



A Patient with an Unruptured Aneurysm in the Internal Carotid Artery-duplicated Middle Cerebral Artery on Whom Coil Embolization with Balloon Remodeling Was Performed

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Objective: Treatment of an unruptured aneurysm at the origin of duplicated middle cerebral artery (DMCA) by coil embolization using balloon remodeling has not been reported. We report a case of coil embolization using balloon remodeling for an unruptured aneurysm at the origin of DMCA.

Case Presentation: A 71-year-old female was found to have an unruptured aneurysm at the origin of DMCA during an examination for headache. Coil embolization using balloon remodeling for the wide neck aneurysm to preserve both the internal carotid artery (ICA) and DMCA was successful. The perioperative course was uneventful.

Conclusion: This treatment enables complete embolization, and preserves both the ICA and DMCA. Thus, it is useful for aneurysms at the origin of DMCA.

Keywords ▶ duplication of middle cerebral artery, cerebral unruptured aneurysm, coil embolization, balloon remodeling

Introduction

Duplicated middle cerebral artery (DMCA) is an abnormality of the middle cerebral artery (MCA) branching from the internal carotid artery (ICA). It branches from the distal of anterior choroidal artery origin of the ICA, passes through the Sylvian fissure, and runs through a portion of the MCA region. The incidence of DMCA is 0.2%–2.9% in autopsy cases.¹⁾ The incidence of concomitant aneurysms is unclear, but few studies have reported aneurysms at the origin. Regarding unruptured

aneurysms, only 11 patients have been reported.^{2–9)} In 9 of the 11 patients, clipping during craniotomy was performed, and the other two underwent conservative treatment due to small aneurysms.

No study has reported coil embolization; however, it is possible in some patients. It is important to embolize aneurysms while preserving the ICA and DMCA. We report a patient in whom an unruptured, wide-neck DMCA origin aneurysm was treated using coil embolization with balloon remodeling to preserve the ICA and DMCA.

Case Presentation

The patient was a 71-year-old female. Magnetic resonance imaging (MRI) and magnetic resonance angiography (MRA) as detailed examinations for headache revealed an unruptured aneurysm in the left ICA (**Fig. 1**). For detailed examination and treatment, she was referred to our department. Left internal carotid angiography confirmed an unruptured aneurysm ($5.2 \times 5.0 \times 4.4$ mm) involving the DMCA and its origin, with a neck length of 3.9 mm and dome/neck (D/N) ratio of 1.25 (**Fig. 2A** and **2B**). We also

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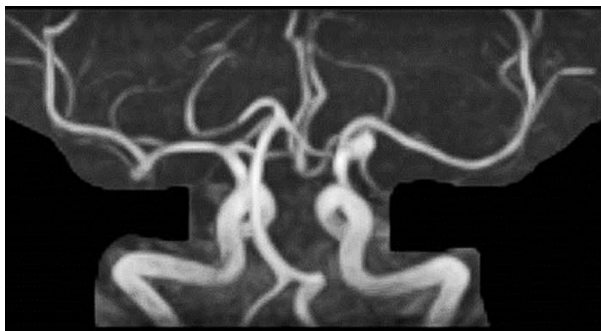


Fig. 1 Preoperative MRA revealed an aneurysm at the origin of left DMCA. DMCA: duplicated middle cerebral artery; MRA: magnetic resonance angiography

confirmed that the anterior choroidal artery had branched from a proximal area adjacent to the origin of the DMCA. Due to the wide-neck aneurysm, coil embolization with balloon remodeling was planned to preserve the ICA and DMCA. To prevent ischemic complications, oral administration of clopidogrel at 75 mg/day was started 1 week before surgery.

Under general anesthesia, a 7Fr shuttle sheath (Cook Medical, Indianapolis, IN, USA) was inserted into the left common carotid artery through the right femoral artery, and a 7Fr FUBUKI (Asahi Intecc, Aichi, Japan) was inserted into the left ICA. Heparin at 4000 units was intravenously injected to maintain the activated clotting time (ACT) at ≥ 250 . First, an SL-10 90° (Boston Scientific, Natick, MA, USA) was guided into the DMCA using a CHIKAI 14 (Asahi Intecc). A Sceptor C 4/15 mm (Microvention, Tustin, CA, USA) was guided into the DMCA using the sheep technique with a CHIKAI 14. A balloon was inserted into the neck region, and the SL-10 90° was inserted into the aneurysm using the CHIKAI 14 (**Fig. 3A**). Balloon-assisted coil embolization was performed; framing was conducted using a V-Trak 10 Cosmos 5 mm/15 cm (Microvention, Aliso Viejo, CA, USA). A total of seven coils (33 cm) were inserted: Orbit Galaxy complex Extrasoft 3 mm/6 cm (Codman Neurovascular, Raynham, MA, USA), ED coil Extrasoft 2 mm/3 cm (Kaneka Medix Corp, Kanagawa, Japan), Target nano Helical 1.5 mm/3 cm (Target; Stryker, Fremont, CA, U.S.A), and Target nano Helical 1.5 mm/2 cm (Target) $\times 3$. The volume embolization ratio (VER) was 35.7%. Final angiography confirmed complete occlusion of the aneurysm, and preservation of the ICA and DMCA (**Fig. 3B**) and anterior choroidal artery (**Fig. 3C**), and the procedure was completed. The postoperative course was favorable. On diffusion-weighted MRI the day after surgery, there

was no acute-phase cerebral infarction (**Fig. 4A**). On MRA, the aneurysm was not visualized, and visualization of the ICA and DMCA was favorable (**Fig. 4B**). There were no symptoms, and the patient was discharged 5 days after surgery. During the 4-year postoperative follow-up, there has been no recurrence on follow-up MRA and the course has been favorable.

Discussion

Common abnormalities of the MCA include accessory MCA (AMCA) and DMCA. Crompton et al.¹⁾ reported 10 patients with excess blood vessels originating from an area between the anterior choroidal artery origin of the ICA and its end, running through a portion of the MCA region, and termed such blood vessels as “AMCA.” They also reported arteries originating from the anterior cerebral artery that exhibited a similar distribution. Thereafter, similar abnormal blood vessels were reported. In 1973, Teal et al.¹⁰⁾ termed a blood vessel originating from the ICA “DMCA” and that originating from the anterior cerebral artery “AMCA.” The two arteries run with the MCA (M1) in the Sylvian fissure through a portion of the MCA region. These are anomalies in which the first branch to the frontal lobe, the orbitofrontal artery, and the first branch to the temporal lobe, the anterior temporal artery, directly branch from the ICA.^{10–12)} Concerning the pathogenesis, several studies suggested dilation of a recurrent artery of Heubner¹³⁾ and residual anterior cerebral artery-MCA anastomosis.^{14,15)}

The incidence of DMCA is 0.2%–2.9% in autopsy cases.¹⁾ Some patients with excess blood vessels develop cerebral aneurysms, but DMCA aneurysms arising at its origin are rare, although their incidence remains to be clarified. In all, 11 patients with unruptured aneurysms at the origin,^{2–9)} including an autopsy case reported by Crompton et al.¹⁾ have been reported. The 12 patients, including the present case, are summarized in **Table 1**. The mean age was 57.8 years. In most patients, the aneurysms measured ≤ 5 mm, excluding one patient with an aneurysmal diameter of 12 mm. The aneurysms were present on the right in four patients and on the left in eight patients. In one patient, bleb formation was observed. In two patients with small aneurysms, conservative treatment was performed, whereas clipping during craniotomy led to favorable results in the other nine patients. No study has reported coil embolization of unruptured aneurysms.

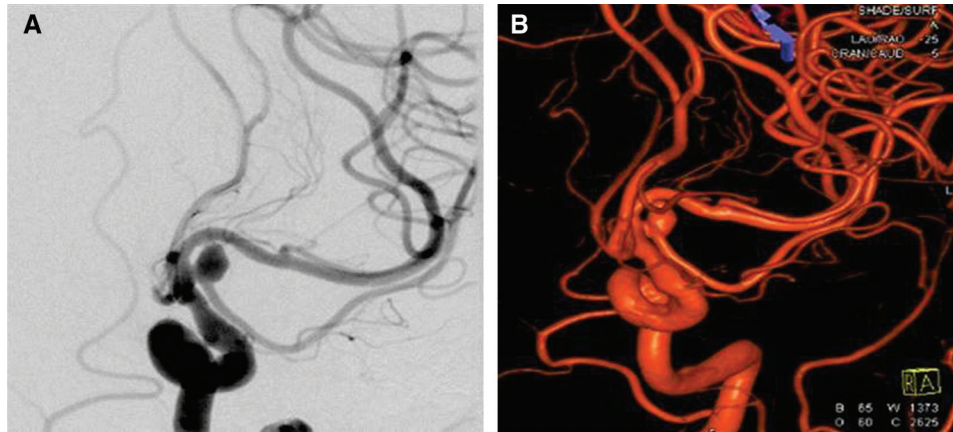


Fig. 2 Preoperative left internal carotid angiography (**A**: oblique position, **B**: 3D-DSA) showed an aneurysm, measuring 5.2 mm in maximum diameter, at the origin of duplicated middle cerebral artery. The DMCA had branched from the aneurysmal neck. 3D-DSA: three-dimensional digital subtraction angiography; DMCA: duplicated middle cerebral artery

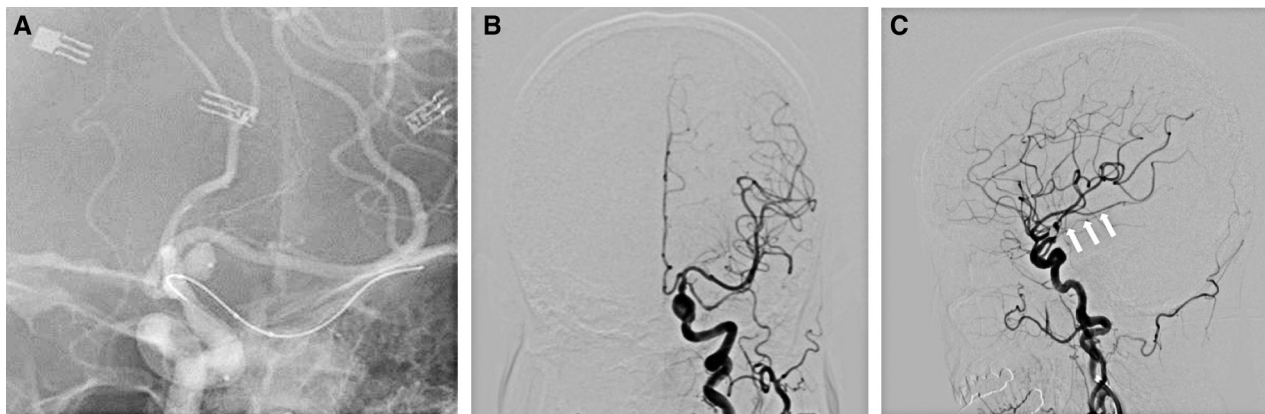


Fig. 3 (**A**) At an intraoperative working angle, a Scepter C had been inserted into the aneurysmal neck. (**B**) Left internal carotid angiography (frontal view) immediately after surgery confirmed occlusion of the aneurysm, and preservation of the ICA and DMCA. (**C**) On left internal carotid angiography (lateral view) immediately after surgery, the anterior choroidal artery was visualized. White arrow: anterior choroidal artery. DMCA: duplicated middle cerebral artery; ICA: internal carotid artery

The DMCA is an important source of blood flow for the temporal lobe and basal ganglia. Therefore, it should be preserved during treatment. Kai et al.⁴⁾ performed superficial temporal artery-DMCA bypass on a patient in whom it was difficult to separate the aneurysm from the DMCA due to adhesion, and reported treatment by occlusion of the aneurysm involving a parent artery. For neck clipping, a clip as short as possible should be used to preserve the anterior choroidal artery adjacent to the aneurysm and medial lenticulostriate artery.⁹⁾ Regarding endovascular treatment, aneurysms at the origin of DMCA, making it difficult to perform coil embolization while preserving the DMCA. Therefore, only a few case reports on ruptured aneurysm at the origin of DMCA treated by endovascular treatment have been published.¹⁶⁻¹⁹⁾ To our knowledge, no

study has reported endovascular treatment for unruptured aneurysm at the origin of DMCA.

During the past few years, coil embolization of wide-neck aneurysms with balloon neck remodeling has been established. Recently, stent-assisted embolization has been routinely performed. In particular, clipping during craniotomy is more appropriate for MCA aneurysms in many cases. However, recent advances in remodeling devices, such as stents and balloons, have improved the results of endovascular treatment for MCA aneurysms to the same level as achieved by clipping.²⁰⁾ In the present case, the aneurysm was present in an area deeper than standard MCA aneurysms, and we selected endovascular treatment because we considered it difficult to separate the aneurysm from the MCA and DMCA.

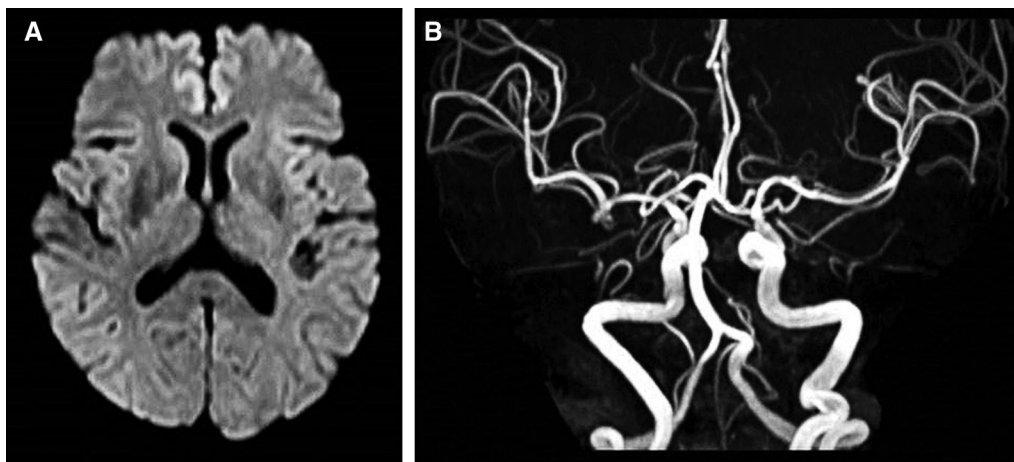


Fig. 4 (A) Diffusion-weighted MRI the day after surgery did not show cerebral infarction. (B) On MRA the day after surgery, the aneurysm was not visualized. The ICA and DMCA were visible. DMCA: duplicated middle cerebral artery; ICA: internal carotid artery; MRA: magnetic resonance angiography; MRI: magnetic resonance imaging

Table 1 Reported cases of an internal carotid artery - duplicated middle cerebral artery unruptured aneurysms

Case	Author	Sex	Age	Aneurysm size	Bleb	Side	Therapy
1	Takano et al. <i>Neurol Med Chir</i> , 1988 ⁸⁾	M	74	<5 mm	–	R	Clipping
2	Nomura et al. <i>Acta Neurochir</i> , 2000 ⁷⁾	F	63	<5 mm	–	L	Clipping
3	Imaizumi et al. <i>Surg Neurol</i> , 2002 ³⁾	M	52	<5 mm	–	R	Clipping
4		M	49	<5 mm	–	L	Clipping
5	Kai et al. <i>Surg Neurol</i> , 2006 ⁴⁾	F	63	<5 mm	–	L	Clipping
6	Miyahara et al. <i>No Shinkei Geka</i> , 2009 ⁶⁾	F	56	<5 mm	–	R	Clipping
7		M	58	7 mm	–	L	Clipping
8	Kimura et al. <i>Neurol Med Chir</i> , 2010 ⁵⁾	F	60	<5 mm	+	L	Clipping
9	Elsharkawy et al. <i>World Neurosurg</i> , 2013 ⁹⁾	M	62	12 mm	–	L	Clipping
10		F	49	<5 mm	–	R	Conservative
11		M	37	<5 mm	–	L	Conservative
12	Our case	F	71	5.2 mm	–	L	Coil embolization

F: Female; M: male; R: Right; L: Left

In our patient, coil embolization was considered to be possible based on the shape. The D/N ratio was 1.25 (wide neck), facilitating coil embolization with balloon neck remodeling for DMCA preservation.

Conclusion

DMCA aneurysms arising at its origin are rare. Previous studies reported clipping of unruptured aneurysm at the origin of DMCA, but no study has reported endovascular treatment. This is the first report of endovascular treatment for an unruptured DMCA aneurysm. Balloon-assisted coil embolization facilitates intra-aneurysmal embolization with preservation of the ICA and DMCA. Whether this

treatment procedure is useful depends on aneurysmal or neck shapes.

Disclosure Statement

We declare no conflict of interest.

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