Middle Cerebral Artery (M3) Aneurysm: Growing Dissecting Opercular Middle Cerebral Artery Aneurysm, Coil Occlusion of the Precentral Artery with a Low-Profile Microcatheter Under Local Anesthesia, Provocative Test for Neurological Monitoring, Parent Artery and Aneurysm Occlusion, and Excellent Clinical Outcome

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Abstract

Aneurysms distal to the middle cerebral artery (MCA) bifurcation are infrequent, comprising only 1–7% of all MCA aneurysms. Rather than originating solely from hemodynamic causes, these distal aneurysms are commonly secondary to other etiologies, including infectious emboli caused by subacute endocarditis, vasculitis, tumor emboli, brain trauma, or dissection. Open surgery is the classical treatment for these aneurysms, with treatment strategies that include aneurysm clipping, aneurysm trapping, and aneurysm trapping plus bypass. The main difficulty with surgery is precise surgical localization of small M3–M4 aneurysms. Inaccurate localization of these vascular lesions may result in larger craniotomies and unnecessary arachnoid and pial dissections, in some cases with permanent neurological injury. Endovascular alternatives present a number of challenges because of the distant, small, and tortuous route. In addition, for peripheral MCA aneurysms, parent arteries are usually difficult to preserve.

We present the case of a 65-year-old woman with an unremarkable medical past except for heavy smoking and arterial hypertension, who consulted after a first-ever transient episode of speech alterations. Left hemispheric transient ischemic attack was diagnosed based on her neurological evaluation in the Emergency Department. MRI confirmed the presence of two distal left MCA aneurysms. Diagnostic angiography confirmed a midsize insular aneurysm of the superior branch of the MCA and a second, more peripheral and larger aneurysm affecting the opercular segment of a tortuous precentral

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artery. The parent artery presented a focal severe arterial narrowing proximal to the aneurysm. The patient was managed with aspirin and statin therapy and recommended neuroradiological follow-up. Transthoracic and transesophageal echocardiogram showed no valvular disease or intracavitary tumor. The patient remained clinically stable. However, diagnostic angiography obtained after 6 months confirmed enlargement of the M3 aneurysm, and therapy was proposed. Under local anesthesia, the parent artery was navigated with a Marathon microcatheter and occluded microcatheter and occluded with a detachable coil at the stenosis immediately proximal to the aneurysm origin, with special care not to jeopardize distal leptomeningeal anastomoses. There were no clinical complications. The patient was discharged after 2 days without a neurological deficit. Angiographic follow-up confirmed complete occlusion of the treated aneurysm. Cranial MRI showed no signs of cortical ischemia. This case illustrates an uncommon and probably underdiagnosed group of distal MCA aneurysms, usually treated surgically, that can be managed by parent artery occlusion with endovascular means. This case also demonstrates the use of a low-profile microcatheter to deploy compatible detachable microcoils that allowed a precise, controlled, and potentially reversible occlusion. The endovascular treatment of distal MCA aneurysms is the main topic of this chapter.

Keywords

Middle cerebral artery · Distal aneurysm · Dissecting aneurysm · Parent vessel occlusion · Coil embolization through Marathon

Patient

A 65-year-old woman with an unremarkable medical past except for smoking and arterial hypertension presented with sudden onset motor dysphasia lasting for 20 minutes. She recovered completely immediately after the episode.

Diagnostic Imaging

Upon Emergency Department admission, neurological examination led to a clinical diagnosis of left hemisphere transient ischemic attack. Cranial MRI examination showed a distal middle cerebral artery (MCA) aneurysm and signs of microvascular brain disease, with no signs of cortical ischemic injury in relation to her speech complaint. Diagnostic digital subtraction angiography (DSA) confirmed a midsized insular aneurysm of the superior branch of the MCA and a second, more peripheral and larger aneurysm affecting the opercular segment of a tortuous precentral artery. Proximal to the aneurysm, there was a high-grade focal stenosis of the parent artery. Repeat DSA obtained 6 months later showed enlargement of the opercular MCA aneurysm (Fig. 1).

Treatment Strategy

The primary goal of the therapy was to exclude the growing aneurysm by occluding the parent artery immediately adjacent to the aneurysm with special care not to jeopardize distal leptomeningeal anastomoses. We considered coil occlusion of the parent artery with soft coils the most precise and controlled occlusion technique that would ensure thrombosis of the aneurysm while leaving the possibility for leptomeningeal retrograde collateral supply to the proven eloquent area. Distal penetration of liquid embolic agents beyond the aneurysm could have jeopardized these anastomoses, and this was the main reason we decided to use coils.

Treatment

Procedure, 29.10.2018: endovascular parent artery occlusion for the treatment of an opercular MCA aneurysm with detachable coils

Anesthesia: local anesthesia; 4000 U unfractionated heparin (Heparin sodium, Teva) IV after placement of the femoral introducer sheath; activated clotting time (ACT) 250 sec

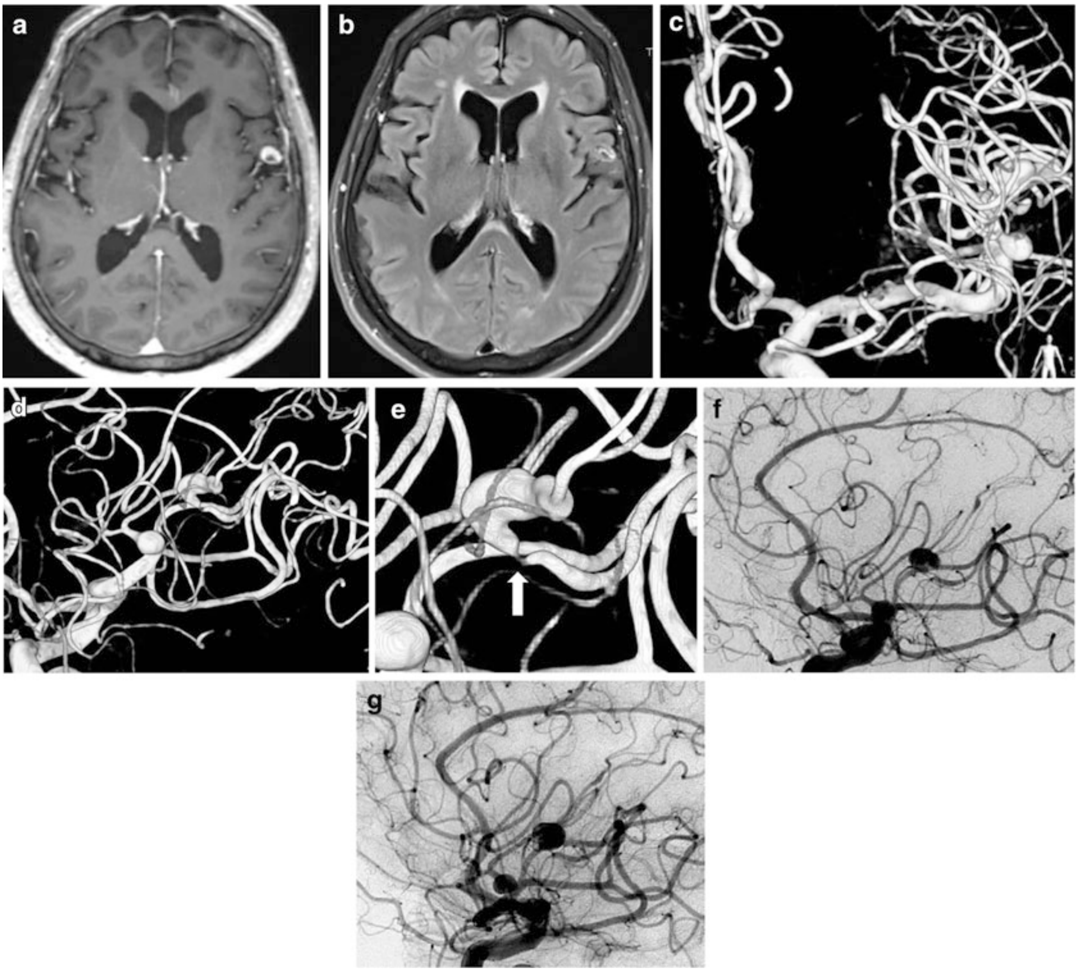

Fig. 1 Cranial contrast-enhanced T1WI (**a**) and FLAIR MRI (**b**) obtained at admission revealed an opercular MCA branch aneurysm and signs of microvascular brain disease. Tridimensional reconstruction of rotational angiographic images, posterior-anterior view (**c**), and oblique views (**d**, **e**), depicted two peripheral MCA aneurysms at the insular and opercular segments. DSA of the left internal carotid artery, lateral view, at admission (**f**). Repeat DSA 6 months later (**g**) showed enlargement of the opercular branch aneurysm

Premedication: 1× 100 mg ASA PO daily, 1× 40 mg atorvastatin PO daily starting 5 days before the intervention; discontinuation of regular anti-hypertensive medications to allow for baseline moderate hypertension

Access: right femoral artery, 6F arrow sheath (Arrow); *guide catheter*: Navien A+ 058 (Medtronic); *microcatheter*: Marathon (Medtronic) for coiling; *microguidewire*: Synchro 0.010″, 200 cm (Stryker)

Implants: 1 Barricade Coil (Blockade Medical): 1× 1/2 Barricade 10 helical finishing

Course of treatment: via femoral access, an arrow sheath was placed at the distal left common carotid artery after exchange of the diagnostic catheter using a 300 cm guidewire. Coaxially, a Navien intermediate catheter was placed at the pre-petrous left ICA. Under magnified road mapping, the precentral branch of the left MCA was catheterized with a Marathon microcatheter aided by a Synchro10 microguidewire and finally at the opercular segment of the artery immediately proximal to the arterial stenosis preceding the aneurysm. Then a single Barricade 10 helical finishing

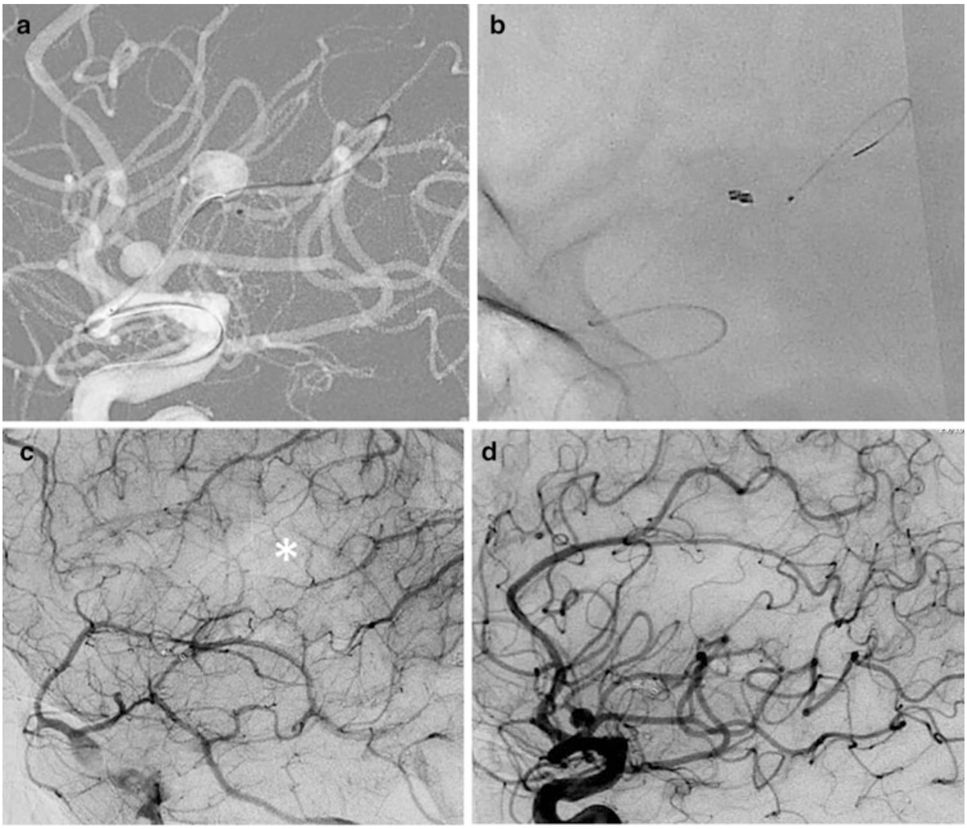

Fig. 2 Endovascular parent artery occlusion for the treatment of a growing distal M3 left-side MCA aneurysm. Periprocedural roadmap image showing navigation of the microcatheter through the precentral artery, reaching the opercular segment, with arterial narrowing proximal to the aneurysm (**a**). Digital radiograph obtained after coil detachment (**b**). Angiography of the left ICA, lateral view (**c**, **d**), obtained immediately after the parent artery occlusion, confirmed exclusion of the treated aneurysm from the circulation. A subtle minor secondary parenchymographic defect is noted (asterisk (**c**))

coil 1 mm/2 cm was deployed forming a compact plug. The patient was alert during the procedure, and spontaneously presented a mean arterial blood pressure of 100 mg HG. After confirming angiographic arterial occlusion, she was evaluated neurologically and found intact. Provocative testing, consisting of reducing the mean arterial pressure to 80 mm Hg arterial blood pressure for 10 minutes (IV nitroglycerine, Nitroglicerine Teva), confirmed an unchanged neurological status. (We usually dilute 5 mg of nitroglycerin into 100 mL of normal saline solution yielding a final concentration of 50 μg/mL. The usual starting adult dose is 25–50 μg/min.) The single coil was then detached. At the end of the procedure, complete exclusion of the distal MCA aneurysm was achieved and no complications occurred (Fig. 2)

Duration: 1st–12th run: 52 min; fluoroscopy time: 7 min

Complications: none

Postmedication: 1× 100 mg ASA PO daily, indefinitely; antihypertensive medications were withheld for 1 month

Clinical Outcome

Immediately after the endovascular procedure, the patient was transferred to the neurosurgical intensive care unit. The introducer sheath was removed 1 h later, after CT evaluation. The patient remained at baseline status with no pain or discomfort. Antihypertensive medications were not administered to assure moderate baseline arterial

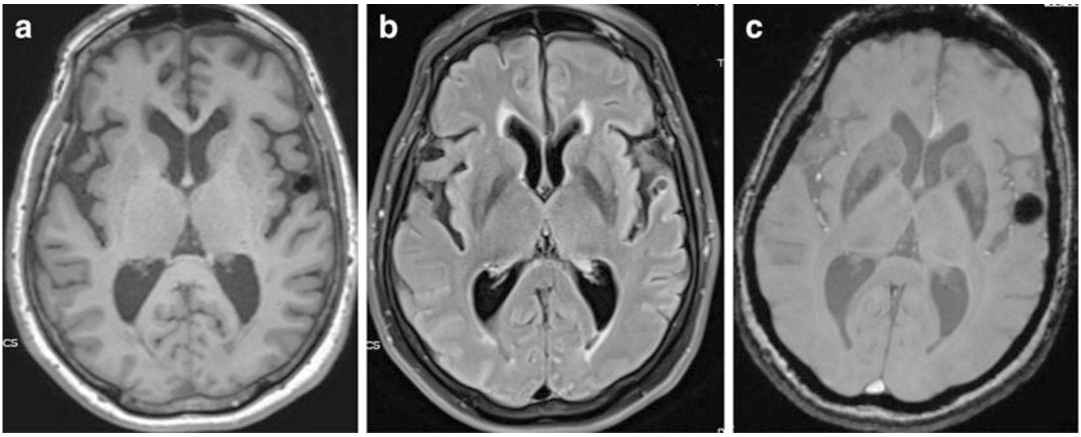

Fig. 3 Follow-up MRI (T1WI (**a**), FLAIR (**b**), SWI (**c**)) obtained 6 months after the endovascular parent artery occlusion showed thrombosis of the target aneurysm with no sign of associated infarction

hypertension. Cranial CT performed 24 h later was unremarkable. The patient was discharged home 2 days after the intervention and was able to return to her full working routine after 2 weeks.

Follow-Up Examinations

Follow-up MRI obtained 6 months after the endovascular procedure showed thrombosis of the embolized aneurysm with no sign of cortical infarction in relation to parent artery occlusion (Fig. 3).

Discussion

Strategies for the treatment of distally located aneurysms are different from those used for aneurysms located more proximally. Endovascular therapy in distal aneurysms offers a valuable and effective option, sparing patients some of the hazards associated with craniotomy, difficult localization of the lesion, manipulation of small vessels, and complex surgical procedures (Baltacioğlu et al. 2002).

On occasion, the configuration of these aneurysms may not be amenable to selective coil embolization, and parent artery occlusion is the preferred treatment. The gradually restricted flow that occurred in the presented case of dissecting aneurysm allowed leptomeningeal collateral vessels time to develop, making acute parent vessel sacrifice safer than it may be in patients with less “mature” lesions in which the channels have not had the need or the time to dilate effectively. In this case, we decided to perform the intervention with the patient fully conscious to enable evaluation of her neurological status during the arterial occlusion procedure.

Provocative testing in neuroendovascular therapy consists of a number of procedures that attempt to predict what, if any, clinical deficit would result from the occlusion of a vessel or resection of the territory supplied by that vessel (Fusco et al. 2016). During the provocative test, the patient is examined to check for new neurological deficits that may result from either lack of blood flow to a vascular territory in the case of mechanical test occlusion or an anesthetic infusion into the neural tissue supplied by the vessel being tested pharmacologically. In the presented case, we assessed the patient’s clinical status after occlusion of the parent vessel with a deployed occlusive microcoil and hypotension-challenging test using IV nitroglycerine, a test that was tailored to her cardiovascular condition. We were aware that this provocative test would have useful but limited implications, since collateral circulation beyond the point of vessel sacrifice is dependent on leptomeningeal channels that are unpredictable in their ability to sustain and protect the cortex.

The Marathon microcatheter is a flow-directed 165 cm-long catheter with a distal inner diameter of 0.013," designed for the delivery of Onyx (Medtronic). Compared to the majority of catheters designed for coil delivery, the Marathon is longer, thinner, and more flexible and thus less traumatic. These characteristics are favorable for improved access through tortuous and distal vessels. However, occlusion with Onyx or nBCA (Glubran2, GEM; Histoacryl, B. Braun) is not always suitable, since liquid agents can be difficult to control. Deployment of detachable coils through the Marathon catheter is possible but has a few technical considerations and challenges (Beckett et al. 2017; Stidd et al. 2014). Barricade (Blockade Medical) is a coil that utilizes a 0.0125″ pusher wire and is therefore compatible with the Marathon catheter. Among the Barricade coils compatible with Marathon are the Barricade Finishing Coil (1.5–2.5 mm and 3–6 mm) and Framing Coil (2–4 mm). Another consideration is the mismatch between the microcatheter length and the length of the coil pusher wire that requires removal of the rotating hemostatic valve hemostatic valve (RHV) to utilize the detachment tool. Without the RHV, it is not possible to maintain continuous flush, which may increase the risk of thrombus formation. Another point to take into consideration is that the Marathon microcatheter lacks a proximal detachment marker and this makes coil delivery and detachment more problematic. These issues have been overcome by the Extrasoft coils (ES) from Kaneka (Bhogal et al. 2019).

For distal MCA aneurysms presenting with hemorrhage, some authors consider surgery the best choice, arguing that surgery allows evacuation of hematoma and excludes the aneurysm from intracranial circulation (Ricci et al. 2017). They also suggest the use of both neuronavigation techniques and of the indocyanine green (ICG) videoangiography for aneurysm surgery (Raza et al. 2012). Our practice differs from this approach. Based on the clinical status of the patient, our preferred approach usually consists of endovascular embolization followed by surgical intervention if necessary. After controlling the aneurysm by endovascular means, surgery may be restricted to a decompressive craniectomy or a much simpler and less risky hematoma evacuation that does not require management of the previously secured aneurysm.

Therapeutic Alternatives

- Coil occlusion of the aneurysm sac
- Microsurgical trapping
- STM-MCA bypass surgery
- Embolization with nBCA under induced asystole

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