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Perioperative complications of superficial temporal artery to middle cerebral artery bypass for the treatment of complex middle cerebral artery aneurysms

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ABSTRACT

Object: Only a few studies have reported the risk of ischemic complications occurring when superficial temporal artery (STA) to middle cerebral artery (MCA) anastomosis is performed during surgery for complex MCA aneurysms.
Subjects and methods: This is a retrospective study of 10 patients (age 52–73) with MCA aneurysms treated with revascularization surgery. The aneurysms were 10–50 mm in size (mean: 21 mm). We studied the causes and frequency of ischemic complications by analyzing postoperative magnetic resonance imaging.
Results: Postoperative diffusion-imaging confirmed ischemic complications in six of the 10 patients (in two of the five ruptured aneurysms and in four of the five unruptured). The ischemic complications that observed were infarction of the lenticulostriate artery territory in three cases, cortical infarction in two cases, and cerebral infarction that was likely to be due to cerebral vasospasm in one case. In one case, both cortical infarction and infarction of the lenticulostriate artery territory were observed. The Glasgow Outcome Scale (GOS) scores at the time of discharge indicated good recovery (GR) and moderate disability (MD) in seven cases, severe disability (SD) in two cases, and death (D) in one case.
Conclusions: The present study suggests the possibility that STA–MCA anastamosis in surgeries for MCA aneurysms can be performed with comparatively better safety. However, the temporary occlusion time with this surgery is longer than that with a temporary clipping for aneurysmal surgery; thus, we believe that adequate countermeasures are required to prevent ischemic complications.

1. Introduction

Large or thrombosed arterial aneurysms may require cerebral revascularization during radical surgery [16,18,22]. Various surgical complications have been reported during high-flow bypass surgery for refractory internal carotid artery (ICA) aneurysms, including those of the cavernous sinus [8,11,20].

On the other hand, only a few studies have reported the possible complications and prognoses of patients treated for refractory middle cerebral artery (MCA) aneurysms by revascularization surgery [21].

Furthermore, there have been no studies on the causes and frequency of ischemic complications due to the anastomosis procedure, including detailed postoperative imaging. Seo et al. [21] compared the surgical outcomes in 10 patients with MCA aneurysms, treated by different revascularization techniques, but cited only the long-term prognoses. They did not mention any postoperative imaging findings to assess the extent of ischemic brain damage due to intraoperative ischemia. Sekhar et al. [23] also reported the results obtained using various surgical techniques for the treatment of MCA aneurysms, and found that two of the seven cases presented with ischemic complications, suggesting that the risk of ischemia may be significant.

The STA–MCA anastomosis procedure for occlusive diseases of arteriosclerotic ICA/MCA [23,24] generally requires approximately 35 min [7] of temporary artery occlusion. This rarely causes ischemic symptoms [3–5], because a collateral pathway develops following the anastomosis operation and blood flow improves. When an antiplatelet agent is administered preoperatively, the risk of ischemic complications from the STA–MCA anastomosis

Abbreviations: An, aneurysm; Angio, angiography; CT, computed tomography; D, dead; DWI, diffusion weighted imaging; G, grade; GOS, Glascow Outcome Scale; GR, good recovery; MCA, middle cerebral artery; MD, moderate disability; MRA, magnetic resonance angiography; MRI, magnetic resonance imaging; PHT, phenytoin; Postop, post operation; Pre-op, pre operation; SD, severe disability; WFNS, World Federation of Neurological Surgeon.

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procedure is further reduced, even when the temporary occlusion lasts longer than 30 min [7].

In contrast, no collateral pathway develops following the STA–MCA anastomosis procedure when treating MCA aneurysms. Also, it is particularly difficult to administer an antiplatelet agent preoperatively due to a significant risk of hemorrhage in these patients. However, the safe temporary occlusion time for the MCA is believed to be only about 15 min [9,17], which is significantly shorter than the time needed to perform the vascular anastomosis. For these reasons, we performed a detailed retrospective study of postoperative imaging to examine the causes of postoperative ischemic complications following STA–MCA anastomosis surgery for MCA aneurysms.

2. Materials and methods

We studied the causes and frequency of ischemic complications from postoperative imaging data in these patients. Ten patients (four males and six females, mean age: 63.0 years, age range: 52–73 years) with MCA aneurysms treated by cerebral revascularization surgery at our hospital and associated institutions between September 2004 and February 2011 were selected as the subjects. The arterial aneurysms ranged from 9.8 to 49 mm (mean: 21 mm) in size. Five of these cases were ruptured aneurysms, of which two were graded as World Federation of Neurological Surgeons (WFNS) [15] grade II (GII), one as GIII, and two as GIV. The other five cases were unruptured aneurysms. The site of the MCA aneurysm was the M1 (sphenoid segment) branch in two cases, the M1/M2 branch in seven cases, and the M2/M3 branch in one case. All cases were saccular arterial aneurysms and were accompanied by thrombosis. A head CT was taken of the patients within 24 h of surgery, and they were also examined by diffusion-weighted imaging (DWI), except for one patient whose general condition made performing an MRI difficult. The patients' prognoses were evaluated at the time of discharge using the Glasgow Outcome Scale (GOS) [1]. A statistical comparative analysis was conducted to correlate the presence or absence of ischemic complications immediately after surgery with the ratio of ruptured to unruptured cases, the use or non-use of neuroprotective agents, the length of the temporary occlusion period, and the size of the arterial aneurysm. All statistical analyses were performed using SPSS software (IBM). Fisher's exact probability test was used to assess the ratio of ruptured to unruptured cases and the use or non-use of neuroprotective agents. A Mann–Whitney test was used to assess occlusion times and the sizes of the arterial aneurysms. The significance was set at $P < 0.05$.

2.1. Surgical technique

STA–MCA bypass was performed in nine cases, while one case with an M1 arterial aneurysm required STA–anterior temporal artery bypass. Typically, in cases with large, thrombosed MCA aneurysms, we dissected the STA during craniotomy considering that such cases require STA–MCA anastomosis. Next, after incising through the duramater and opening the Sylvian fissure, we attempt to select an appropriate recipient segment after securing the M2 branch with the aneurysm at the periphery. For the two cases with M1 arterial aneurysms, a single bypass was performed for the M2 branch in one case and for the anterior temporal artery in the other case. For the cases with branched arterial aneurysms, a single bypass was performed for the anterior M2 branch in one case and for the posterior M2 branch in two cases, a double bypass was performed for the M3 branch in one case, and a single bypass was performed for the M4 branch in one case. For the case with an arterial aneurysm at the M2/M3 branch, a double bypass was performed for the M3 branch.

3. Results

Table 1 provides a summary of the 10 cases. The GOS [1] scores at the time of discharge indicated good recovery (GR) + moderate disability (MD) in seven cases, demonstrating a comparatively favorable prognosis, and severe disability (SD) + death (D) in three cases. Among the cases with ruptured aneurysms, GOS scores indicated GR in one case (WFNS G2), MD in two cases (WFNS G2 and G4), SD in one case (WFNS G4), and D in one case (WFNS G3). Among the five cases with unruptured aneurysms, GOS scores indicated GR in two cases, MD in two cases, and SD in one case.

Of the 10 patients, five (one of the five cases with ruptured aneurysms and four of the five cases with unruptured aneurysms) had ischemic complications, as revealed by MRI and CT images taken immediately after surgery ($P = 0.206$). In addition, one of the cases with a ruptured aneurysm had extensive cerebral infarction, believed to be caused by cerebral vasospasm on day 9 after surgery.

Three of the five cases with ischemic lesions had perforator territory infarction, one had cortical branch infarction, and one had both perforator territory and cortical branch infarctions. The perforator territory infarctions were believed to be due to occlusion of the distal portion of the M1 branch, which was performed to treat the arterial aneurysm; that is, there were two cases with cortical branch infarction caused by the vascular anastomosis surgery (cases 1 and 8). The case with a ruptured aneurysm that developed ischemic complications from the surgery (case 8) had a WFNS [15] grade II and an arterial aneurysm at the M1/M2 branch, which was treated on the day of the rupture. A CT was taken the day after surgery showed cortical branch infarction. Case 1, which had an unruptured aneurysm, will be described in greater detail below. The mean temporary occlusion time for these two cases presenting with postoperative ischemic complications was 39 min (38 and 40 min), and the mean temporary occlusion time for the five cases with no ischemic complications was 29 min (24–39 min; $P = 0.379$).

We found no significant difference in the risk of ischemic complications between the use or absence of intraoperative neuroprotective agents (edaravone or phenytoin; $P = 0.524$).

The mean size of the arterial aneurysms in the five cases with postoperative ischemic complications was 16 mm (10–25 mm), and that in the five cases without ischemic complications was 26 mm (18–50 mm; $P = 0.069$). Of the two cases with cortical branch infarction due to vascular anastomosis, one case had an arterial aneurysm 9.7 mm in size. The initial surgical plan for this patient was to perform clipping; however, the aneurysm neck ruptured during dissection, so emergency reconstruction of the peripheral blood vessel had to be conducted.

The one case resulting in death (case 10) had a WFNS [15] grade III ruptured aneurysm and demonstrated no ischemic complications on an MRI taken on day 3 after surgery. However, 10 days after surgery, severe cerebral vasospasm resulted in cerebral infarction, and the patient subsequently died of cerebral herniation.

The case resulting in MD (case 6) and the case resulting in SD (case 7) both had a WFNS [15] GIV ruptured aneurysm and demonstrated no ischemic complications on MRIs taken after surgery, and no cerebral vasospasm occurred in these patients. However, a severe WFNS grade, originating from ruptured aneurysms, can influence both MD and SD. For instance, the case resulting in MD (case 8) had a WFNS [15] GII ruptured aneurysm. A postoperative CT revealed an extensive ischemic lesion in the temporal lobe resulting in technical anastomosis. This ischemic complication influenced the outcome of MD.