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Case Report

Coil embolization for post-bypass aneurysm of middle meningeal artery for moyamoya disease – preservation of transdural anastomosis

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ABSTRACT

Background: Middle meningeal artery (MMA) pseudoaneurysm following revascularization surgery for moyamoya disease (MMD) is rare.

Case Description: Here, a 29-year-old man presented with an MMA pseudoaneurysm after he underwent revascularization surgery (superficial temporal artery-to-middle cerebral artery bypass and encephalo-duro-myo-arterio-pericranial synangiosis) for hemorrhagic MMD. At 3 months post-surgery, digital subtraction angiography showed a pseudoaneurysm in the right MMA. Transdural anastomosis to the parietal and occipital lobes was opacified at the distal MMA of the pseudoaneurysm. Intra-aneurysmal coil embolization was performed for preservation of transdural anastomosis. The postoperative course was uneventful. At 1 month post-embolization, angiography revealed an entirely occluded pseudoaneurysm.

Conclusion: An increase in blood flow in the MMA due to bypass surgery may accelerate aneurysm development by increasing the hemodynamic stress. This case suggested that intra-aneurysmal embolization may be a potential treatment.

Keywords: Endovascular treatment, Moyamoya disease, Pseudoaneurysm

INTRODUCTION

Moyamoya disease (MMD) is an uncommon cerebrovascular disorder characterized by progressive occlusion of the internal carotid artery and its main branches within the circle of Willis.[16] This occlusion results in the dilation of the perforating arteries at the base of the brain. These pathological features are often associated with recurrent strokes. Surgical revascularization is the most successful therapy for improving cerebral hemodynamics and reducing the risk of subsequent ischemic and hemorrhagic stroke.[9,13] The effectiveness of several bypass surgeries for MMD has been reported.[5,6,10] However, several complications have also been reported.[2] Among them, middle meningeal artery (MMA) pseudoaneurysm following revascularization surgery is an extremely rare complication. Here, we present a rare case of a patient with MMA pseudoaneurysm after revascularization surgery for MMD. The patient was subsequently treated with intra-aneurysmal coil embolization with preservation of transdural anastomosis.

CASE PRESENTATION

A 29-year-old man was referred to our hospital for MMD treatment. The patient had experienced transient left-sided hemiparesis when he was 11-years-old, and he was eventually diagnosed with MMD at 12 years of age. He was prescribed aspirin at a previous hospital. Sixteen years had passed uneventfully; however, at 28 years of age, he presented with a sudden headache. Computed tomography revealed right thalamic hemorrhage with ventricular hemorrhage [Figures 1a and b]. Digital subtraction angiography (DSA) showed MMD (Suzuki grade 4) development of the thalamic channel with hemorrhage in the ipsilateral hemisphere [Figures 1c-f]. We performed superficial temporal artery-to-middle cerebral artery (STA-MCA) bypass and encephalo-duro-myo-arterio-pericranial synangiosis (EDMAPS) in the right hemisphere for the prevention of rebleeding. The postoperative course was uneventful. After 3 months, STA-MCA bypass and EDMAPS were performed in the left hemisphere. DSA performed 3 months after the last surgery showed patency of the direct bypass and development of transdural anastomosis due to the indirect bypass. In addition, a pseudoaneurysm was observed in the right posterior branch of the MMA [Figures 2a and b]. The pseudoaneurysm was located immediately under the edge of the craniotomy site [Figure 2c].

Figure 2d demonstrated the intraoperative photo of STA-MCA bypass and EDMAPS on ipsilateral hemisphere of pseudoaneurysm development. The arrow showed the location of pseudoaneurysm hereafter. The damage to MMA by craniotomy or dura cut may be a cause of aneurysm development.

Endovascular treatment for MMA pseudoaneurysm

We planned to perform the internal trapping under general anesthesia. After intravenous administration of 4000 U of heparin, the right external carotid artery was catheterized with a 4-Fr guiding sheath (ASAHI FUZBUKI, Asahi Intech, Japan). Subsequently, a distal access catheter (Guidepost, Tokai Medical Products, Japan) and microcatheter (Echelon-10, Medtronic, USA) were navigated into the right MMA. Microangiography of the posterior trunk of MMA revealed transdural anastomosis by indirect bypass [Figure 3a]. The aneurysm size was 4.2 mm × 3.9 mm and neck length was 1.1 mm [Figure 3b]. Fortunately, aneurysm neck was small against our expectations; as a result, we could embolized aneurysm tightly without MMA occlusion.

The microcatheter was navigated into the pseudoaneurysm, and the pseudoaneurysm was embolized using five platinum coils (Optima Coil System™, BALT, USA) [Figure 3c]. Angiography after embolization showed complete occlusion of the pseudoaneurysm, patency of the MMA, and transdural anastomosis [Figure 3d]. The postoperative course was uneventful, and the patient was discharged without

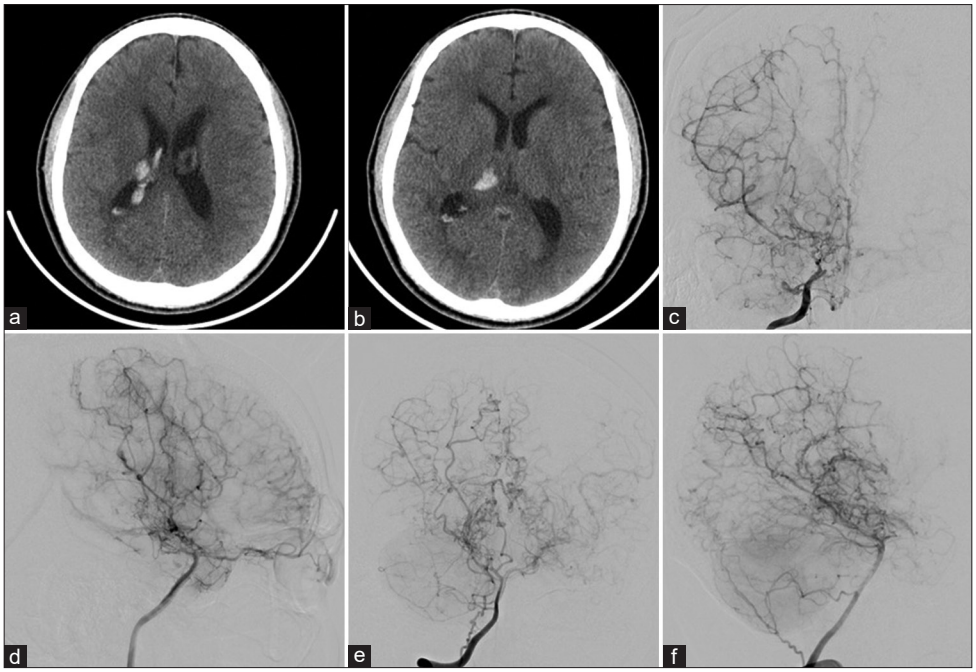

Figure 1: (a and b) Computed tomography revealing thalamic hemorrhage. (c) Anterior-posterior and (d) lateral angiography of the right internal carotid artery before bypass surgery showing Suzuki grade 4 moyamoya disease. (e) Anterior-posterior and (f) lateral angiography of the right vertebral artery demonstrating development of the thalamic channel.

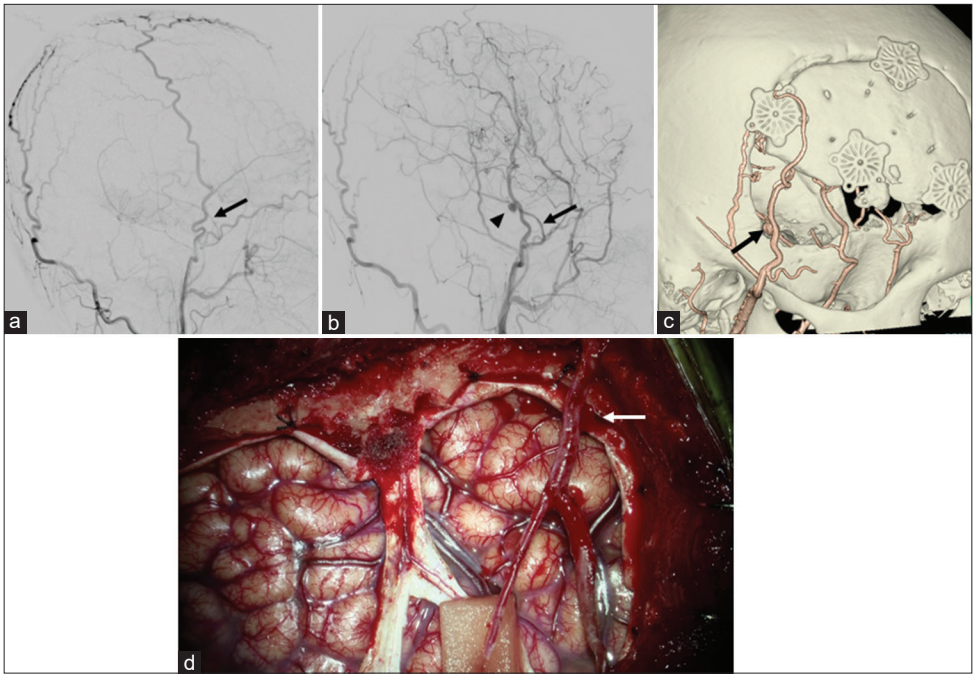

Figure 2: (a) Anterior-posterior angiography before revascularization surgery. (b) Lateral angiography of the right external carotid artery at 3 months after revascularization surgery. The angiogram shows a pseudoaneurysm (arrowheads, b) at the middle meningeal artery (arrows, a and b). The diameter of the middle meningeal artery at 6 months after the superficial temporal artery-to-middle cerebral artery (STA-MCA) bypass and encephalo-duro-myo-arterio-pericranio-synangiosis (EDMAPS) was larger than that before surgery. (c) Fusion image of computed tomography and right external carotid artery angiography. The pseudoaneurysm is located at the edge of the craniotomy (black arrow). (d) Intraoperative photo of STA-MCA bypass and EDMAPS. The arrow is location of pseudoaneurysm hereafter.

neurological deficits. Follow-up DSA performed 1 month after the endovascular treatment showed no recanalization of the pseudoaneurysm [Figures 3e and f].

DISCUSSION

In this study, we present a rare case of MMA pseudoaneurysm after STA-MCA bypass and EDMAPS for MMD. Endovascular coil embolization with preservation of transdural anastomosis was successfully performed for the treatment of the MMA pseudoaneurysm. We further discuss the mechanism of MMA pseudoaneurysm formation and its treatment strategy.

Development of MMA pseudoaneurysm following revascularization surgery for MMD

Surgical revascularization for MMD is a widely accepted treatment due to the extremely high rate of recurrent stroke associated with MMD.[3,13] Revascularization for MMD consists of direct, indirect, and combined bypass surgery. Usually, STA-MCA bypass is used for direct bypass.[6] However, some variations in indirect bypass, including encephalo-duro-arterio-synangiosis (EDAS),[12] encephalo-myo-synangiosis,[7] encephalo-duro-arterio-myo-synangiosis,[11] and EDMAPS,[10] have also been reported. In these methods, the dura mater is radially cut and folded onto the brain surface. In our surgical method, the MMA was preserved so that it can function as the main collateral route through indirect bypass.[4] Therefore, along with the development of an indirect bypass, the blood flow of the MMA is increased. In our case, the diameter of the MMA at 6 months after the STA-MCA bypass and EDMAPS was larger than that before surgery. The formation of the pseudoaneurysm was multifactorial. Pseudoaneurysms occur after a focal injury to the vessel wall, which produces a hematoma between the adventitia and muscularis layers at the injury site. Subsequent resolution of the hematoma leads to the formation of the outer layer of the newly formed pseudoaneurysm.[11,15] An increase in blood flow in the MMA may accelerate this process by increasing the hemodynamic stress.

Treatment for MMA pseudoaneurysm

In the current case, the treatment of the MMA pseudoaneurysm was prioritized due to the high risk of rupture, which can be fatal. Seo *et al*.[15] reported a case of MMA pseudoaneurysm after revascularization surgery for

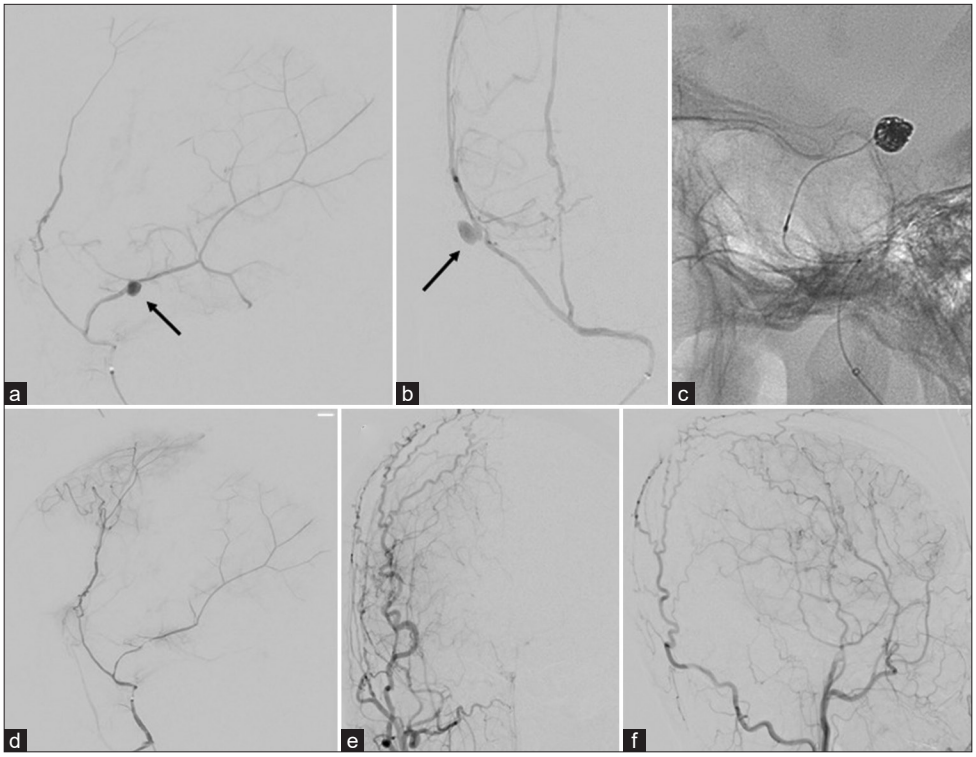

Figure 3: (a) Right middle meningeal artery (MMA) angiography shows the indirect bypass to the parietal and occipital lobe. The pseudoaneurysm is located at the posterior branch of the MMA (black arrow). (b) The working angle of coil embolization. The aneurysm size is 4.2 mm × 3.9 mm and neck length is 1.1 mm (black arrow) (c) Intra-aneurysmal embolization using platinum coils. (d) Post-embolization angiography of the MMA reveals patency of the posterior branch of the MMA. (e and f) Follow-up angiography at 1 month after pseudoaneurysm embolization. Complete occlusion of the aneurysm and patency of the middle meningeal artery is observed.

MMD. A pseudoaneurysm at the MMA was found 12 days after STA-MCA bypass and EDAS. Endovascular treatment was planned; however, the pseudoaneurysm ruptured, and a massive subdural hematoma was observed before treatment. Decompressive craniectomy and hematoma evacuation were then performed. The patient had global aphasia and was discharged with a modified Rankin scale score of 4. To the best of our knowledge, this is the only previously reported case of MMA pseudoaneurysm after revascularization surgery for MMD.

Several treatment options are available for pseudoaneurysms of the MMA, such as surgical trapping and endovascular treatment. Park *et al*.[14] reported a case of MMD associated with subarachnoid hemorrhage and intracerebral hematoma resulting from the rupture of an MMA pseudoaneurysm. Neck clipping for the pseudoaneurysm was first attempted. However, the dura was attached to the brain surface through small, fragile vascular channels. Next, they performed endovascular treatment of the pseudoaneurysm. The MMA was entirely occluded, immediately proximal to the pseudoaneurysm. In the present case, transdural anastomosis had already developed. To avoid ischemic infarction due to collateral dissipation, endovascular treatment was performed. In the previous reports on traumatic MMA pseudoaneurysms, aneurysm embolization with parent artery occlusion using a platinum coil or Onyx has been performed.[1,8,11] In our case, intra-aneurysmal embolization was performed without parent artery occlusion to preserve transdural anastomosis. In these methods, the most important issue is aneurysm recurrence. In our patient, the aneurysm did not recur in the follow-up angiography; however, long-term follow-up is required. Thus, intra-aneurysmal embolization may be a feasible treatment method in such cases.

CONCLUSION

Pseudoaneurysm formation after revascularization surgery for MMD is an infrequent but possible complication. The mechanism of pseudoaneurysm formation in such cases may be related to the increased blood flow resulting from transdural anastomosis. Intra-aneurysmal embolization with preservation of transdural anastomosis may be a possible treatment strategy for MMA pseudoaneurysm occurrence following revascularization surgery for MMD.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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