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Size and Location of Ruptured Intracranial Aneurysms: A 5-Year Clinical Survey

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■ BACKGROUND: **Prospective international cohort trials have suggested that incidental cerebral aneurysms with diameters less than 10 mm are unlikely to rupture. Consequently, small ruptured cerebral aneurysms should rarely be seen in clinical practice. To verify this theory, dimensions and locations of ruptured cerebral aneurysms were analyzed across the state of Tasmania, Australia.**

■ METHODS: **We retrospectively reviewed medical records and diagnostic tests of all patients admitted with ruptured cerebral aneurysms during a 5-year interval. Aneurysm location, maximum size, dome-to-neck ratio, volume, and presence of daughter sacs were determined by preoperative digital subtraction angiography or computed tomography angiography.**

■ RESULTS: **A total of 131 ruptured cerebral aneurysms were encountered and treated by microsurgical clipping ($n = 59$) or endovascular techniques ($n = 72$). The mean maximum aneurysm diameter was 6.4 ± 3.7 mm, dome-to-neck ratio 2 ± 0.8, aneurysm volume 156 ± 372 mm^3, and daughter sacs were present in 70 aneurysms (53.4%). The anterior communicating artery was the most common location (37.4%). Cumulative maximum diameters of ruptured aneurysms were ≤5 mm in 49%, ≤7 mm in 73%, and ≤10 mm in 90%.**

■ CONCLUSIONS: **Despite findings from prospective international cohort trials, small ruptured intracranial aneurysms are common in clinical practice. In consequence, it seems important to identify those patients with small but vulnerable unruptured aneurysms before conservative management is considered.**

INTRODUCTION

The management of patients with small unruptured intracranial aneurysms (UIAs) is controversial. The prevalence of these lesions is approximately 3% within the general population[1]; however, the annual incidence of aneurysm-related subarachnoid hemorrhage (SAH) is much lower, at 6–10 cases per 100,000.[1-4] SAH from rupture of an intracranial aneurysm remains a devastating condition, associated with a 30-day mortality of approximately 45% and survival morbidity of 50%.[3,4]

Size and location of intracranial aneurysms frequently are thought to be the best predictors for future aneurysm rupture.[5-8] The retrospective International Study of Unruptured Intracranial Aneurysms (ISUIA) has demonstrated a 0.05% annual risk for aneurysm rupture in asymptomatic patients when the maximum aneurysm size was less than 10 mm[2]. The prospective ISUIA trial has shown a rupture risk of 0.52% for aneurysm diameters between 7 and 12 mm in the anterior circulation and 2.9% for aneurysms within the posterior circulation at corresponding diameters. The ISUIA study concluded that asymptomatic aneurysms with diameters smaller than 7 mm were benign.[9] Similar findings were encountered in the Unruptured Cerebral Aneurysm Study (UCAS). Additionally, UCAS stated that larger aneurysm size was associated with a greater hazard ratio for rupture[10]; however, these large multicenter trials were criticized for severe selection bias. Several other investigators have

Key words
- Clipping
- Coiling
- Intracranial aneurysm
- Rupture
- Subarachnoid hemorrhage

Abbreviations and Acronyms
CT: Computed tomography
DNR: Dome-to-neck ratio
DSA: Digital subtraction angiography
PcalA: Pericallosal artery
RIA: Ruptured intracranial aneurysm
SAH: Subarachnoid hemorrhage
UIA: Unruptured intracranial aneurysm
VRT: Volume-rendering technique

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Citation: World Neurosurg. (2016) 91:260-265.
http://dx.doi.org/10.1016/j.wneu.2016.04.044

Journal homepage: www.WORLDNEUROSURGERY.org

Available online: www.sciencedirect.com

contradicted the ISUIA and UCAS trial results according to individual case series.[1,4,5,11-14]

According to ISUIA and UCAS suggestions, small ruptured intracranial aneurysms (RIAs) should be encountered rarely in clinical practice. In reality, however, small RIAs appear quite commonly. To better understand the impact of aneurysm size and location, we have reviewed clinical data and medical imaging of all patients who presented with aneurysm-related SAH for emergency microsurgical or endovascular repair within the state of Tasmania, Australia.

MATERIALS AND METHODS

Medical records and diagnostic imaging studies were reviewed retrospectively in all patients admitted with RIAs between July 2010 and August 2015. Other causes of SAH, including mycotic or traumatic aneurysms, were excluded. Patient age, sex, and Hunt & Hess and Fisher grades were recorded. Informed written consent was obtained before emergency treatment and included data collection for research purposes. The study was approved by the institution's review board (H0015446). Maximum and minimum aneurysm sizes, dome-to-neck ratios (DNRs), aneurysm volumes, presence of daughter sacs, and location of RIAs was determined. In patients presenting with multiple aneurysms, the ruptured aneurysm was located according to specific blood distribution on computed tomography (CT) imaging, aneurysm morphology, and/or intraprocedural findings. In cases in which 2 aneurysms were present and located in immediate vicinity, and the rupture site could not be clearly verified, both proximity aneurysms were considered ruptured and treated.

Electronic caliper measurements were obtained from preoperative digital subtraction angiograms (DSA), including cone beam CT imaging with multiplane reconstructions and volume-rendering techniques (VRTs). In cases in which a preoperative DSA had not been performed, measurements were obtained from computed tomography angiograms, including multiplane reconstructions and VRTs. We measured maximum aneurysm diameters, including loculated compartments, by using the largest diameter measurement based on the long or perpendicular axis of the aneurysm. Aneurysm volumes were calculated according to the equation for ellipsoid spheres in mm^3 after we obtained electronic caliper measurements for aneurysm height, width, and depth:

$$\text{Vol} = \pi \cdot (\text{Width} \cdot \text{Depth} \cdot \text{Height})/6$$

Aneurysms were divided into 4 groups according to their maximum diameter: (A) ≤5 mm; (B) >5–≤7 mm, (C) >7–≤10 mm, and (D) >10 mm.

Locations of RIAs were classified as follows: (1) anterior communicating artery, including A1 segments of the anterior cerebral arteries; (2) middle cerebral artery; (3) posterior communicating artery; (4) internal carotid artery, including anterior choroidal artery; (5) vertebrobasilar artery, including posterior cerebral artery; (6) posterior inferior cerebellar artery; and (7) pericallosal artery (PcalA), including A2 segments of the anterior cerebral artery.

Maximum aneurysm size was used as the dependent variable. Relationships between aneurysm sizes, volumes, DNRs, locations, age, and Hunt & Hess and Fisher grades were evaluated by Pearson correlation among the 4 size groups. Statistical evaluation for significance was performed with the Student *t* test, and $P \leq 0.05$ was considered significant.

RESULTS

Demographics, Diagnostics, and Surgical Management

Within the 5-year survey interval, 120 patients were admitted and treated with the diagnosis of RIAs. A total of 89 patients (74%) were female, median age 55 ± 13.5 (SD) years (range 18–86 years), and 31 patients (26%) were male, with a median age of 50 ± 11.1 (SD) years (range, 19–70 years). No significant age difference was found between the 2 sexes ($P > 0.05$, *t* test).

Preoperative DSA was performed in 107 patients (89%). In 13 patients (11%), computed tomography angiograms was used exclusively before neurosurgical clipping. Preoperative imaging demonstrated 180 aneurysms among the 120 patients with SAH. More than 1 aneurysm was present in 34 patients (26.8%). In 11 patients (9.2%) with 2 aneurysms in immediate vicinity, it was uncertain which aneurysm had ruptured. Consequently, both aneurysms were considered ruptured, resulting in 131 treated aneurysms among the 120 patients. Of these RIAs, 127 were saccular (97%), 2 were fusiform, and 2 were dissecting (1.5% each). Both dissecting aneurysms were located within the vertebrobasilar arteries, and both fusiform aneurysms were situated within the anterior cerebral arteries.

Fifty-nine (45%) of the 131 RIAs were treated by surgical clipping and 72 (55%) with endovascular coiling. The perioperative complication rate leading to disability or death was 5.9% in this series.

Aneurysm Size

Mean maximum aneurysm sizes, volumes, DNRs, and Fisher and Hunt & Hess grades including SDs according to specific aneurysm locations and for all aneurysms are summarized in Table 1. The overall mean size of all maximum aneurysm diameters, volumes, and DNRs was 6.4 mm (SD ± 3.7, range: 1.5–23 mm), 156 mm^3 (SD ± 372, range 2–3463 mm^3), and 2.0 (SD ± 0.8, range 0–4.7), respectively.

Sixty-five (49%) of RIAs had maximum diameters ≤5 mm. Ninety-five aneurysms (73%) had maximum aneurysm diameters ≤7 mm and the maximum diameter of ruptured aneurysms was ≤10 mm in 117 patients (90%). A total of 10% of RIAs were larger than 10 mm. Correlation between aneurysm volumes and maximum diameters was $r = 0.8$. No significant differences were found for Fisher grades of SAH among the 4 size groups. Hunt & Hess grades were significantly lower in aneurysms with maximum diameters ≤7 mm (Groups A and B, mean 2.4 ± 1.2) compared with aneurysm diameters >7 mm (Groups C and D, mean 3.1 ± 1.3; $P < 0.05$; Table 2). A typical example of a small ruptured aneurysm at the origin of the left posterior inferior cerebellar artery with SAH extending into the fourth ventricle and subsequent endovascular management is illustrated in Figure 1A–H.

DNRs and Daughter Sacs

Seventy (53.4%) RIAs showed daughter sacs (aneurysm loculations). The frequency of RIAs according to the 4 different size groups is shown in Figure 2. Specific means and SDs for