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Review article

Clinical characteristics of ruptured distal middle cerebral artery aneurysms: Review of the literature

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ABSTRACT

Middle cerebral artery (MCA) aneurysms usually arise at the primary MCA bifurcation or trifurcation. Distal MCA aneurysms are rarely considered as sources of aneurysmal subarachnoid hemorrhage (SAH). It has been reported that ruptured distal MCA aneurysms are associated with head trauma, neoplastic emboli, arterial dissection, or bacterial infection. We experienced five cases of ruptured distal MCA aneurysms and evaluated their clinical characteristics. Retrospective analysis of aneurysmal SAH at Kobayashi Neurosurgical Neurological Hospital was performed from January, 2004 to December, 2014. Clinical characteristics of ruptured distal MCA aneurysms were analyzed using our database. Among 191 aneurysmal SAH patients, there were five ruptured distal MCA aneurysms. All patients did not have any specific medical problems such as infectious disease, head trauma, or cardiac disorders. The incidence of ruptured distal MCA aneurysm was higher than expected and was equivalent to 9.4% of the total ruptured MCA aneurysms. Strong male predominance (80%) and M2–3 junction aneurysm preponderance (80%) were observed. In addition, there were only two patients (40%) with intracerebral hematoma in our study. We reported five cases of ruptured distal MCA aneurysms. Although ruptured distal MCA aneurysms are thought to be rare as sources of aneurysmal SAH, the incidence of ruptured distal MCA aneurysm was 9.4% of all ruptured MCA aneurysms in our study. Ruptured distal MCA aneurysms should be considered as sources of aneurysmal SAH without intracerebral hematoma.

1. Introduction

Middle cerebral artery (MCA) aneurysms are a well-known common cause of aneurysmal subarachnoid hemorrhage (SAH), and the most commonly affected site of ruptured MCA aneurysm is the primary M1–2 bifurcation or trifurcation [1,2]. As aneurysms originating from the distal MCA or its branches are rare lesions, accounting for 2–6% of total MCA aneurysms, they are a much rarer source of aneurysmal SAH [3–6]. It has been reported that common etiologies for distal MCA aneurysms are associated with head trauma, vasculitis, neoplastic emboli, or mycotic emboli associated with endocarditis [7–10]. There have been few previous reports of ruptured distal MCA aneurysms, and the clinical characteristics of these lesions are not clear. In this study, we evaluated the clinical characteristics of ruptured distal MCA aneurysms using our aneurysmal SAH database and reviewed the literature.

2. Material and methods

From the aneurysmal SAH database of Kobayashi Neurosurgical Neurological Hospital, we retrieved the data of consecutive ruptured distal MCA aneurysm patients from January 2004 to December 2014. Initial clinical condition was assessed by the World Federation of Neurosurgical Societies (WFNS) Grading Scale for SAH [11]. According to the MCA classification of Gibo [12], distal MCA was classified into four segments: M2 (insular segment), M2–3 junction, M3 (opercular segment), and M4 (cortical segment). The patients' clinical outcome was assessed at the time of discharge according to the Glasgow Outcome Scale (GOS) as good recovery (GR), moderate disability (MD), severe disability (SD), vegetative state or dead [13]. Based on clinical presentation, radiological features, and intraoperative findings, the characteristics of ruptured distal MCA aneurysms were evaluated.

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3. Results

During the 11-year study period, 273 aneurysmal SAH patients were admitted for surgical treatment. One hundred ninety-one of the 273 patients underwent direct surgery and 82 patients received endovascular treatment. Of the total of 273 aneurysmal SAH patients, 53 patients had ruptured MCA aneurysms. All 53 patients with ruptured MCA aneurysm underwent direct surgery. The ruptured MCA aneurysms were located in the M1 segment in four cases (7.6%), M1–2 junction in 44 cases (83.0%), and distal MCA in five cases (9.4% of the total ruptured MCA aneurysms). The clinical characteristics of all five patients with distal MCA aneurysm are presented in Table 1. History of present illness, general evaluations, laboratory examinations, and cardiac ultrasonographic findings indicated that none of the patients had any specific medical problems, such as infectious disease, head trauma, or heart disease. Overall, the patients consisted of four men and one woman, with a mean age of 70.4 ± 7.0 years. The mean aneurysm size was 9.2 mm, ranging from 2 to 25 mm. The radiological findings of all five cases are shown in Fig. 1. Four aneurysms were located at the M2–3 junction and one was located in the M3 segment. There were no aneurysms at the M2 or M4 segment in our study population. Four aneurysms were saccular and one was thrombosed. One aneurysm (Case 3) developed at the branchless region (Fig. 1H). The initial CT scans showed intracerebral hematoma (ICH) in only two patients (Fig. 1A and B). Four of the five patients had diffuse subarachnoid hemorrhage. One patient (Case 3) had SAH in the left sylvian fissure (Fig. 1C). No subdural hematoma was seen. Multiple aneurysms were seen in one case (Case 5) (Fig. 1J). Four patients underwent direct surgeries in the early stage (within 48 h of diagnosis) and one patient (Case 4) was treated on day 6 as he was referred to our hospital on day 5. All ruptured distal MCA aneurysms were well obliterated with clipping. At discharge, favorable (GR or MD) and unfavorable (SD) outcomes were documented in three and two cases, respectively. Unfavorable outcome resulted from initial ICH of the dominant hemisphere (Case 2) (Fig. 1B) and preoperative diffuse ischemia due to vasospasm (Case 4) (Fig. 1D).

4. Discussion

Since Poppen first reported distal MCA aneurysm in 1951, some case series studies of ruptured distal MCA aneurysms have been reported [3,4,14–16]. We searched PubMed for related studies and a thorough survey of the English literature identified four case series of ruptured distal MCA aneurysm (Table 2) [3,4,14,15].

4.1. Characteristics of ruptured distal MCA aneurysms

4.1.1. Sex and age differences

Based on the previously reported cases and the present case, among a total of 42 cases (sex data were missing in one case series [15]), 17 (40%) were women and 25 (60%) were men (Table 2) [3,4,14]. Aneurysmal SAH is known to occur more frequently in women than in men [17–19]. Horiuchi and colleagues [3] reported female predominance in their study. In contrast, the other studies showed male predominance in ruptured distal MCA aneurysms [4,14]. In our study, strong male predominance was seen. It has been reported that intrinsic arterial wall weakness may be responsible for aneurysmal formation in women [17–19]. On the other hand, hemodynamic stress is more important in aneurysmal formation in men [4,17,18]. Therefore, distal MCA aneurysm would be formed by hemodynamic stress rather than intrinsic arterial wall weakness.

The mean age in our study population was 70.4 ± 7.0 years and was higher than in other studies (Table 2) [3,4,14,15]. Furthermore, mean age of the ruptured MCA aneurysm patients in our study was 64 years (range: 42–93 years), which was older than the mean age of 52 years (range: 18–84 years) patients registered in the Neurosurgery Group of International Subarachnoid Aneurysm Trial (ISAT) [20]. Although the precise reason is unclear, this may have been due to the recent aging in Japan.

4.1.2. Incidence

As aneurysms originating from the distal MCA are rare, with a reported incidence of 2–6% of all MCA aneurysms, distal MCA aneurysms are rarely reported as sources of aneurysmal SAH [3–6]. Of the four studies examined, overall there were 2030 patients with ruptured MCA aneurysms [3,4,15]. Forty of these 2030 cases had ruptured distal MCA aneurysms, which was equivalent to 2.0% of the total ruptured MCA aneurysms. In the present study, the incidence of ruptured distal MCA aneurysm was 9.4% of all ruptured MCA aneurysms, and 1.8% of all 273 aneurysmal SAH patients. This incidence is high compared with that reported in the literature. Although the reason for this high incidence is unclear, it is possible that unruptured M1–2 aneurysms may be discovered with screening MRI during brain check-ups in Japan, and some may have been treated to prevent their rupture. Therefore, it is likely that the incidence of ruptured distal MCA aneurysms was relatively high in our study.

4.1.3. Aneurysm size

The mean aneurysm size in our study was 9.2 mm (range: 2–25 mm). Although hemodynamic stress is seen less frequently in the distal than in the proximal portion, it is relatively rare for distal MCA aneurysms to become giant aneurysms ($\geqslant$25 mm) [15]. However, recent reported described several cases of giant aneurysms [14,15,4]. Joo et al. [4] reported a 22-year-old man with a giant fusiform aneurysm (35 mm) at the M2 segment. Although the details were not described, Dashti et al. [15] reported one case of giant aneurysm (25 mm), and Calvacante and colleagues [14] reported three cases of giant ruptured distal MCA aneurysms. We also encountered a 71-year-old man (Case 2) with a giant thrombosed aneurysm (25 mm) at the M2–3 junction. In patients with giant aneurysms, clinical symptoms evolve most commonly from the mass effect [21]. Two patients (including our case) presented with SAH without a preceding mass effect. The giant aneurysm reported by Joo et al. [4] may have ruptured before showing a mass effect because it was a fusiform aneurysm in a young patient. On the other hand, our case was a thrombosed aneurysm in an elderly

Table 1
Summary of five patients with ruptured distal middle cerebral artery aneurysms.

Case No.	Age (yrs), sex	Preop. WFNS grade	Side and location	Aneurysm type	Size (mm)	Intracerebral hematoma	Op. timing (days)	GOS
1	66, M	III	rt. M2–3	Saccular	5	Yes	0	MD
2	71, M	IV	lt. M2–3	Thrombosed	25	Yes	0	SD
3	85, M	I	lt. M3	Saccular	8	No	0	GR
4	69, W	V	rt. M2–3	Saccular	6	No	6	SD
5	61, M	I	rt. M2–3	Saccular	2	No	2	GR

WFNS = World Federation of Neurosurgical Societies; GOS = Glasgow Outcome Scale; GR = good recovery; MD = moderate disability; SD = severe disability.