A Case of Ruptured Anterior Communicating Artery Aneurysm Treated in Which Residual Aneurysm after Coil Embolization Was Treated by Placement of LVIS Jr. Stent

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Objective: We report a case of ruptured anterior communicating artery aneurysm in which residual aneurysm after coil embolization could be completely occluded by LVIS Jr. stent placement.

Case Presentation: A 73-year-old woman underwent coil embolization in the acute phase of ruptured anterior communicating artery aneurysm. Since the parent artery was narrow with a diameter of 1 mm, and since the bifurcation angle of the A1 segment was sharp, manipulation of the microcatheter was difficult, and the treatment was terminated after partial embolization. After 40 days, retreatment was performed by LVIS Jr. stent placement. No intra- or postprocedural complication was observed, and complete occlusion of the aneurysm was confirmed by angiography after 3 months.

Conclusion: Complete occlusion of the residual aneurysm could be achieved due to the flow diversion effect of LVIS Jr. stent. This procedure can be an option in retreatment.

Keywords ▶ ruptured intracranial aneurysm, small parent vessel, low-profile visualized intraluminal support junior device, flow diverter

Introduction

Although the advent of flow diverters has made it possible to obliterate aneurysms difficult to treat by coil embolization,¹⁾ the indications for the pipeline embolization device (PED) (Medtronic, Minneapolis, MN, USA) are limited to large aneurysms in the proximal portion of the internal carotid artery in Japan. Also, while there has been a report that a flow diversion effect could be obtained by placing a neck bridging stent,²⁾ this effect is not absolute, and the safety of its placement in a small-diameter vessel has not been established.

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This report presents a case of ruptured anterior communicating artery aneurysm with a parent artery 1 mm in diameter in which coil embolization performed in the acute phase ended in partial occlusion, and LVIS Jr. stent (Terumo Corporation, Tokyo, Japan) was placed in the chronic phase in expectation of a flow diversion effect, resulting in complete obliteration of the residual aneurysm.

Case Presentation

A 73-year-old woman with a history of subarachnoid hemorrhage (SAH) 35 years before was emergently transported to our hospital due to disturbance of consciousness. On arrival, the score on the Glasgow coma scale (GCS) was 8 (E2, V1, M5), Hunt & Kosnik grade was IV, and Fisher group 4 SAH accompanied by intracranial hematoma in the left frontal lobe was disclosed by plain CT scan of the head (**Fig. 1A**). While clipping of the anterior communicating artery aneurysm was performed by craniotomy at the previous episode of SAH, details were unclear. 3D-CTA of the intracranial vessels showed anterior communicating artery aneurysm, but as its detailed morphology or positional relationship with the clips was uncertain,

Fig. 1 Imaging examinations on the first visit. (A) Plain head CT: Subarachnoid hemorrhage was observed with intracranial hematoma in the left frontal lobe. (B) Right internal carotid artery angiography (3D-RA LAO 124/CRA 65): No aneurysm was observed in the right A1-A2 segments. (C) Right internal carotid artery angiography (frontal image, Matas test by left carotid artery compression): The aneurysm and the anterior communicating artery to the left ACA were not delineated. (D) Left internal carotid artery angiography (frontal image): Aneurysm was observed in the left A1-A2 segments (arrow), and the left A1 segment bifurcated at a sharp angle (arrowhead). (E) Left internal carotid artery angiography (3D-RA LAO 14/CRA 40): Working projection during coil embolization. The aneurysm had two humps and showed a superiorly projected bleb (arrow). The maximum aneurysmal diameter was 7.5 mm, neck diameter was 2.6 mm, and parent artery diameter was 1.0 mm. (F) Left internal carotid artery angiography (LAO 14/CRA 40): Working projection during coil embolization. ACA: anterior cerebral artery; CRA: cranial; LAO: left anterior oblique; 3D-RA: three dimensional rotational angiography

intracranial angiography was performed successively. On right internal carotid artery angiography, two clips were found on the right A1-A2 segments, and the aneurysm was not delineated (**Fig. 1B**). In addition, the anterior communicating artery or aneurysm was not visualized on the Matas test by compression of the left common carotid artery (**Fig. 1C**). Left internal carotid artery angiography showed an aneurysm with a maximum diameter of 7.5 mm and a neck diameter of 2.6 mm in the left A1-A2 segments. It had vertically elongated two-hump morphology with a bleb projecting superiorly (**Fig. 1D** and **1F**). The left A1 segment was hypoplastic with a diameter of 1 mm, and it arose with an acute angle from the internal carotid artery.

Treatment of this aneurysm by coil embolization was expected to be difficult because the results of the Matas test indicated occlusion of the anterior communicating artery, so the lesion had to be approached from the left A1, which was hypoplastic and arose with a sharp angle, and because of its vertically elongated morphology of the aneurysm.

However, as the risk of repeat craniotomy was also judged to be high due to the closeness of the clips placed in the previous surgery to the aneurysm, coil embolization was selected with consent of the family of the patient.

Initial endovascular treatment

A 6 Fr Slim Guide 90 cm (Medikit Co., Ltd, Tokyo, Japan) was placed in the left internal carotid artery via the right femoral artery, and a 4.2 Fr FUBUKI 120 cm (Asahi Intecc Co., Ltd, Aichi, Japan) was placed coaxially in the left C3 portion. We attempted to guide an Excelsior SL-10 (Stryker, Kalamazoo, MI, USA) to the left A1 segment using a CHIKAI 14 microguidewire (Asahi Intecc Co., Ltd), but it was impossible as the effort to advance the microcatheter was hampered by its loop forming to the middle cerebral artery (MCA). Therefore, we inserted a 5 Fr ENVOY 90 cm (Cordis, Johnson & Johnson, Fremont, CA, USA) into the left internal carotid artery via the left femoral artery, placed a TransForm C 4 mm × 10 mm

Fig. 2 Initial treatment: Coil embolization. (A) A TransForm C 4 mm × 10 mm (arrow) was placed in the left M1 segment, and an Excelsior SL-10 was guided to the A1 segment (arrowhead) using the balloon as a wall. (B) The tip of the microcatheter was placed in the aneurysm. (C) A Target 360 Ultra 4 mm × 15 cm was inserted into the aneurysm (arrow), and a frame slightly shifted to the lower part of the aneurysm was formed. (D) After 4 Target Nano 360 Coils 15 cm were inserted serially, the microcatheter kicked back and escaped out of the aneurysm (arrowhead). Coils could not be placed sufficiently in the upper part of the aneurysm (arrow). (E) Angiography at the end of coil embolization: Although the bleb was not visualized, the contrast agent flowed into the dome in the upper part of the aneurysm (arrow). (F) Vasospasm occurred in the left A1 segment, and blood flow was slowed, but collateral flow from the left middle cerebral artery was clearly observed (arrows).

(Stryker) in the left M1, inflated the balloon, and guided the microcatheter to the aneurysm from the A1 (**Fig. 2A**). While the tip of the catheter was shaped at 90°, it was placed in the lower part of the aneurysm along the axis of the parent artery (**Fig. 2B**). Framing was made using a Target 360 Ultra 4 mm × 15 cm (Stryker) (**Fig. 2C**), followed by insertion of 4 Target NANO coils with a total length of 15 cm, but the microcatheter escaped out of the aneurysm as the stability of the microcatheter was not good at this point (**Fig. 2D**). Although the lower two-thirds of the aneurysm were densely embolized, coiling in the upper part was loose, and blood flow persisted in the dome (**Fig. 2E**). Attempts to re-insert coils were unsuccessful, and although blood flow in the A1 segment was slowed due to vasospasm, the procedure was ended in this state because adequate collateral blood flow was observed from the MCA (**Fig. 2F**).

Postprocedural course

After the procedure, the GCS score improved to 15, and while mild right-sided motor paralysis was noted, it resolved

within a few days. Intracranial angiography on the 11th day after the procedure showed narrowing of the left A1 due to vasospasm, blood flow of the residual aneurysm was slight, and the bleb was not delineated (**Fig. 3A**). However, as angiography 23 days after the procedure showed marked delineation of the aneurysm with alleviation of vasospasm of the left A1 (**Fig. 3B**), retreatment was planned. Since guiding of the microcatheter into the aneurysm was expected to be difficult, we aimed for thrombosis of the aneurysm utilizing flow diversion effect by placing a neck bridging stent.

Retreatment

To prevent re-rupture, the systolic blood pressure was maintained at ≤120 mmHg and 75 mg of clopidogrel and 100 mg of aspirin were administered orally 1 week prior to stenting. Retreatment was performed on the 40th hospital day. On left internal carotid artery angiography, the aneurysmal bleb was also visualized (**Fig. 3C**). Although we attempted to guide a Headway 17 (Terumo Corporation) to a point near the aneurysm using a CHIKAI 14 and insert a microwire into the

Fig. 3 Retreatment: LVIS Jr. stent placement. **(A)** Left internal carotid artery angiography 11 days after coil embolization: In the left anterior cerebral artery, vasospasm after subarachnoid hemorrhage was noted (arrowhead). The bleb and part of the aneurysm were not delineated due to thrombosis (arrow). **(B)** Left internal carotid artery angiography 23 days after coil embolization: Vasospasm of the left anterior cerebral artery was alleviated, and most of the dome in the upper part of the aneurysm was recanalized (arrow). **(C)** Left internal carotid artery angiography at retreatment (RAO 23/CRA 22): The thrombus disappeared due to the effect of antiplatelet medication (clopidogrel/aspirin), and the upper part of the aneurysm including the bleb was completely recanalized (arrow). **(D)** The LVIS Jr. stent 2.5 mm $\times$ 17 mm was deployed satisfactorily (arrow: distal end, arrowhead: proximal end). **(E)** After deployment of LVIS Jr. stent: Blood flow into the aneurysm was attenuated, and washout of the contrast medium was delayed to the venous phase. **(F)** 3 months after LVIS Jr. stent placement: The aneurysm was completely occluded (arrowheads). The parent artery at the aneurysmal neck was straightened, and endotheliogenesis was suggested (arrow). CRA: cranial; RAO: right anterior oblique

aneurysm, it was impossible. A microwire and a guidewire could be guided readily to the left A2 segment. We deployed a LVIS Jr. stent 2.5 mm $\times$ 17 mm to cover the aneurysmal neck (**Fig. 3D**) and confirmed adequate dilatation over the entire length. On angiography immediately after stent placement, blood flow to the left A1-A2 was satisfactory, and stagnation of the contrast medium in the aneurysm could be confirmed (**Fig. 3E**). No periprocedural hemorrhagic or ischemic complications were observed throughout the course. Angiography after 3 months showed complete occlusion of the residual aneurysm and patency of the left anterior cerebral artery without stenosis. In addition, the parent artery at the neck was straightened, suggesting endothelialization of the blood vessel (**Fig. 3F**). Antiplatelet therapy with 75 mg of clopidogrel and 100 mg of aspirin was continued until 6 months after the procedure and was thereafter reduced to clopidogrel alone. No neurological abnormalities were noted 1 year and 6 months after the procedure, and the modified Rankin Scale score was 0.

Discussion

In this present case, coil embolization of intracranial aneurysm was performed because of the history of craniotomy and clipping, but it was inevitable to approach the lesion via the left A1, which was hypoplastic and arose at a sharp angle. Therefore, manipulation of the microcatheter was markedly restricted, the double catheter technique or balloon assist technique could not be employed, and delicate manipulation of the microcatheter was also difficult, resulting in insufficient embolization on the initial treatment. In additional treatment for the residual aneurysm, since recoiling was difficult, methods expected to have a flow diversion effect by parent vessel occlusion or stent placement were considered. As the lesion was a remnant of ruptured intracranial aneurysm, parent artery occlusion was considered more effective if the objective was to ensure occlusion of the aneurysm, but we avoided the balloon occlusion test because of the risk of vascular damage due to balloon

catheter insertion or balloon dilatation in the narrow A1 and selected a treatment with preservation of the parent artery.

The mechanism of aneurysm occlusion by the flow diversion effect is explained as follows: A fine metal mesh stent placed at the aneurysmal neck reduces the blood flow into the aneurysm, promotes thrombus formation in the aneurysm, and induces repair of the parent artery by serving as a scaffold for endotheliogenesis.³⁾ In the PUFs study,¹⁾ in which the effect of PED placement in large internal carotid artery aneurysms proximal to the posterior communicating artery was evaluated, high therapeutic efficacy was reported with complete occlusion rates of 86.8% after 1 year, 93.4% after 3 years, and 95.2% after 5 years. However, concerning PED placement in peripheral aneurysms, although a few successful cases have been reported,^{4,5)} the use of the stent in this situation is not an approved indication at present, and its safety or efficacy has not been clarified.

In Japan, LVIS Jr. stent, which is suited to be placed in peripheral vessels, was approved in 2016. It can be guided with a microcatheter 0.017 inch in internal diameter, and as three radiopaque tantalum wires are woven in the stent, it is highly visible under fluoroscopic guidance, and permits resheathing even after deployment up to 75%. According to the report by Gupta et al.,⁶⁾ LVIS Jr. stent was placed alone as a flow diverter in 4 of 20 patients treated using the device, and complete occlusion was achieved in 3 (75%). Since LVIS Jr. stent has a small cell size of 1.5 mm and a higher metal coverage rate (about 18%) compared with conventional stents, it is considered to have a high aneurysm-obliterating effect by more effectively reducing the blood flow into the aneurysm and promoting thrombosis and endotheliogenesis in the aneurysm.

In our patient, the parent artery was narrow with a diameter of 1 mm, but there have been a few reports of placement of conventional neck bridging stents in small-diameter parent arteries. In a report of eight cases in which Neuroform was placed in parent arteries 1.1–1.8 mm in diameter,⁷⁾ the stent could be placed in all cases, but in-stent thrombosis occurred in 2 (25%). In 44 cases treated by placement of Neuroform or Enterprise in parent arteries 2 mm or smaller in diameter, stenting was successful in 93.2%, but thromboembolism occurred in 13.6%.⁸⁾ Thus, thrombotic events tended to occur frequently after stenting of small-diameter parent arteries.

Table 1 shows the recent literature concerning LVIS Jr. stent placement in peripheral vessels.^{6,9–16)} To summarize these reports, stents could be successfully placed in 99.4%,

Table 1 Literature concerning LVIS Jr. stent

Author	Year	Aneurysms (n)	Ruptured (n, %)	Distal artery diameter (range mm)	Technical success (n, %)	Initial occlusion (n, %)	Overall procedural ischemic events (n, %)	Overall procedural hemorrhagic events (n, %)	Overall permanent morbidity (n, %)
Gupta ⁶⁾	2017	20	1 (5)	1.8–2.5	20 (100)	16 (80)	0 (0)	0 (0)	0 (0)
Grossberg ⁹⁾	2016	85	17 (20)	1.2–3.5	84 (98.8)	61 (73)	1 (1.2)	3 (3.5)	2 (2.4)
Shankar ¹⁰⁾	2016	100	13 (13)	NA	100 (100)	87 (87)	14 (14)	1 (1)	3 (3)
Alghamdi ¹¹⁾	2016	43	3 (7)	1.5–3.0	43 (100)	41 (95)	1 (2.5)	2 (5)	2 (5)
Behme ¹²⁾	2015	32	12 (35)	1.1–3.4	34 (100)	22 (65)	2 (6.3)	0 (0)	2 (6.3)
Feng ^{13,14)}	2015	30	12 (40)	1.5–3.2	30 (100)	25 (83)	1 (3.3)	0 (0)	0 (0)
Samaniego ¹⁵⁾	2015	7	4 (57.1)	1.7–2.6	7 (100)	NA	1 (14.3)	0 (0)	0 (0)
Möhlenbruch ¹⁶⁾	2014	22	4 (18)	1.1–2.6	21 (95.5)	22 (100)	3 (13.6)	0 (0)	0 (0)
Total		339	19.5	1.1–3.5	99.4	82.3	6.8	1.8	2.7

NA: not applicable

and satisfactory occlusion could be achieved in 82.3%, indicating high therapeutic efficacy. While procedure-related ischemic complications were observed in 6.8%, and neurological exacerbation persisted in 2.7%, their incidences were lower than that of thromboembolism after conventional stent placement mentioned above, and LVIS Jr. stent is considered to be a safer and more effective device to be placed in small-diameter vessels.

In our patient, LVIS Jr. stent was selected as it could be guided with a small-diameter microcatheter. In consideration of the possibility of slip down of the microcatheter during stent deployment, its excellent radiovisibility and resheathability were also important. While its deployment in the parent artery of 1 mm in diameter was considered to have a high risk of in-stent thrombosis, satisfactory dilatation was obtained without thrombotic events. Shankar et al.¹⁰⁾ suggested that placement of LVIS Jr. stent in aneurysms in the acute phase of rupture increases the risk of intraprocedural complications and that such events are related to an insufficient antiplatelet loading dose. Therefore, more strict antiplatelet therapy is essential. Stenting for the treatment of ruptured intracranial aneurysms in the acute phase is an off-label use and increases the risk of ischemic complications. In our patient, therefore, we restricted the acute-phase treatment to coil embolization and performed stenting 40 days after the initial treatment following sufficient antithrombotic therapy. In the series of 43 cases reported by Alghamdi et al.,¹¹⁾ <50% in-stent stenosis developed in 17.5%, and ischemic events accompanied by neurological symptoms occurred in two cases due to discontinuation of antiplatelet medication by the patient's judgment and in one case due to clopidogrel resistance. Therefore, long-term follow-up by imaging examinations and management of antithrombotic therapy are vital.

Conclusion

Following incomplete coil embolization of ruptured anterior communicating artery aneurysm, complete occlusion of the residual aneurysm could be achieved by placing an LVIS Jr. stent. While the parent artery was narrow with a diameter of 1 mm, the stent could be successfully guided and placed, and a satisfactory outcome was obtained without complications. This technique may be an option when retreatment is necessary for aneurysms that are difficult to recoil.

Disclosure Statement

Neither the first author nor any of the coauthors have any conflicts of interest.

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