



Original Article

# Prevalence of intracranial aneurysms among acute ischemic stroke patients

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## ABSTRACT

**Background:** The prevalence of unruptured intracranial aneurysms varies with age, sex, and genetic diseases, including atherosclerotic diseases. The objectives of this study are to determine the prevalence of intracranial aneurysms among acute ischemic stroke patients and the clinical outcomes of the patients.

**Methods:** The authors included patients with acute ischemic stroke within 7 days of onset. Demographic data, stroke subtypes, risk factors, and modified Rankin scale (mRS) scores at 6 months after stroke were collected. Magnetic resonance angiography was performed to diagnose intracranial aneurysms. The occurrence of aneurysmal subarachnoid hemorrhage (aSAH) was recorded during the follow-up at 6 months.

**Results:** Thirteen (7%) of the 186 patients were found to have incidental intracranial aneurysms. Age and sex were not different between the patients with and without aneurysms ( $P > 0.999$ ,  $P > 0.999$ ). Ten patients (76.9%) had a saccular aneurysm. The most common site of the aneurysm was the cavernous part of the internal carotid artery ( $n = 6$ ). Nine patients (69.2%) had very small (<4 mm) aneurysms. No aSAH was detected until 6 months after stroke. Favorable outcomes (mRS 0–2) at 6 months were not different between the patients with and without aneurysms (69.2% vs. 75.1%,  $P = 0.665$ ).

**Conclusion:** A higher prevalence of intracranial aneurysms was observed among acute ischemic stroke patients than among the general population. However, the variability of the general population should be considered. The functional outcomes of acute ischemic stroke patients are not affected by the presence of an intracranial aneurysm.

**Keywords:** Acute ischemic stroke, Intracranial aneurysms, Prevalence

## INTRODUCTION

Ruptured intracranial aneurysm is a serious condition with high morbidity and mortality. In the modern era, the detection of unruptured intracranial aneurysms is increasing due to the high quality and higher frequency of cerebral vascular imaging. According to a systematic review and meta-analysis, the overall prevalence of unruptured intracranial saccular aneurysms is 3–3.2%.<sup>[4,11]</sup> The decision regarding management is difficult because of a lack of clinical trial data. However, treatment depends on the natural history of the disease, aneurysm size, and location and complications due to interventions. Large unruptured intracranial aneurysms or symptomatic aneurysms should be considered for treatment because the risk of rupture is probably greater than the risk of treatment.<sup>[3]</sup> Untreatable risk factors that increase the occurrence of intracranial

aneurysms include old age, female sex, and genetic diseases. Autosomal dominant polycystic kidney disease (ADPKD), Ehlers-Danlos syndrome, Marfan's syndrome, hereditary hemorrhagic telangiectasia, and multiple endocrine neoplasia types are common inherited disorders related to intracranial aneurysms. Moreover, the occurrence of intracranial aneurysms has also been associated with Moyamoya disease, arteriovenous malformation, systemic lupus erythematosus, fibromuscular dysplasia, and coarctation of the aorta.<sup>[2]</sup> From systematic review studies, atherosclerotic diseases, such as atherosclerotic heart diseases, ischemic cerebrovascular disease, and internal carotid stenosis, seem to increase the risk of intracranial aneurysm. This relationship may be explained by the same risk factors for both conditions.<sup>[5]</sup> Hypertension and tobacco use are important risk factors that increase the occurrence of both atherosclerotic diseases and intracranial aneurysms.<sup>[5,9]</sup> In a previous study, the prevalence of unruptured intracranial aneurysms among acute ischemic stroke patients was 4.7–6.6%.<sup>[7,8]</sup> However, no data regarding the prevalence of unruptured intracranial aneurysms among acute ischemic stroke patients in Thailand were provided. The objectives of this study are to determine the prevalence of intracranial aneurysms among acute ischemic stroke patients and the clinical outcomes of the patients.

## MATERIALS AND METHODS

This study was a descriptive study. The authors included patients diagnosed with acute ischemic stroke within 7 days of onset or with the transient ischemic attack. The patients were admitted to our institutions between July 2012 and December 2017, and magnetic resonance angiography (MRA) was performed to assess the cerebral vessels. Brain MRI and MRA were performed with a 1.5T MR scanner (Ingenia 1.5T, Philips Medical Systems). MRA was performed using an intravenous injection of contrast, and then, the cerebral vessels were reconstructed into three dimensions. The MRI and MRA data of all patients were reviewed by one experienced neuroradiologist. Demographic data, stroke subtypes according to the modified Trial of ORG 10172 in Acute Stroke Treatment (TOAST) classification,<sup>[1]</sup> risk factors (hypertension, dyslipidemia, diabetes mellitus, heart diseases, smoking, and genetic diseases), and modified Rankin scale (mRS) scores at 6 months were collected. A favorable outcome was defined as a mRS score of 0, 1, or 2 at 6 months. The occurrence of aneurysmal subarachnoid hemorrhage (aSAH) was recorded. The exclusion criteria consisted of stroke from arterial dissection, venous sinus thrombosis, and incomplete data.

Descriptive statistics (the mean, median, and standard deviation) were used for demographic data. Fisher's exact test was used to identify between-group differences among the factors related to the presence of unruptured intracranial aneurysms.

## RESULTS

One hundred ninety-one acute ischemic stroke patients were admitted and underwent MRI/MRA. Five patients were excluded due to incomplete data. Of a total of 186 patients, 13 (7%) were found to have incidental intracranial aneurysms. All intracranial aneurysm patients were diagnosed by MRA. The demographic data are shown in [Table 1]. From the medical record, none of our study population had genetic diseases (ADPKD, Ehlers-Danlos syndrome, etc.). Work-up for genetic diseases was not routinely done in our practices.

Ten patients had a saccular aneurysm, two patients had a fusiform aneurysm, and one patient had a blister aneurysm. No thrombosed aneurysm related to ischemic stroke was identified. The most common location of the incidental intracranial aneurysms was the cavernous part of the internal carotid artery ( $n = 6$ ), followed by the supraclinoid part of the internal carotid artery ( $n = 3$ ), basilar tip artery ( $n = 2$ ), middle cerebral artery ( $n = 1$ ), and anterior cerebral artery ( $n = 1$ ). The size of the neck aneurysms ranged from 1.4 to 3.1 mm, and the dome of the aneurysm ranged from 1.2 to 5.2 mm. Nine patients had very small (<4 mm) aneurysms. All aneurysm data are shown in [Table 2].

After 6 months of follow-up, no aSAH occurred. The patients with aneurysms are still stable, and neurological deficits related to the aneurysms have not been found. Moreover, no patient underwent surgical or interventional treatment for 6 months. Regarding favorable outcomes according to mRS scores at 6<sup>th</sup> months, no difference was found between the patients with aneurysms and those without aneurysms (9/13 [69.2%] vs. 130/173 [75.1%],  $P = 0.665$ ).

**Table 1:** Comparison of demographic data and 6-month clinical outcomes between ischemic stroke patients with and without incidental unruptured intracranial aneurysms.

	Intracranial aneurysm		P-value
	Yes (n=13)	No (n=173)	
Mean age	67.7 y	63.6 y	>0.999
Sex (male), %	8 (61.5%)	107 (61.8%)	>0.999
Underlying diseases			
Hypertension	10 (76.9%)	128 (74%)	>0.999
Diabetes mellitus	4 (30.8%)	59 (34.1%)	>0.999
Dyslipidemia	9 (69.2%)	119 (68.8%)	>0.999
Smoking	0	15 (8.7%)	0.605
TOAST subtype			
Small-vessel disease	8 (61.5%)	102 (59%)	0.692
Large-vessel disease	4 (30.8%)	33 (19.1%)	
Cardioembolism	0	8 (4.6%)	
Transient ischemic attack	1 (7.7%)	30 (17.3%)	
Six-month mRS			
Favorable outcome (0,1,2)	9 (69.2%)	130 (75.1%)	0.665

**Table 2:** Locations, shapes, and sizes of the total ischemic stroke in patients with incidental unruptured intracranial aneurysms.

Patient	Location	Shape	Dome (mm)	Neck (mm)
Male, 79 y	Basilar tip	Saccular	3	1.5
Female, 70 y	Basilar tip	Saccular	5.2	2.2
Male, 65 y	Cavernous	Saccular	1.2	1.5
Male, 56 y	Cavernous	Saccular	2.5	2
Female, 75 y	Cavernous	Saccular	2.7	1.4
Female, 74 y	Cavernous	Saccular	3.6	3.1
Female, 59 y	Cavernous	Saccular	1.4	1.4
Male, 70 y	Middle cerebral artery	Saccular	3.1	2.3
Female, 77 y	Supraclinoid	Saccular	2	1.5
Male, 64 y	Anterior cerebral artery	Saccular	1.6	1.4
Male, 58 y	Supraclinoid	Blister	-	-
Male, 65 y	Supraclinoid	Fusiform	-	-
Female, 68 y	Cavernous	Fusiform	-	-

## DISCUSSION

This is the first study to report the prevalence of unruptured intracranial aneurysms among acute ischemic stroke patients in Thailand. The prevalence of unruptured intracranial aneurysms is approximately 3–3.2%.<sup>[4,11]</sup> However, the previous studies have shown a higher prevalence of incidental unruptured intracranial aneurysms among acute ischemic stroke (4.7–6.6%) than among the general population.<sup>[7,8]</sup> From the authors' study, approximately 7% of acute ischemic stroke patients have incidental unruptured intracranial aneurysms, and the results seem to be similar to those of a previous study. Risk factors for *de novo* intracranial aneurysms include hypertension, female sex, a family history of SAH, and current cigarette smoking. Hypertension and current smoking also are risk factors for ischemic stroke. The same risk factors may explain the higher prevalence. However, no history of smoking was reported by the patients with incidental unruptured intracranial aneurysms, and no sex differences were identified in contrast to previous studies, which might be attributable to the inadequate sample size.<sup>[5,9]</sup>

In our study, a high proportion of the patients with unruptured intracranial aneurysms had large-vessel disease, possibly because the pathology of large-vessel disease is atherosclerosis. Atherosclerosis can change the morphology of arterial vessels, leading to weakened vessel walls, dilation, and aneurysmal formation.<sup>[5,6]</sup> In this study, the most common location was the cavernous part of the internal carotid artery (6/13; 46.2%). Thien *et al.* calculated the prevalence of asymptomatic unruptured intracranial aneurysms in a Southeast Asian population that presented cavernous segment aneurysms in approximately 72/165 (43.6%) patients.<sup>[10]</sup> The race of the patients may be the

reason for the common location. Another reason may be that the intracranial carotid artery is a common site for atherosclerosis which may be related to aneurysms.<sup>[5,13]</sup>

According to the international study of unruptured intracranial aneurysms, the natural history of unruptured intracranial aneurysms depends on the size and location of the aneurysm. Aneurysms <7 mm in size have 5-year cumulative rupture rates of approximately 0–2.5%, and cavernous carotid artery aneurysms have the lowest rates of rupture.<sup>[12]</sup> In this study, no aSAH was detected, which may be explained by the small sizes, and cavernous locations of the aneurysms and a follow-up of only 6 months.

The limitations of this study include the single-center study design and the small number of patients. The study population cannot represent the general Thai population. In addition, no healthy control group was established. Second, the patients with aneurysms were diagnosed by MRA alone, which can have a high false-positive rate. Four-vessel conventional cerebral angiography, which is the gold standard, was not performed to confirm the diagnosis in all patients. Third, the films were analyzed by only one neuroradiologist. Fourth, the intracranial aneurysm patients did not undergo investigations for genetic diseases, which might be a confounding factor.

## CONCLUSION

The prevalence of incidental unruptured intracranial aneurysms among acute ischemic patients in a single center in Thailand is 7%, which seems higher than that in the general population, although differences in the baseline characteristics of the population and confounding by indication for screening should be considered. No rupture of the unruptured intracranial aneurysms was observed during the 6-month follow-up period. Functional outcomes did not differ between the patients with and without aneurysms.

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## Declaration of patient consent

Institutional Review Board permission obtained for the study.

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## Conflicts of interest

There are no conflicts of interest.

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