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Opposite L-configuration double stenting for rupture of an extremely wide-necked anterior communicating artery aneurysm at the acute stage: illustrative case

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BACKGROUND Wide-necked aneurysms can be treated by double stenting in an X- or Y-configuration or by a double waffle-cone technique. However, some aneurysms remain untreatable.

OBSERVATIONS The rupture of a complex wide-necked anterior communicating artery (AcomA) aneurysm that caused acute subarachnoid hemorrhage (SAH) was treated successfully using double stents with an opposite L-configuration as an alternative to the X-stent technique. The aneurysm involved both A1-A2 junctions in the aneurysm neck with acutely oriented A2 segments of the anterior cerebral artery bilaterally. It was densely packed and completely obliterated angiographically with preserved blood flow by implanting each stent in the ipsilateral A1-A2 bilaterally. Blood flow from the left A1 to the right A2 was confirmed through the AcomA on injection of the left internal carotid artery immediately after the procedure without critical infarction in the subthalamic area. Although the AcomA was not demonstrated by injection of the left internal carotid artery on angiography at 3 months or 1 year later, no cerebral infarction was seen on magnetic resonance images at the final hospital visit.

LESSONS Opposite L-configuration double stenting was used successfully as rescue stent-assisted coiling for a rupture of a complex wide-necked AcomA aneurysm in a patient with acute SAH.

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KEYWORDS wide-necked ruptured anterior communicating artery aneurysm; opposite L-configuration double stenting; stent-assisted coil embolization; anterior communicating artery perforator

The anterior communicating artery (AcomA) is the most common site of intracranial aneurysms. AcomA aneurysms account for 23%–40% of all ruptured intracranial aneurysms and are more likely to rupture than other types because of their anatomical and hemodynamic characteristics.[1] Rupture of an intracranial aneurysm results in potentially life-threatening subarachnoid hemorrhage (SAH).

Although surgical clipping of an AcomA aneurysm is safe and effective, it may be technically challenging because of its location in the deep midline, presence of small branches and perforators, unfavorable fundus projection, frequent anatomical variation, and an increased risk of cognitive impairment postoperatively. Of all the anterior circulation aneurysms, the incidence of postoperative morbidity is highest for those involving the AcomA.[2]

Since publication of the International Subarachnoid Aneurysm Trial (ISAT), the treatment paradigm has shifted to favor endovascular treatment of cerebral aneurysms, including those in the AcomA region.[3] Endovascular embolization is a less traumatic, feasible, and effective treatment option for AcomA aneurysms and is now performed more often than open craniotomy and with more frequent use of intracranial stents.

Embolization of AcomA aneurysms may be difficult in comparison with other types of intracranial aneurysms due to the high frequency of small or complex aneurysms and vascular variants that

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ABBREVIATIONS 3D = three-dimensional; ACA = anterior cerebral artery; AComA = anterior communicating artery; CT = computed tomography; CTA = computed tomography angiography; DSA = digital subtraction angiography; ICA = internal carotid artery; ISAT = International Subarachnoid Aneurysm Trial; MRI = magnetic resonance imaging; OLDS = opposite L-configuration double stenting; PED = Pipeline embolization device; SAH = subarachnoid hemorrhage; WEB = Woven EndoBridge.

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are common in this anatomical location. Although neck-bridge stent-assisted coil embolization is a useful technique for wide-necked AcomA aneurysms, we sometimes encounter more difficult cases that need to be treated with double stents. Double-stent implantation, such as X- or Y-configuration stenting or a double waffle-cone technique, may be used.[2,4,5] However, some aneurysms of this type remain untreatable using these techniques. Here we describe a case of rupture of a complex wide-necked AcomA aneurysm that was successfully treated in the acute phase of SAH by double stent placement with an opposite L-configuration as an alternative to the X-stent technique without major complications, including no critical infarction in the subthalamic area fed by small or perforating branches of the AcomA, despite the aneurysm sac being densely packed with coils.

Illustrative Case

A 54-year-old previously healthy female presented with severe sudden-onset headache and was referred to our hospital. Computed tomography (CT) of the brain revealed an SAH with a small area of intense hyperattenuation in the AcomA region (Fig. 1). Subsequent three-dimensional (3D) computed tomography angiography (CTA; Fig. 2A–B) revealed a wide-necked AcomA aneurysm involving the bilateral A1 A2 junction of the anterior cerebral artery (ACA) in the aneurysm neck with an acutely oriented bilateral A2 segment of the ACA. The aneurysm dome was oriented posteriorly and had a small bleb, suggesting that the rupture point was in the left posterior wall (Fig. 2B, white arrow). The diameter of the aneurysm dome was 4.7 mm and that of the neck was 4.8 mm.

Three-dimensional constructions obtained by digital subtraction angiography (DSA; Fig. 2C–D) and 3D rotational angiography (Fig. 2E–F) using a biplane flat-panel DSA unit (Allura Xper FD20, Philips) confirmed a complex wide-necked (dome [4.7 mm]/neck [4.8 mm] ratio = 0.98) aneurysm measuring 8.0 × 4.8 × 2.4 mm with a bleb (Fig. 2B, D, and F, white arrow). The diameter of the right A1 was 1.5 mm and that of the right A2 was 1.7 mm. The diameters of the left A1 and A2 were 2.1 mm and 2.4 mm, respectively. No AcomA perforators, such as hypothalamic and subcallosal arteries, were visualized.

Given the deep midline location of the aneurysm, unfavorable posterior fundus projection, and wide neck involving the bilateral A1–A2 junction of the ACA with an acutely oriented bilateral A2 segment of the ACA without demonstration of the small branches and perforating arteries, stent-assisted coiling was deemed better than surgical clipping for treatment of the acutely ruptured complex wide-necked AcomA aneurysm. For dense coil packing with certain preservation of bilateral A1–A2 blood flow, a double-stent technique with an X-configuration was chosen as the initial treatment strategy (Fig. 2G).

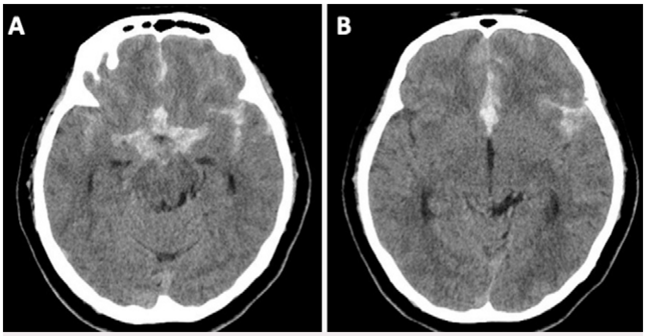

FIG. 1. Axial brain CT scans obtained on admission, showing an SAH with hyperattenuated basal cisterns, an anterior interhemispheric fissure, bilateral sylvian fissures, and a small, intensely hyperattenuated area in the AcomA.

Three hours before the procedure, 300 mg of clopidogrel and 300 mg of aspirin was administered orally.[6,7] Bilateral femoral access was achieved percutaneously under general anesthesia. The patient received systemic heparinization, and her activated clotting time was maintained at 2–3 times the baseline throughout the procedure.

An 8F Roadmaster guiding catheter (Goodman) was introduced into the left common carotid artery. Next, a 6F Cerulean DD6 catheter (Medikit) was then placed in the left internal carotid artery (ICA) as a distal access catheter. A 6F Envoy guiding catheter (Codman) was then placed in the right ICA and a 3.4F TACTICS (Technocrat Corp.) in the A1 segment of the right ACA as a distal access catheter.

Working projections were defined. Under roadmap guidance, an Excelsior SL-10 catheter (Stryker) with a CHIKAI Black 14 soft tip guidewire (Asahi Intecc Co. Ltd) was readily introduced into the left A2 segment from the ipsilateral A1 segment by turning an intra-aneurysm guidewire. However, it was not possible to secure the right A2 segment from the left A1 segment across the aneurysm sac. Therefore, we changed our strategy from an X-configuration stenting to an opposite L-configuration double stenting (OLDS; Fig. 2H). Another Excelsior SL-10 catheter could be similarly placed into the A2 segment of the right ACA from the right ICA with a CHIKAI black 14 soft-tip guidewire. A 3.0 × 21–mm Atlas stent (Neuroform, Stryker) was deployed from the A2 segment to the ipsilateral A1 segment of the right ACA. The SL-10 catheter was advanced into the aneurysm from the left ICA through the left A1 segment and jailed after deployment of a second Neuroform Atlas stent (4.5 × 21 mm) from the A2 segment to the ipsilateral A1 segment of the left ACA. OLDS was confirmed to be successfully placed by both DSA and cone-beam CT (Fig. 3A–B). Next, bare platinum detachable coils were gradually placed in the aneurysm sac with careful attention to the preservation of blood flow in the AcomA until the aneurysm sac was completely obliterated (Fig. 3C–F). At the end of the procedure, branches of the A2 segment of the right ACA were demonstrated in the AcomA on DSA with injection of the left ICA (Fig. 3E and F, white arrow). The patient did not develop any neurological problems during the procedure. Hemostasis at the puncture sites was achieved using a vascular closure device (Angio-Seal VIP 8F, St. Jude Medical).

Heparin reversal was not performed. The patient was started on oral cilostazol 200 mg and aspirin 100 mg the following morning. Magnetic resonance imaging (MRI) of the brain performed on the next day showed several punctate infarcts in the head of the right caudate nucleus, left cerebral cortex, and white matter but no critical infarction in the subthalamic area (Fig. 4). The intraprocedural and postprocedural courses were uneventful. The patient was prescribed 75 mg of clopidogrel and 100 mg of aspirin for 6 months to be started after the vasospasm period. The patient was discharged 3 weeks later with no neurological signs or symptoms.

Complete obliteration of the aneurysm and bilateral blood flow from the A1 to the ipsilateral A2 through the opposite-L stents were confirmed on follow-up DSA 3 weeks and 1 year later (Fig. 5). Although the AcomA was not demonstrated on DSA by injection of either ICA, no further cerebral infarction was seen on MRI scans through to the final hospital visit.

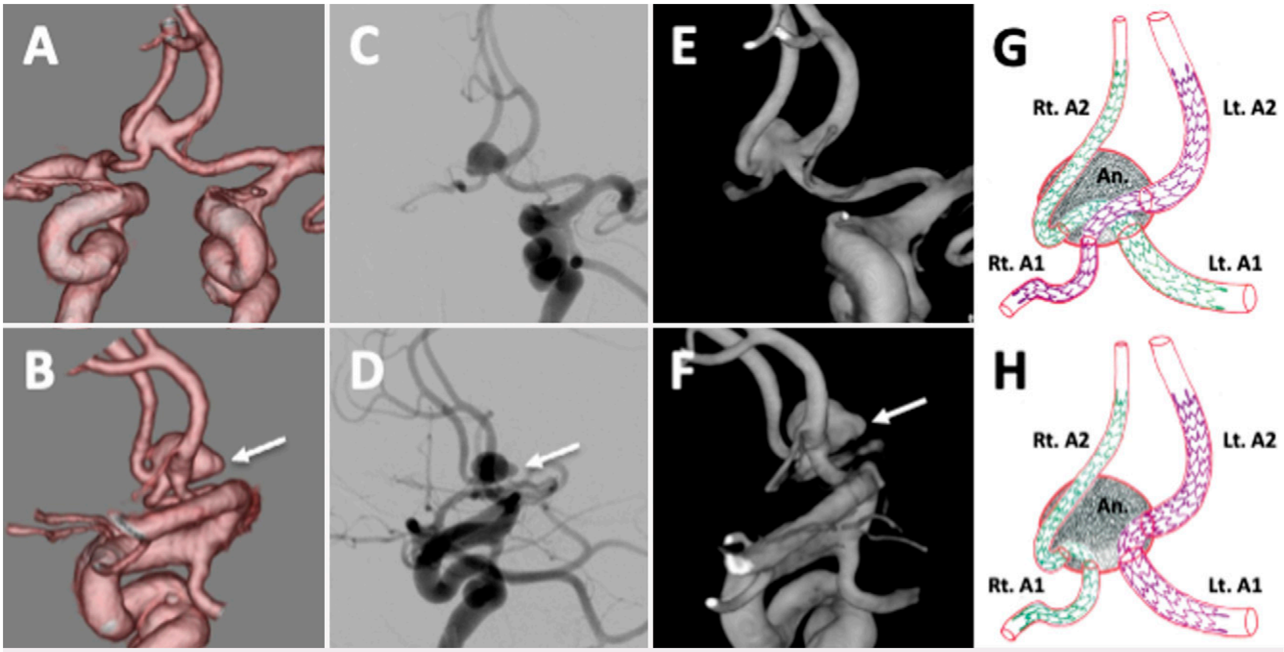

FIG. 2. Anteroposterior (**A**) and left lateral (**B**) 3D CTA views in working angles demonstrating a complex wide-necked aneurysm in the AcomA involving the A1–A2 junction of the ACA in the aneurysm neck bilaterally with an acutely oriented A2 of the ACA bilaterally. The aneurysm dome measured 8.0 × 4.7 × 2.4 mm and the dome/neck ratio (4.7 mm/4.8 mm) was 0.98. A suggested ruptured point is the bleb on the left posterior wall of the aneurysm sac (*white arrow*). The diameters of the right A1 and A2 are 1.5 mm and 1.7 mm, respectively, and those of the left A1 and A2 are 2.1 mm and 2.4 mm, respectively. Anteroposterior (**C**) and left lateral (**D**) digital subtraction angiography views in working angles. ACA perforators, such as hypothalamic arteries, were not visible. Anteroposterior (**E**) and left lateral (**F**) views on 3D rotational angiography in working angles. Drawings of an X-configuration (**G**) and an opposite L-configuration double-stenting (OLDS, **H**). An = aneurysm; Lt. = left; Rt. = right.

Discussion

Observations

This report describes a patient with acute SAH in whom a rupture of a complex wide-necked AcomA aneurysm involving both the A1–A2 junctions in the aneurysm neck with an acutely oriented A2 segment of the ACA bilaterally was successfully treated by OLDS as an alternative to an initially planned X-stent coiling technique. Blood flow in both ipsilateral A1–A2 junctions was preserved by opposite-L stenting. The aneurysm sac was densely packed and completely obliterated angiographically. However, blood flow from the left A1 to the right A2 through the AcomA was confirmed on injection of the left ICA immediately after the procedure without critical infarction in the subthalamic area, fed by small or perforating arteries from the AcomA, seen on subsequent diffusion-weighted images.

Lessons

In stent-assisted coiling of acutely ruptured aneurysms, adverse events, including clinically significant intracranial hemorrhagic complications and thromboembolic events, appear more common and clinical outcomes are likely to be worse than those achieved without stent assistance. However, it appears that thromboembolic complications can be reasonably well controlled. Stent-assisted coiling can be performed for ruptured aneurysms with a high degree of technical success.[8]

Various adjunctive techniques have been used to facilitate coil embolization of wide-necked AcomA aneurysms, including neck remodeling with balloons or micro-guidewires and simultaneous deployment of coils. Furthermore, self-expanding stent-assisted coil embolization has been proposed as an alternative method for endovascular reconstruction of complex aneurysms.[6] Stent deployment across the neck of the intracranial aneurysm during a coiling procedure prevents herniation of a coil mass into the parent artery and allows denser packing of the aneurysm with coils, supposedly resulting in a better long-term occlusion rate. In addition to these mechanical functions, stenting has been reported to have hemodynamic and biological effects.[2] Growth of the endothelium induced by stents promotes beneficial remodeling of the neck of an aneurysm and parent artery but may also lead to in-stent stenosis. A change in intraaneurysm flow following stent implantation is considered to induce progressive thrombosis of incompletely occluded aneurysms. However, thrombosis is less common in aneurysms that involve the AcomA than in those at other locations. Changing the direction of blood flow may also decrease the likelihood of recanalization in the future. The stent placement strategy depends on the location of the aneurysm neck and the symmetry or asymmetry of the AcomA. Three possible stent placement configurations can be used across an AcomA aneurysm: stent deployment from one A1 segment to the contralateral A2 segment across the AcomA; from one A1 segment to the ipsilateral A2 segment; and from one A1 segment across the contralateral A1 segment.[9] However, single stent-assisted coiling may not be suitable for very wide-necked aneurysms with complex anatomy.[10] The problem posed by a wide-necked bifurcation aneurysm is different from that of a wide-necked sidewall artery aneurysm. Single stent-assisted coiling provides only partial protection against herniation of the coil into the parent artery. To solve this problem, Chow et al.[10] reconstructed the bifurcation by deploying a second stent in another branch through

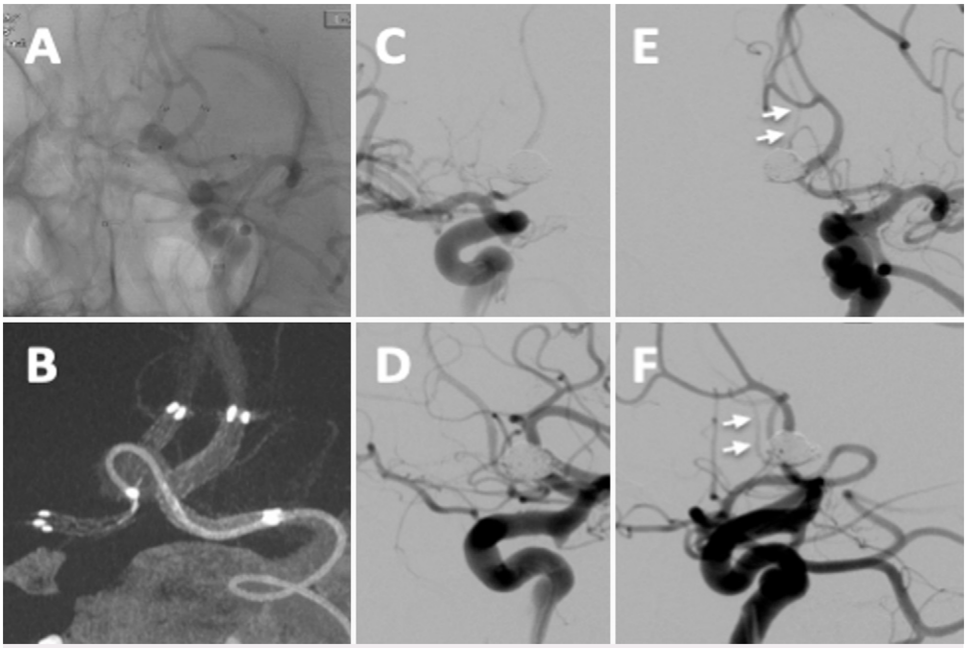

FIG. 3. Anteroposterior digital angiogram (**A**) after double-stent placement showing an opposite L-configuration. Anteroposterior cone-beam CT reconstruction (**B**) showing appropriate opposite L-double stenting implantation. A jailed catheter is inserted into the aneurysm from the left ICA. Anteroposterior (**C**) and left lateral (**D**) right ICA DSA demonstrating complete obliteration of the aneurysm. The ipsilateral A2 of the right ACA is opacified by injection of the right ICA. Anteroposterior (**E**) and left lateral (**F**) left ICA DSA demonstrating the contralateral right A2 segment (*white arrows*) through the AcomA in addition to the ipsilateral left A2.

the interstices of the first stent placed in a branch, a method they named the Y-configuration, double-stent technique. This method was first applied for a wide-necked aneurysm at the basilar apex, although many aneurysms at the bifurcation of other intracranial arteries could be treated using this technique because it creates a new bifurcation point that provides a mechanical scaffold, which prevents protrusion of the coil.[11]

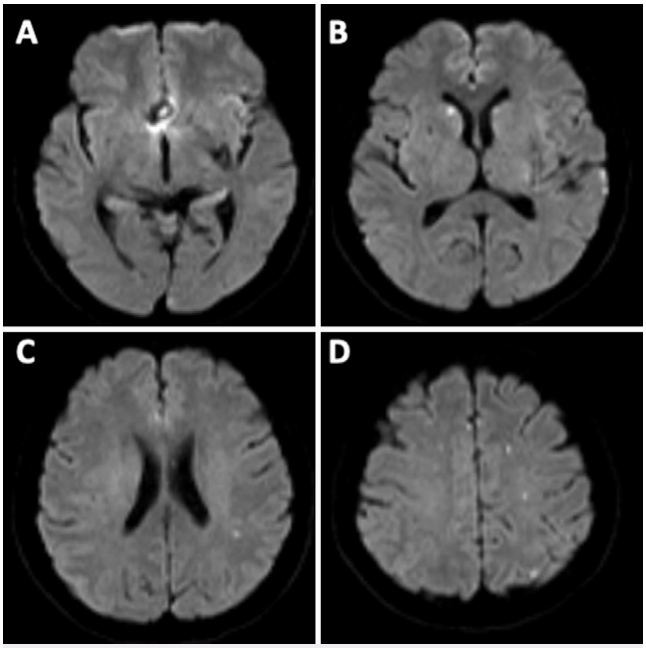

FIG. 4. Diffusion-weighted images of the brain (**A–D**) obtained on the day after the procedure, showing several punctate infarcts in the right caudate head, left cerebral cortex, and white matter. No critical infarction is seen in the subthalamic region.

Saatci et al.[12] recently described a novel X-configuration technique involving double Enterprise stents or a combination of a Solitaire stent and an Enterprise stent, which they had used as endovascular treatment for unruptured complex AcomA aneurysms in five selected cases with sharp angles between the A1 and A2 segments and good-sized A1 segments bilaterally. In-stent stenosis has been reported in patients whose aneurysms have been treated by stent-assisted coiling. However, no in-stent stenosis or artery occlusion occurred in their small group of patients, despite dual-stent placement in relatively small vessels.[12]

Technically, placement of stents from the ipsilateral A2 to the A1 segment with OLDS can be considered an option. X-stent placement is considered more feasible, and a change in the direction of flow at the neck of the aneurysm which, hypothetically, has an impact on long-term durability, is thought to be more efficient with the X-configuration than with OLDS. The patency of the reconstructed AcomA is preserved by X-stent placement but the vessel may become occluded when a later stent configuration is used.[12] Maintaining vessel patency is critical when performing stent-assisted coiling without stent reconstruction of the neck of an AcomA aneurysm. However, in-stent stenosis seems less likely with OLDS than with an X-configuration, in which stent crossing is inherent.

Parent vessel occlusion of an AcomA aneurysm with the neck located at the A1–A2 junction and without A1 aplasia is a potentially safe treatment for aneurysms, although infarcts in the basal forebrain occur in many patients with aneurysms in which the neck is

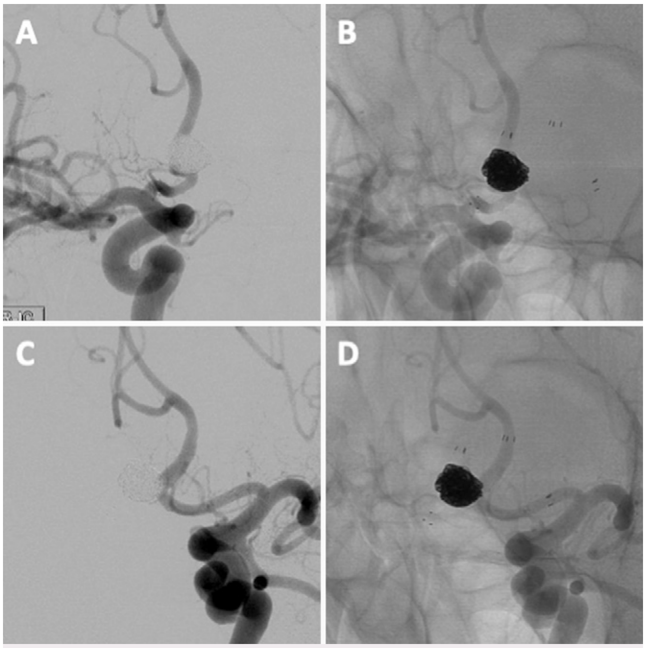

FIG. 5. Anteroposterior right ICA DSA (**A**) and digital angiogram (**B**) obtained 1 year after the procedure, demonstrating complete obliteration of the aneurysm. Filling of the A2 in the right ACA is from the ipsilateral right ICA. Anteroposterior left ICA DSA (**C**) and a digital angiogram (**D**) obtained 1 year after the procedure, demonstrating complete obliteration of the aneurysm (as above) and the ipsilateral left A2.

located directly on the AcomA.[13] In our patient, blood flow from the A1 segment to the opposite A2 segment through the AcomA was carefully preserved in the procedure. In OLDS, a protective balloon would be advanced to the AcomA through a strut of the stent, if necessary, from the contralateral ICA to that in which the jailed catheter for coiling was placed to prevent herniation of densely packed coils into the AcomA.

Another double-stenting technique for ultrawide-necked bifurcation aneurysms with acutely oriented daughter vessels, such as the aneurysm in our patient, is the double waffle-cone construct using a Solitaire electrolytically detachable slotted stent featuring large-sized cells.[5] This method enables doubling of the neck coverage to treat an ultra-wide-necked middle cerebral aneurysm. The wide-necked aneurysm in our patient would be covered by this technique. However, the configuration of an aneurysm involving both A1–A2 junctions in an aneurysm neck with a large dome/neck ratio (0.97) is not amenable to this method for preservation of A1–A2 blood flow. Furthermore, this technique relies on fine adjustment of the relative position of the stents with the aid of cross-sectional cone-beam computed tomographic angiography to achieve optimal coverage prior to detachment of the stents in position.[5] Such a requirement would be less feasible when coiling a ruptured AcomA aneurysm in the acute phase of SAH.

Recently, an intrasaccular flow disruptor, Woven EndoBridge (WEB; Sequent Medical), has been developed and successfully introduced for intrasaccular treatment of small wide-necked, ruptured aneurysms without the need for adjunctive support.[14] However, double stent technique would be necessary in our case for preservation of bilateral A1–A2 blood flow without residual neck before placement of the WEB device.

Interventionists may choose a lighter coil pack or dome-occlusive strategy to secure an acutely ruptured aneurysm while minimizing the risk of intraprocedural rupture.[15] Two major drawbacks of endovascular coiling, namely, an incomplete initial occlusion rate and relatively less long-term durability remain in the treatment of AcomA aneurysms with wide-necked, unfavorable anatomical configurations and partial incorporation of branches.[12] The AcomA aneurysm in our patient was completely obliterated by dense coil packing using OLDS without serious complications in the acute stage of SAH, and complete obliteration of the aneurysm was confirmed on follow-up angiography performed 3 months and 1 year later.

The right A2 segment that was seen to be opacified on DSA by injection of the left ICA at the end of the procedure was not visualized on follow-up angiography. However, no further infarction occurred in our patient at the final hospital visit. Most of the hypothalamic branches originate from the posterior or posteroinferior aspect of the AcomA. Impairment of the AcomA perforators is reported to cause serious complications, including memory disturbance similar to that seen in Korsakoff syndrome, personality changes, and decreased spontaneous activity.[16] However, the hypothalamic area is richly fed by multiple hypothalamic branches and a large subcallosal branch that are anastomosed together.[16] In our patient, appropriate use of both heparin during the procedure and dual antiplatelet therapy with preprocedural loading and postprocedural maintenance seemed necessary to preserve the patency of the AcomA and its perforators during the procedure and avoid cerebral infarction in the critical area.[6,7]

A similar technique in which a Pipeline embolization device (PED) is placed bilaterally in a two-stage procedure, known as H-pipe PED placement, has been applied in selected cases of aneurysms in the AcomA region, including previously ruptured and/or treated aneurysms either with clipping or coiling.[15] Procedural success was achieved in 96% of patients. Complete occlusion of the aneurysm was observed in 85% of cases at the last follow-up. Part of the reluctance to use a PED in the AcomA region arises from reports of ischemic stroke attributed to occlusion of perforating arteries, including the medial lenticulostriate arteries and the recurrent artery of Heubner, when covered by flow-diverting devices. However, an H-pipe may be a rescue technique in the later stage of SAH in patients with ruptured AcomA aneurysms that are not treatable with an X-stent or the OLDS technique.

OLDS has been regarded as a technically possible alternative stent-assisted coiling method for complex, wide-necked AcomA aneurysms. However, successful application of this method for an acutely ruptured AcomA aneurysm has not been reported. We have successfully treated a ruptured AcomA aneurysm involving the A1–A2 junctions in the aneurysm neck using the OLDS technique. The aneurysm sac was densely packed with coils, and blood flow through the AcomA was preserved without any serious complications. OLDS with careful preservation of AcomA flow could be considered an alternative treatment method for complex wide-necked ruptured AcomA aneurysms that cannot be treated using an X-stent technique.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: all authors. Acquisition of data: Genkai. Analysis and interpretation of data: Genkai, Okamoto. Drafting the article: all authors. Critically revising the article: Genkai, Okamoto. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Genkai. Statistical analysis: Genkai. Administrative/technical/material support: Genkai, Hasegawa. Study supervision: all authors.

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