (.69 versus .077 mm/year, $P < .01$). The annual growth rates of ruptured aneurysms showed a negative correlation between the duration from initial MRA to the time of rupture. *Conclusion:* A high annual growth rate is a key risk factor for aneurysm rupture. This finding provides strong evidence for the treatment of unruptured cerebral aneurysms. **Key Words:** Intracranial aneurysm—risk factor—subarachnoid hemorrhage—magnetic resonance angiography.

Introduction

Based on its natural course, an unruptured cerebral aneurysm is categorized into one of the following three types: aneurysms that rupture immediately after developing, aneurysms that remain relatively unchanged for a prolonged period without rupture, and aneurysms that continue to grow and ultimately rupture.[1] The growth of unruptured cerebral aneurysms has been associated with an increased risk of rupture,[2-7] but the specifics of this risk remain unclear. Over the past few years, magnetic resonance angiography (MRA) has been increasingly performed for the diagnosis of various intracranial disorders. In an increasing number of instances, physicians are often faced with deciding how to treat unruptured cerebral aneurysms.

In patients with ruptured cerebral aneurysms, MRAs have sometimes previously been performed. We were able to analyze previously performed MRAs in such patients. To investigate the risk factors for aneurysm rupture, changes in size of ruptured aneurysms before and after rupture were compared with changes in size of unruptured cerebral aneurysms.

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Materials and Methods

Written informed consent was obtained from all patients. Ethics approval for the study was obtained from the Ethical Committee of our hospital.

The subjects consisted of two series of patients. One set of subjects consisted of patients with ruptured cerebral aneurysms who were admitted to our hospital for treatment from November 2004 to February 2015. MR images including MRA were obtained from these patients before rupture of the aneurysm. These images were stored on an image server and were available for evaluation before and after aneurysm rupture. Evaluation of MRA images was possible for 50 patients (9 men, 41 women; age range, 45-92 years; median age, 72 years). Fifty cerebral aneurysms were reviewed in these patients. Locations of aneurysms were as follows: internal carotid artery (n = 21), anterior communicating artery (n = 14), middle cerebral artery (n = 4), distal anterior cerebral artery (n = 5), vertebrobasilar arterial system (n = 6) (Table 1). The median period from initial MRA to aneurysm rupture was 40.5 months (range, 2-108 months). Seven (14%) of 50 patients underwent MRA three times during this period; two (4%) of 50 patients underwent MRA four times; and one patient (2%) underwent MRA five times. Forty of 50 patients (80%) underwent MRA two times, initially and upon aneurysm rupture.

Another set of subjects consisted of patients with an unruptured cerebral aneurysm who underwent MR images including MRA at our hospital during the same period. One hundred aneurysms in 73 serial patients (21 men, 52 women; age range, 45-84 years; median age, 68 years) who were followed on an outpatient basis were selected in a random manner by N. T. (a neuroradiologist in our institute) for the present study. Locations of aneurysms were as follows: internal carotid artery (n = 32), anterior communicating artery (n = 9), middle cerebral artery (n = 43), distal anterior cerebral artery (n = 7), vertebrobasilar arterial system (n = 9) (Table 1). Of the aneurysms, 35 were treated by clipping or coiling to prevent aneurysmal rupture after follow-up. The period from the initial MRA to the latest follow-up MRA was designated the follow-up period (at least once every 12 months). Median follow-up was 72 months (range, 14-172 months). These 73 serial patients (with unruptured aneurysms) underwent MRA from two to 14 times (median, seven times).

Table 1. *Summary of patients characteristics*

	Patients with unruptured aneurysm	Patients with ruptured aneurysm
No. of cases	73	50
M:F	21:52	9:41
Age in years: median (range)	68 (45-84)	72 (45-92)
Follow-up period (M): median (range)	72 (14-172)	40.5 (2-108)
No. of aneurysms	100	50
Site of aneurysms		
ICA	32	21
A-com A	9	14
MCA	43	4
Distal ACA	7	5
V-B	9	6

Abbreviations: ACA, anterior cerebral artery; A-com A, anterior communicating artery; F, female; ICA, internal carotid artery; M, male; MCA, middle cerebral artery; V-B, vertebrobasilar arterial system.

Table 2. *Imaging parameters of 1.5-T and 3-T MRI*

	1.5-T	3-T
Coil	8ch Head coil	8ch Head coil
TE	3.5 ms	3.2 ms
TR	26 ms	35 ms
FA	20°	20°
Sequence	TOF SPGR	TOF SPGR
Matrix	288*160	512*320
NEX	1	1
Thickness	1.2 mm	1.0 mm
Band width	16.67 Hz	31.25 Hz
FOV	20 cm	20 cm

Abbreviations: ch, channel; FA, flip angle; FOV, field of view; MRI, magnetic resonance imaging; NEX, number of excitations; SPGR, spoiled gradient recalled acquisition in steady state; TE, time of echo; TOF, time-of-flight; TR, time of repetition.

MRI units used in the present study were a 1.5-T system (Signa Excite XI version 11.1; GE Healthcare, Milwaukee, WI) and a 3-T system (Signa HDx Optima Edition; GE Healthcare). For all ruptured aneurysms, only the 1.5-T system was used. For unruptured aneurysms, both the 1.5-T and 3-T systems were used. MRI scanning parameters for the 1.5-T versus 3-T systems are shown in Table 2.

Data were transferred to a workstation (GE Advantage Workstation, version 4.6; GE Healthcare), and maximum intensity projection (MIP) images were created. The maximum diameter of the aneurysm was measured in multiple orientations in .5-mm increments by three experienced radiologic technicians. The resulting measurement served as the "size" of the aneurysm (Fig 1).

Using these data, changes in size of aneurysms and patterns of their changes in each group and comparisons of the annual growth rate between the two groups were studied. To examine the changes in the sizes of aneurysms in both groups, the size of an aneurysm upon rupture or on the latest follow-up MRA (last size [mm]: L) and the size of the aneurysm on the initial MRA (initial size [mm]: I) were determined. Changes between L and