Intraoperative Functional and Perfusion Monitoring During Surgery for Giant Serpentine Middle Cerebral Artery Aneurysms

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Key words
- Cerebral revascularization
- Giant aneurysm
- Indocyanine-green
- Microvascular bypass
- Motor-evoked potentials monitoring
- Serpentine aneurysm
- Ultrasound flowmetry

Abbreviations and Acronyms
CT: Computed tomography
DSA: Digital subtraction angiography
GOS: Glasgow Outcome Scale
ICGA: Indocyanine-green angiography
MCA: Middle cerebral artery
MEP: Motor evoked potentials
MRI: Magnetic resonance imaging

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■ BACKGROUND: **Giant serpentine aneurysms are a rare entity, which can be managed using either endovascular or surgical techniques. Although the perioperative morbidity and mortality have decreased since the development of bypass revascularization procedures, their surgical treatment is still challenging. Intraoperative functional and perfusion monitoring techniques can be precious to make better decisions and improve outcomes.**

■ CASE DESCRIPTION: **We report on the case of a giant, unruptured, partially thrombosed, serpentine middle cerebral artery aneurysm that was treated with partial endovascular coiling of intra-aneurysmal vascular channels, surgical resection of the aneurysm, and end-to-end M1-temporal M2 anastomosis.**

■ CONCLUSIONS: **Intraoperative continuous motor evoked potentials monitoring, flowmetry, and indocyanine-green angiography provide precise and reproducible information about cerebral function and perfusion, respectively, allowing for more rational decision making during surgery for these challenging malformations.**

INTRODUCTION

The treatment of giant middle cerebral artery (MCA) aneurysms by either endovascular means or direct clipping is difficult to achieve and carries a high risk of mortality and morbidity (7, 15, 53). Giant aneurysms of the MCA represent 13%–15% of all giant intracranial aneurysms (7, 13). Approximately 4% of the aneurysms located on the MCA are giant and most frequently occur at the bifurcation. The natural history of these aneurysms carries a poor prognosis (14, 35). The treatment of large and giant aneurysms is therefore generally indicated (17, 27, 29, 53). In rare cases a giant aneurysm may be partially thrombosed, cause mass effect, and have a residual serpiginous vascular channel that ends in a distal branch of the feeding artery. These aneurysms are located on the MCA in about 50% of cases and often present with rapid neurological deterioration secondary to an ischemic evolution (11). At admission these malformations may be misdiagnosed as brain tumor or hemorrhagic stroke (16) because they usually present with mass-related symptoms and neuroimaging shows well-circumscribed edges, perilesional edema, and obvious brain shift (1, 6, 11, 12, 39). The available therapeutic options for serpentine aneurysms include surgery, endovascular therapy, or their combination. Direct microsurgical clipping of giant serpentine aneurysms is associated with morbidity and mortality rates as high as 30%–35% (17, 31). The cerebral revascularization obtained by means of bypass surgery, alone or combined with endovascular approaches, has resulted in a reduced risk of cerebral ischemia and more satisfactory outcomes (10, 14, 24, 35, 37, 41-44, 49, 51). Intraoperative monitoring of motor evoked potentials (MEPs) combined with flowmetric measurements and indocyanine-green angiography (ICGA) enhances the capacity of rational decision making during such a complex surgical procedure. However, a thorough review of the pertinent literature showed that only rarely have ultrasound flowmetry and MEPs monitoring been used.

We describe for the first time the simultaneous use of intraoperative MEPs, ultrasound flowmetry, and ICGA during bypass surgery to treat a giant serpentine aneurysm of the bifurcation of the MCA. Neurological and angiographic studies showed the complete disappearance of the malformation with an effective restoration of the cerebral blood flow and a good neurological outcome.

CASE REPORT

A 66-year-old obese and hypertensive woman presented at the emergency department complaining of a gradually worsening left hemiparesis, intermittent headache, and psychomotor impairment. Neuroradiological workup with angio-CT, MRI, and digital subtraction angiography (DSA) showed a 5.5-cm unruptured giant partially thrombosed serpentine MCA aneurysm, surrounded by adjacent edema with midline shift (**Figure 1**).

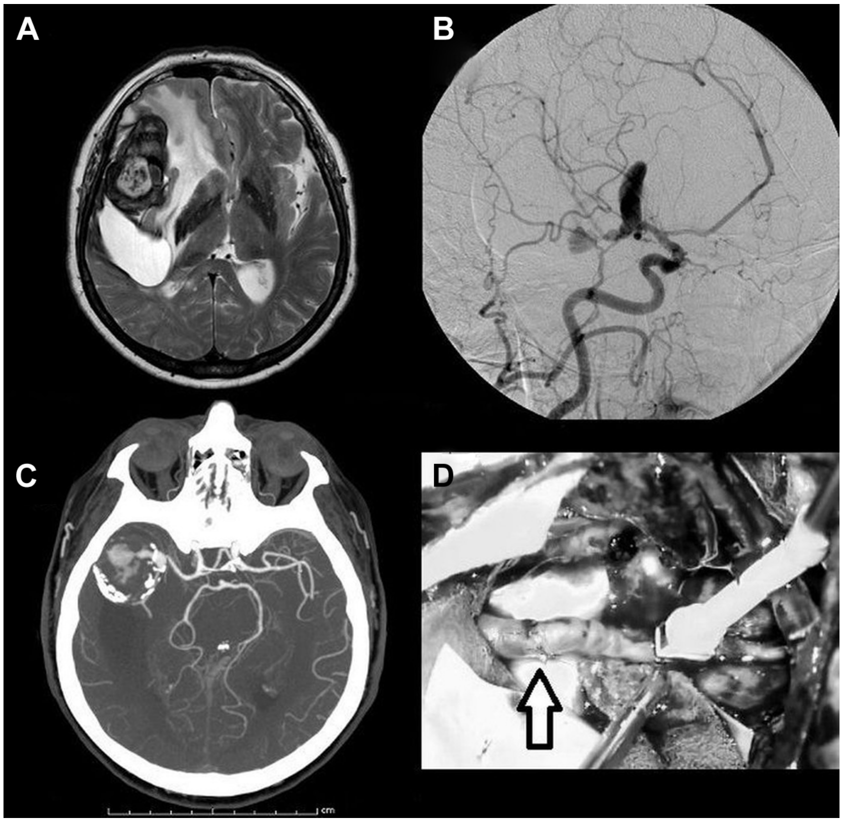

Figure 1. (**A**) T2-weighted axial magnetic resonance imaging (MRI) showing a giant thrombosed aneurysm dome surrounded by cerebral edema and a posterior cyst. (**B**) On digital substraction angiography (DSA) the aneurysm is only partially filled, with a serpentine pattern. (**C**) Angio—computed tomography showing calcifications of the thrombosed part. (**D**) Intraoperative view of the microanastomosis between M1 and temporal M2, while checking the flow on distal M2.

A revascularization procedure with aneurysm thrombectomy and clip reconstruction was scheduled. Two days before surgery, the patient underwent an endovascular treatment with partial coiling of intra-aneurysmal vascular channels in order to reduce intraoperative bleeding, especially during thrombectomy. In order to minimize the risk of new infarction, neuroradiologists embolized only the areas of the aneurysm that were safely distant from the channels potentially feeding the brain parenchyma.

A frontotemporal craniotomy was performed (13). Intraoperative motor evoked potentials (MEPs) were monitored continuously. After exposing and trapping the aneurysm with temporary clipping, we opened its thickened wall and performed a decompressive thrombectomy with the ultrasonic surgical aspirator. Intraoperative clip reconstruction of the MCA bifurcation proved to be impossible due to the stiffness of the wall of the aneurysm neck. For this reason we decided to resect the aneurysm cutting the inflowing M1 just proximal to the aneurysm and both the outflowing M2 vessels right after their exit. The dissected superficial temporal artery was too small and not suitable for a high-flow revascularization procedure. Therefore we performed an end-to-end M1 to temporal M2 anastomosis with a 9-0-monofilament nylon, obtaining a cerebral blood flow of 30 mL/min as measured by flowmeter microprobe. The frontal M2 artery was not revascularized on the basis of a sufficient backflow, as measured by intraoperative flowmetry (−12 mL/min) and confirmed by ICGA. Accordingly, MEP monitoring showed no variations of amplitude and latency during surgery. Total occlusion time of M1 was 56 minutes. The total intraoperative blood loss was 450 mL.

At postoperative day 2 the patient was awakened, and the neurological examination showed a left hemiparesis. A perfusion CT scan revealed a fronto-insular ischemic area. Angiographic control confirmed the patency of the M1-M2 anastomosis and the presence of collateral perfusion in the frontal cortex (**Figure 2**). At 1-year follow-up after rehabilitation the patient has only a mild hyposthenia of the inferior left limb, requiring occasional assistance (GOS 4).

DISCUSSION

The treatment of giant serpentine MCA aneurysms by endovascular means or direct clipping is seldom achievable and carries a high risk of mortality and morbidity (1, 49). Although different endovascular techniques have been introduced in the management of serpentine giant aneurysms, they cannot reduce the aneurysm mass effect nor properly deal with cases when insufficient collateral distal blood flow occurs (7, 21, 49). However, preoperative endovascular coiling of serpentine aneurysmal channels can be helpful in reducing intraoperative bleeding during thrombectomy. Anyway, endovascular treatment in such complex cases must be tailored according to the specific characteristics of anatomy and hemodynamics. Only 31 cases of giant serpentine aneurysms have been surgically treated (**Table 1**). Techniques of cerebral revascularization, alone or combined with clipping or endovascular approaches, offer an effective protection against cerebral ischemia, making aneurysm exclusion a safer procedure (7, 36). Before the availability of the bypass option, giant serpentine aneurysm surgery resulted in overall morbidity and mortality rates of 30%—35% (31). It has also been shown that aneurysm surgical resection associated with bypass surgery may, in selected cases, lead to successful aneurysm obliteration and mass effect symptoms relief, limiting the risks of postoperative ischemic complications