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Aneurysms Located at the Horizontal Segment of the Anterior Cerebral Artery or the Middle Cerebral Artery  
(前大脳動脈及び中大脳動脈水平部の局在性動脈瘤)

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## **Aneurysms Located at the Horizontal Segment of the Anterior Cerebral Artery or the Middle Cerebral Artery**

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### **Abstract**

**Aneurysms at the horizontal segment of the middle cerebral artery or anterior cerebral artery are relatively rare. The characteristics of 13 cases were analyzed retrospectively. Six of the 13 cases had multiple aneurysms, nine had aneurysmal rupture, and three of these nine were complicated by intracerebral hematoma. Neck clipping of the aneurysm was performed in 11 cases and four developed a new cerebral infarction in the territory of the perforating arteries. Overall mortality and morbidity was 15% and 38%, respectively. The outcome for patients with aneurysms at these sites was evidently poorer than for those with aneurysms at other sites.**

Key words: aneurysm, anterior cerebral artery, middle cerebral artery, perforating artery, subarachnoid hemorrhage

### **Introduction**

Cerebral aneurysms located at the horizontal portion of the anterior cerebral artery ( $A_1$ ) or the middle cerebral artery (MCA) ( $M_1$ ) are relatively rare,<sup>2,6,8,11,13-15</sup> so neurosurgeons have limited opportunities for personal experience. Consequently, there are no comprehensive reports on the outcome of this aneurysm following surgical treatment. We conducted a retrospective study on the surgical outcome of aneurysms at the  $A_1$  or  $M_1$  segment and analyzed the etiology.

### **Patients and Methods**

This study analyzed 13 patients with aneurysms of the  $A_1$  or  $M_1$  segment among 918 patients with cerebral aneurysms who underwent surgery (via a direct approach) at the Asahikawa Medical College or four affiliated facilities between 1980 and 1994. All patients underwent computed tomography (CT) and four-vessel angiography by a conventional method or digital subtraction angiography. Aneurysms located at the  $A_1$ -anterior communicating artery complex or at the early bifurcation of the MCA and those developing along the fenestration

were excluded. Postoperative CT was repeated at least twice in all patients. Postoperative angiography was performed in all surviving patients. Final outcome was evaluated using Glasgow Outcome Scale<sup>5</sup> at 6 months after surgery or at the time of death.

### **Results**

The patients were aged from 47 to 81 years (mean 61 years) and the male/female ratio was 4/9 (Table 1). The sites of the aneurysms, surgical procedures, and postoperative CT findings are summarized in Table 2. The nine cases of ruptured aneurysms at these sites were graded according to Hunt and Hess<sup>4</sup> as follows: grade I, one case; grade II, four cases; grade III, one case; and grade IV, three cases. Final outcome according to the Glasgow Outcome Scale was as follows: good recovery for six patients; moderately disabled, three; severely disabled, two; and died, two. The two patients who died and one who was severely disabled were all rated as grade IV prior to surgery due to intracerebral hemorrhage. The three patients rated as moderately disabled had motor paresis caused by infarction of the internal capsule, which developed following clipping.

**Table 1 Clinical summary of 13 patients with M<sub>1</sub> or A<sub>1</sub> segment aneurysms**

Case No.	Age/Sex	Admission grade*	Site of aneurysm	Ruptured aneurysm	No. of aneurysms	Surgical procedure	Postoperative CT	Cause of low density	Outcome**
1	59/M	II	rt M <sub>1</sub>	rt M <sub>1</sub>	1	clipping	low density in the caudoputamen and corona radiata	clipping	MD
2	68/F	IV	lt M <sub>1</sub>	lt M <sub>1</sub>	2	clipping	low density in the putamen and internal capsule	hematoma	SD
3	55/M	IV	lt M <sub>1</sub>	lt M <sub>1</sub>	1	clipping	low density in the putamen and internal capsule	hematoma	died
4	71/F	II	lt M <sub>1</sub>	lt ICPC	2	clipping	low density in the putamen and internal capsule	clipping	SD
5	52/F	II	rt M <sub>1</sub>	AComA	2	wrapping	no low density	—	GR
6	72/F	II	rt M <sub>1</sub>	rt ICPC	2	wrapping	no low density	—	GR
7	81/M	III	lt A <sub>1</sub>	lt A <sub>1</sub>	1	clipping	low density in the caudate	clipping	MD
8	65/F	IV	rt A <sub>1</sub>	rt A <sub>1</sub>	1	clipping	low density in the subcortex	hematoma	died
9	52/M	II	rt A <sub>1</sub>	rt A <sub>1</sub>	1	clipping	low density in the internal capsule	clipping	MD
10	58/F	II	lt A <sub>1</sub>	lt ICPC	2	clipping	no low density	—	GR
11	47/F	II	lt A <sub>1</sub>	lt A <sub>1</sub>	2	clipping	no low density	—	GR
12	48/F	I	rt A <sub>1</sub>	rt A <sub>1</sub>	1	clipping	no low density	—	GR
13	63/F	II	rt A <sub>1</sub>	rt A <sub>1</sub>	1	clipping	no low density	—	GR

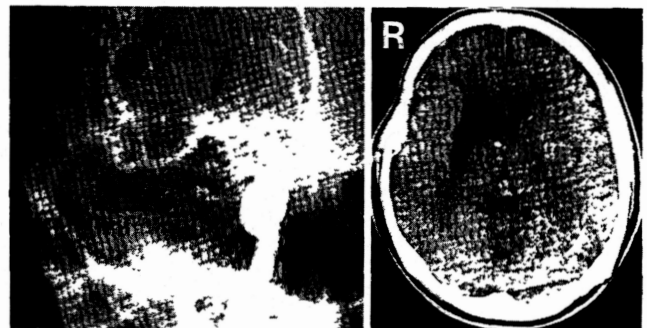
\*Hunt and Hess classification.<sup>4)</sup> \*\*Grading according to the Glasgow Outcome Scale<sup>5)</sup>: GR, good recovery; MD, moderately disabled; SD, severely disabled. AComA: anterior communicating artery, CT: computed tomography, ICPC: internal carotid artery-posterior communicating artery.

**Table 2 Site of the aneurysms, surgical procedures, and postoperative computed tomography (CT) findings**

Site of aneurysm	No. of cases	No. of aneurysms		Ruptured aneurysm	Clipping	Low density on CT	Low density due to clipping
		Single	Multiple				
M <sub>1</sub>	6	2	4	3	4	4	2
A <sub>1</sub>	7	5	2	6	7	3	2

### Illustrative Cases

**Case 1:** A 59-year-old male suffered onset of sudden, severe headaches. CT on admission showed the presence of diffuse subarachnoid hemorrhage in the right sylvian fissure, extending toward the basal cistern. Right carotid angiography showed an irregularly shaped aneurysm at the M<sub>1</sub> segment (Fig. 1 left). Moreover, there was a small aneurysm at the bifurcation of the left MCA. Based on the CT findings, we suspected a ruptured aneurysm at the right M<sub>1</sub> portion. The patient underwent surgery on the same day. The aneurysmal wall was thin and a perforating artery originated about 1 mm distal to the origin of the neck. A clip (Sugita No. 4) was applied in the direction parallel to the long axis of M<sub>1</sub> segment, sparing this artery. However, postoperative CT indicated a low density area in the right caudate nucleus and internal capsule (Fig. 1 right).



**Fig. 1** Case 1. *left:* Preoperative cerebral angiogram of the right internal carotid artery demonstrating that the M<sub>1</sub> is tortuous and bowed upward, with an irregularly shaped small aneurysm (arrow) situated at the top of the M<sub>1</sub>. *right:* Computed tomography scan, obtained 1 month after surgery, showing a low density area in the right caudate nucleus and internal capsule.

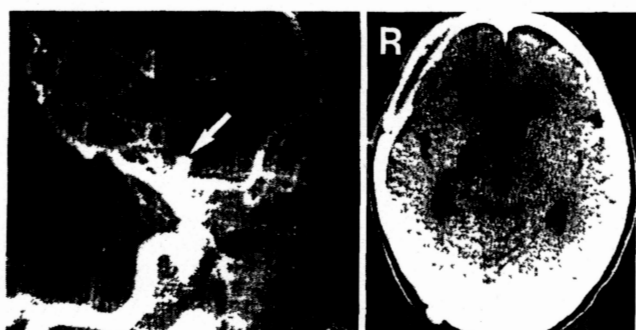


**Fig. 2** Case 2. *left*: Computed tomography (CT) scan at admission showing a large hematoma in the left basal ganglia. *center*: Preoperative cerebral angiogram of the left internal carotid artery demonstrating an aneurysm (arrow) at the M<sub>1</sub> segment. Several small clips, placed in the previous operation, are visible at the bifurcation of middle cerebral artery. *right*: Postoperative CT scan revealing a low density area in the left putamen, internal capsule, and thalamus.

**Case 2:** A 68-year-old female had undergone surgery of an aneurysm at the bifurcation of the left MCA (performed at another hospital) 20 years ago. On June 10, 1993, the patient suddenly lapsed into a coma. On admission, her consciousness was rated as 9 according to the Glasgow Coma Scale. CT revealed an intracerebral hematoma measuring 6 × 4 × 3 cm in the left basal ganglia (Fig. 2 left). Cerebral angiography demonstrated a saccular aneurysm at the left M<sub>1</sub> segment (Fig. 2 center). The patient underwent emergency surgery. A perforating artery originated from the dome of the aneurysm, and was therefore sacrificed. Following surgery, the patient

became alert but developed motor aphasia and right hemiparesis. However, she was able to communicate adequately and recovered sufficiently to feed herself unaided (Fig. 2 right).

**Case 9:** A 52-year-old male suffered onset of severe headaches and vomiting. CT showed thick subarachnoid hemorrhage in the basal cistern. Cerebral angiography showed an aneurysm at the right A<sub>1</sub> portion (Fig. 3 left). The patient underwent surgery on the same day. A perforating artery origi-



**Fig. 3** Case 9. *left*: Preoperative cerebral angiogram of the right internal carotid artery showing a saccular aneurysm (arrow) at the proximal portion of A<sub>1</sub> segment. *right*: Postoperative computed tomography scan demonstrating a low density area in the right internal capsule.



**Fig. 4** *left*: Right internal carotid angiogram of Case 6 showing saccular aneurysms at internal carotid artery (arrowheads) and the M<sub>1</sub> segment (arrow). The M<sub>1</sub> segment is bowed upward and an aneurysm is situated at the top. *right*: Left internal carotid angiogram of Case 7 demonstrating a saccular aneurysm at the A<sub>1</sub> segment (arrow). The distal A<sub>1</sub> sharply bends downward at the origin of aneurysm.

nated from the top of the aneurysmal dome, so had to be sacrificed. Following surgery, the patient developed moderate left hemiparesis. CT revealed a low density area in the right internal capsule (Fig. 3 right).

**Cases 6 and 7:** Preoperative angiograms of Cases 6 and 7 are presented in Fig. 4.

## Discussion

The incidence of aneurysms at the  $A_1$  segment is 0.88% to 5.3%<sup>2,6,8,11,13-15</sup> and that at the  $M_1$  segment is 1.5% to 3.6%.<sup>6,8,15</sup> Our study found the incidence of aneurysms at the  $A_1$  segment was 0.76% and the  $M_1$  segment was 0.65%. These lower incidences may be due to exclusion of aneurysms with fenestration or those developing at the early bifurcation of MCA. However, our results revealed a high incidence of multiple aneurysms at these sites (46%) in agreement with previous reports.<sup>3,10,13</sup>

The formation of intracranial aneurysm is generally accepted to result from a combination of inherent weakness of the vessel wall, hemodynamic and other contributing factors, such as arteriosclerosis.<sup>1,12</sup> The incidence of multiple aneurysms in the  $A_1$  and  $M_1$  segments seems to indicate the importance of inherent factors. However, retrospective analysis of angiograms demonstrated that the  $A_1$  and  $M_1$  tend to curve upward or sharply downward, and the aneurysm develops at the summit of this segment. This strongly implies that hemodynamic stress participates in aneurysm formation at these sites.

Nine of the 13 aneurysms at the  $A_1$  or  $M_1$  sites had ruptured, among which three (33%) were complicated by intracerebral hematomas. A recent cooperative study showed the frequency of intracerebral hematomas complicating the rupture of cerebral aneurysm is 17.4%.<sup>7</sup> Therefore,  $A_1$  and  $M_1$  segment aneurysms may be more likely to develop intracerebral hematomas in comparison with aneurysms that develop at other sites.<sup>3</sup> Aneurysms that develop at the  $M_1$  section, in particular, can cause hemorrhage in the basal ganglia with a resultant poor prognosis.

The main cause of morbidity associated with clipping of aneurysms at the  $A_1$  or  $M_1$  segment is cerebral infarction in the area supplied by the perforating artery. Four of our six patients with low density areas had the perforating artery originating from the aneurysmal dome, so infarction was inevitable after complete clipping, although two of these patients already had a large hematoma at the basal ganglia and the development of infarction could not be confirmed. In the other two patients with infarction of this area, the surgeons considered that the

perforating artery was preserved, but postoperative CT showed a low density area. Other workers have also described preservation of this branch during the surgical procedure but low density areas on the postoperative CT scan.<sup>3,9</sup> The frontal view of angiography frequently shows the horizontal portion of the MCA was extremely tortuous and bowed upward (Figs. 1 and 4). Therefore, the base of the frontal lobe must be retracted using a spatula during surgery. Even when the perforating artery is preserved during clipping, the position of the clip may shift when the retraction of the brain is released, resulting in compression or kinking of the perforating artery. These situations could cause infarction in the area of this artery. To prevent this outcome, the use of the minimal size clip or application of the clip in a direction parallel to the long axis of the parent artery could be considered; but whether this would be effective in preventing infarction of the perforating artery is uncertain. When the perforating artery originates from the aneurysm, the surgical procedure may be completed by wrapping to obviate the risk of infarction. When the aneurysm in this portion is responsible for a subarachnoid hemorrhage, the wall of the aneurysm is very thin (in our experience) and rebleeding seems to be almost inevitable. We are not certain if wrapping is adequate as a surgical treatment. We have performed wrapping in two aneurysms at these sites. Neither of these aneurysms had ruptured but were associated with the rupture of aneurysms at other sites. No rebleeding has been recognized in the follow-up of these patients for 44 and 48 months.

We recommend that particular attention be directed to the perforating artery in this area. Even unruptured aneurysms should be treated by an adequately safe clipping or wrapping plus coating procedure if preservation of the perforating artery is not confirmed.

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### Commentary

Aneurysms of the horizontal portion of the anterior cerebral artery or the middle cerebral artery are relatively rare. The incidence of A<sub>1</sub> aneurysms is about 0.88% to 5.3% and that of M<sub>1</sub> is 1.5% to 3.6% in some reported papers. In our series at Seoul National University Hospital, the incidence of A<sub>1</sub> aneurysms was nine out of 1206 intracranial aneurysms (0.75%) and those of M<sub>1</sub> aneurysms was 29 out of 1206 aneurysms

(2.4%). The mean age of the patients with M<sub>1</sub> aneurysms was 54 years and those with A<sub>1</sub> was 33 years. Most aneurysms manifested as spontaneous subarachnoid hemorrhage except one giant aneurysm on M<sub>1</sub> with mass effect. Multiple aneurysms are more common in M<sub>1</sub> (52%) than A<sub>1</sub> (28.5%). In M<sub>1</sub> aneurysms, female was dominant by 18 to eight ratio. The site origin of M<sub>1</sub> aneurysms was most commonly at the branching site of the anterior temporal artery (19 cases), the lenticulostriate artery (8 cases), and the diffuse fusiform type without a definite origin site. We had two operative complications, one with an M<sub>1</sub> aneurysm and one with an A<sub>1</sub> aneurysm. Both were due to perforator injury resulting in hemiparesis.

We conclude that we must preserve the perforators during the clipping of aneurysms at the A<sub>1</sub> or M<sub>1</sub> sites.

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Sako and his colleagues provide a useful review of 13 patients with aneurysms located at the horizontal segment of the anterior cerebral artery or the middle cerebral artery. The article presents characteristic clinical features and a important description of the surgical pitfalls.

The incidence of multiple aneurysms at these sites is high (46%) and one third of the ruptured aneurysms had associated intracerebral hematomas with a resultant poor prognosis. Overall mortality and morbidity was 15% and 38%, respectively. The authors also emphasize the main cause of morbidity associated with clipping is cerebral infarction in the area supplied by the perforating artery and recommend that even unruptured aneurysms should be treated by an adequately safe clipping or wrapping plus coating procedure if the preservation of the perforating artery is not confirmed. The surgical approach and clipping technique presented here are adequate. I prefer to use the lateral transylvian approach to expose the horizontal segment of the anterior cerebral artery or the middle cerebral artery. With this approach, the surgeon has an easier access to the aneurysm, manipulation of the aneurysm, and definition of the perforators, the parent arteries can be achieved easily and definitely, and significant retraction is avoided, especially in the acute stage.

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