A Patient Who Underwent Stent-assisted Parent Artery Occlusion for a Ruptured Anterior-wall Aneurysm of the Internal Carotid Artery

Seiya Nagao,1 Kohtaro Tsumura,2 Michihisa Narikiyo,1 Gota Nagayama,1 Hirokazu Nagasaki,1 Yoshifumi Tsuboi,1 and Chisaku Kambayashi

Objective: We report the case of a patient who presented with a subarachnoid hemorrhage as an initial symptom and who underwent parent artery occlusion of the internal carotid artery while maintaining the anterior circulation through the posterior circulation using a stent to treat an anterior-wall aneurysm of the internal carotid artery.

Case Presentation: The patient was a 54-year-old female who was brought to our hospital by ambulance with symptoms of headache and vomiting. A cephalic CT scan revealed a subarachnoid hemorrhage. DSA led to a diagnosis of a right internal carotid artery dissection. A balloon occlusion test (BOT) was conducted 2 days after admission, and endovascular treatment was performed 3 days after admission. An Enterprise vascular reconstruction device (VRD) was inserted into the right middle cerebral artery via the posterior communicating artery through the posterior cerebral artery, and a parent artery occlusion, which incorporated the rupture site, was performed proximal to the stent.

Conclusion: The number of patients for whom this procedure is indicated is limited, but it may facilitate safe treatment at the distal end of a parent artery occlusion while maintaining the anterior circulation.

Keywords: anterior-wall aneurysm of the internal carotid artery, subarachnoid hemorrhage, parent artery occlusion, Enterprise vascular reconstruction device

Introduction

As an etiological factor for subarachnoid hemorrhage, the incidence of anterior-wall aneurysms of the internal carotid artery is not high. According to a national survey published in Japan in 2004, these aneurysms accounted for 3.3% of ruptured/unruptured internal carotid artery aneurysms.1,2) Furthermore, the number of patients with unfavorable prognosis is relatively high for those with hemorrhages, and the prognosis for patients with dissection-related aneurysms is worse.

Dissecting aneurysms, as described above, cannot be treated with coil embolization or clipping in many cases. In this study, we report a patient for whom parent artery occlusion of a dissecting internal carotid artery lesion, involving the site of rupture, was performed while maintaining blood flow to anterior circulation through the posterior communicating artery using an Enterprise vascular reconstruction device (VRD; Johnson & Johnson, Miami, FL, USA).

Case Presentation

The patient was a 54-year-old female who was brought to our hospital by ambulance with a headache, nausea, and vomiting. The headache had developed suddenly 5 days before admission, it did not subside, and it was followed by nausea and vomiting. The patient’s medical history was not considered to have contributed to her condition.
Physical examination on arrival: Concerning the consciousness level, the Japan Coma Scale score, Glasgow Coma Scale score, WFNS grade, and Hunt & Kosnik grade were 1, E3V5M6, 2, and 2, respectively. There was no neurologic deficit. Regarding the vital signs, the blood pressure, pulse, oxygen saturation, and body temperature were 140/90 mmHg, 77 beats/min, 98% (room air), and 36.8°C, respectively.

Imaging findings: A cephalic CT scan revealed a Fisher’s group 3 subarachnoid hemorrhage (Fig. 1). On the day of admission, cerebral angiography was performed that revealed a dilation in the anterior wall of the right internal carotid artery, which indicated a dissection (Fig. 2A and 2B). The findings from Allcock test showed that the anterior circulation was favorably enhanced through an advanced posterior communicating artery (Fig. 2C and 2D).

Course after admission: Conservative treatment was started initially, because 5 days had passed since the initial onset of the symptoms. Two days after admission, a detailed angiography, which involved a balloon occlusion test (BOT), was conducted under general anesthesia. The dilated site in the right internal carotid artery measured 5.0 × 2.8 mm, and it was located in the anterior wall at the level of the posterior communicating artery bifurcation (Fig. 2A and 2B). The posterior communicating artery was evaluated as being of the fetal type, and the vascular diameter was 1.8–2.1 mm (Fig. 2C and 2D). The basilar artery was evaluated as being of the causal fusion type, and the P1 segment of the posterior cerebral artery was 1.7–1.9 mm (Fig. 2C and 2D). Regarding the hemodynamics, the cross flow from the contralateral side via the anterior communicating artery was slight, and retrograde blood flow from the posterior communicating artery was predominant. The findings from the BOT showed an occlusion at the bifurcation of the right internal carotid artery, and the mean stump pressure was 68/46 mmHg and this was maintained at approximately 70% of the mean body blood pressure (95/60 mmHg).

As a therapeutic strategy, we selected endovascular treatment, considering that craniotomy may promote vasospasm, as the point of 1 week after onset corresponds to the vasospasm stage. Furthermore, we considered that stent insertion into the middle cerebral artery through the posterior communicating artery might facilitate an accurate embolization of the dilated site that incorporated the periphery, thereby maintaining the blood flow in the area of the right middle cerebral artery. Initially, we planned a parent artery occlusion after stent insertion from the lateral side of a stent at the peripheral end of the internal carotid artery. The use of a stent in the acute phase of ruptured cerebral aneurysms is not covered by health insurance, but we considered it necessary to accurately perform parent artery occlusion. Hence, a stent was used after obtaining informed consent from the patient’s family. After the BOT, general anesthesia was continued, and endovascular treatment was scheduled to be conducted 3 days after admission.

Endovascular treatment: Immediately before surgery, loading doses of Bayaspirin (300 mg) and clopidogrel (300 mg) were administered. After surgery, dual-antiplatelet therapy (DAPT) with Bayaspirin at 100 mg and clopidogrel at 75 mg was continued.

A 7 Fr. sheath was inserted into the right femoral artery, and a 6 Fr. sheath into the left femoral artery. A 7 Fr. OPTIMO occlusion catheter (Tokai Medical Products, Aichi, Japan) was inserted into the right internal carotid artery, and a 6 Fr. Launcher guide catheter (Medtronic, Minneapolis, MN, USA) was inserted into the left vertebral artery. A Prowler Select Plus straight microcatheter (Codman & Shurtleff, Inc., Johnson & Johnson, Raynham, MA, USA) was guided to the right internal carotid and the middle cerebral arteries via the right posterior...
Stent-assisted Parent Artery Occlusion for an Anterior-wall Aneurysm

initially, the dilated site and its periphery were embolized. As a framing coil, an OrbitGalaxy complex XTRASOFT 4.0 × 80 mm (Codman & Shurtleff, Inc., Johnson & Johnson) was used. Subsequently, the dilated site was embolized using a Target Detachable coil (Stryker, Kalamazoo, MI, USA) and an ED coil (Kaneka Medix Corp., Osaka, Japan) (Fig. 3C). Stent assistance facilitated the accurate treatment of the dilated site in the internal carotid artery adjacent to the bifurcation of the posterior communicating arteries. After the rupture site had been embolized, right internal carotid artery blood flow became stagnant, and the blood flow disappeared beyond the rupture site (Fig. 3D).

The parent artery occlusion was performed as described next. An Echelon-14 preshaped 45° microcatheter (Medtronic) was guided to the dilated site within the right internal carotid artery using a CHIKAI-14 microguidewire. Initially, the dilated site and its periphery were embolized. As a framing coil, an OrbitGalaxy complex XTRASOFT 4.0 × 80 mm (Codman & Shurtleff, Inc., Johnson & Johnson) was used. Subsequently, the dilated site was embolized using a Target Detachable coil (Stryker, Kalamazoo, MI, USA) and an ED coil (Kaneka Medix Corp., Osaka, Japan) (Fig. 3C). Stent assistance facilitated the accurate treatment of the dilated site in the internal carotid artery adjacent to the bifurcation of the posterior communicating artery. After the rupture site had been embolized, right internal carotid artery blood flow became stagnant, and the blood flow disappeared beyond the rupture site (Fig. 3D).

As the imaging findings had indicated that the dissection had originated from a stenotic site immediately after the ocular artery (Fig. 3E), the internal carotid artery...
was embolized using OrbitGalaxy and ED coils to preserve the ocular artery, which incorporated the stenotic site (Fig. 3F). Vertebral arteriography for confirmation showed blood-flow-delay-free perfusion of the right middle cerebral artery by posterior-communicating artery (Fig. 3G).

Postoperative course: Immediately after surgery, the patient’s awakening was favorable, and there was no neurologic deficit. Drip infusion therapy and blood pressure control were performed, and there was no problem until the morning after surgery. However, the consciousness level declined in the morning the day after treatment, and right paralysis appeared. A cephalic CT scan revealed an intracerebral hemorrhage (ICH) of the left temporal lobe and marked swelling of the brain (Fig. 4). On the same day, hematoma removal under craniotomy and external decompression were conducted. After surgery, the patient’s consciousness disturbance and right paralysis had improved, but moderate aphasia remained. Subsequently, heart failure and pneumonia developed, and the patient’s general condition deteriorated temporarily, but neither cerebral vasospasm nor hydrocephalus was evident. After an improvement in cerebral swelling was achieved (37th postoperative day), cranioplasty was performed. However, subsequent angiography showed slight recanalization of the right internal carotid artery (Fig. 5A and 5B). Although there was no blood flow at the dilated site of the internal carotid artery, the middle cerebral artery was slightly enhanced along the posterior wall of the internal carotid artery; therefore, we planned additional treatment. For additional treatment, additional embolization was performed at the proximal area of the coil mass on initial treatment. In addition, additional coil embolization of the carotid canal to internal carotid artery at the petrous bone was conducted, leading to the complete disappearance of intracranial blood flow (Fig. 5C and 5D). The patient did not experience any vision disorders after treatment, and a xenon CT scan for blood flow assessment did not show any reduction in blood flow in the right middle cerebral artery area. During the course, there was no ischemic attack. Finally, aphasia remained, and the patient was referred to a recovery-phase hospital. After discharge from
stents have been reported. However, recently, some studies proposed treatment with a flow diverter. According to a study involving a systematic review published by Gonzalez et al., coil embolization was selected for 23.7% of 97 patients who underwent endovascular treatment for ruptured anterior-wall aneurysms of the internal carotid artery, stent-assisted coil embolization for 34.0%, stenting alone for 21.6%, treatment with a flow diverter for 9.3%, and parent artery occlusion for 6.2%. Of these, additional hemorrhage occurred in 17.4, 15.2, 9.5, 0, and 0%, respectively. Furthermore, 47.8, 51.5, 33.3, 11.1, and 16.7% required additional treatment. We reviewed the therapeutic strategies for the current case in the context of a diagnosis of a dissection of internal carotid artery, which was based on the imaging findings that showed dilation and stenosis. Based on the findings from the BOT, we considered that blocking the internal carotid artery was possible in the presence of a posterior communicating artery blood flow, and we selected parent artery occlusion, which may not lead to recurrence or additional hemorrhage.

As an issue regarding parent artery occlusion, treatment at the distal end has often been raised. Furthermore, the number of relevant branches for the internal carotid artery

**Discussion**

Anterior-wall aneurysms of the internal carotid artery are classified into two types, namely, dissection-related blood-blister-like aneurysms and non-blood-blister-like aneurysms with a standard wall thickness. According to a national survey in Japan in 2004, the incidence of dissection in patients with anterior-wall aneurysms of the internal carotid artery was estimated to be ≥40%. In those in whom aneurysms were shown to be related to dissection, the results of treatment were significantly poorer than in those with non-dissecting aneurysms. Coil embolization or clipping is possible for some patients with standard aneurysm, but it is difficult to evaluate the type of aneurysm before treatment.

The reports from recent studies describe bypass-combined trapping (direct surgery) as a treatment procedure for ruptured anterior-wall aneurysms of the internal carotid artery. In relation to endovascular treatment, stent-assisted coil embolization and a method using several
Nagao S, et al.

Fig. 5 (A) Frontal and (B) lateral views of the right carotid arteriography prior to additional treatment, the dilated site was not enhanced, but the intracranial space was slightly enhanced along the posterior wall of the internal carotid artery. (C) Frontal and (D) lateral views of the right carotid arteriography after additional treatment showed the complete loss of intracranial enhancement.

is larger than that for the vertebral artery; therefore, short-segment treatment is necessary, and more tight packing must be performed to achieve complete occlusion, considering the vascular diameter and blood flow volume. Some studies reported parent artery occlusion for vertebral artery dissection in which stenting was performed that involved the affected-side or contralateral vertebral artery to the posterior inferior cerebellar artery.\textsuperscript{14–16} To our knowledge, there has been no similar report on the internal carotid artery system.

The hemorrhage in the present case was located on the anterior wall of the internal carotid artery at the level of the posterior communicating artery bifurcation. By treating the dilated site using parent artery occlusion, it was possible that the posterior communicating or anterior choroidal arteries might be affected. Concerning stenting, various insertion methods, such as T-stenting, Y-stenting, and horizontal stenting, have been reported. Stenting involving the middle cerebral artery via the posterior communicating artery through the basilar artery, as described for this method, may be possible in some patients. At this point, in the present case, a long stent was used, considering its stability, and inserted into the posterior to middle cerebral arteries. However, we should have reviewed stent insertion in a short distance between the posterior communicating and internal carotid arteries, considering the possibility of vascular stretching or stent kinking. In fact, the stent insertion site became linear in the present case, but, fortunately, neither vascular dissections nor blood flow reductions occurred.

Furthermore, in the present case, endovascular treatment was performed 7 days after the onset of symptoms. However, using a stent during the acute phase of rupture is controversial. According to a previous review, the incidences of ischemic and hemorrhagic complications in patients in whom a stent was used in the acute phase of rupture were 5.6 and 8%, respectively.\textsuperscript{17} In the present case, loading with Bayaspirin and clopidogrel was performed immediately before surgery. Dual-antiplatelet therapy was continued after surgery, and there was no
ischemic complication. However, ICH of the contralateral temporal lobe occurred the day after treatment. In the neurosurgical field, such remote ICH is known as a complication related to direct surgery, but they may be relatively rare in the field of cerebral endovascular treatment. Sim et al.\(^\text{19}\) reported that the incidence of remote ICH after endovascular treatment for unruptured cerebral aneurysms was 0.46% (11/2258 patients), and that it developed as subcortical hemorrhage on the treated side within 1 week in most patients. The risk factors for remote ICH include aneurysms of the internal carotid artery system, stent use, and a history of hypertension. As the etiology of remote ICH, the following factors are assumed: 1) DAPT, 2) hemorrhagic changes of the infarcted focus, including asymptomatic changes, 3) inflammatory or ischemic responses related to the remote migration of a portion of the material of a device used during the procedure,\(^\text{19}\) and 4) changes in hemodynamics after treatment. Concerning the item 4), stent insertion decreases arterial compliance at the site of insertion when adopting a stent, especially a flow diverter, and the peripheral pulse pressure increases through Windkessel effects, causing remote ICH.\(^\text{20}\) In the present case, contralateral hemorrhage occurred; the above possibilities 2)–4) may be ruled out, and the influence of DAPT may be the most marked. As another etiological factor, contralateral hemodynamic load may have increased with parent artery embolization, but this is speculation on our part.

The present case required additional treatment as a consequence of recanalization during the chronic phase although an additional rupture did not occur. According to the above study,\(^\text{29}\) the incidence of additional hemorrhage after parent artery embolization was 0%, but 16.7% of the patients required additional treatment. When reviewing anterior-wall aneurysms of the internal carotid artery, the additional treatment rate after endovascular treatment was 38.1%. In the present case, the patient’s general condition temporarily became unfavorable after surgery, and the timing of follow-up imaging was delayed. However, in patients with these aneurysms, the risk of additional hemorrhage/treatment is high; therefore, postoperative follow-up imaging must be conducted earlier compared with standard treatment. Tight packing may not have been achieved in the present case, which may explain why additional treatment was required. However, we cannot exclude the possibility that the stenotic site (Fig. 3E) of the proximal lesion may have severely dilated, leading to recanalization related to the space from the coil. The findings from the angiography that was performed when the recanalization occurred indicated that while the dilated site was not enhanced, the middle cerebral artery was gradually becoming enhanced along the posterior wall of the internal carotid artery, which suggested that the recanalization was related to the morphologic changes that had occurred at the site of the dissection. In the present case, the distance between the ocular artery and site of dissection (stenotic site) was short, and it may have been impossible to completely treat the exact lesion site while preserving the ocular artery. When performing parent artery occlusion for dissecting lesions, it may be important to treat normal to normal blood vessels if possible.

### Conclusion

We have described a patient who developed a subarachnoid hemorrhage as an initial symptom and who underwent a parent artery occlusion using an Enterprise VRD to treat an anterior-wall aneurysm of the internal carotid artery. Although the number of patients who can undergo stent-assisted treatment is limited because of the position of the dissection and the diameter of the posterior communicating artery, the use of a stent may facilitate treatment at the distal end of the occluded site, which is often raised as an issue in association with parent artery occlusion. This procedure was beneficial for the present case.

### Disclosure Statement

The authors declare that they have no conflicts of interest.

### References