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Case Report

Treatment of Recurrent Aneurysm of the Internal Carotid Artery-poster Communicating Artery Using the Marathon Microcatheter: A Case Report

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Objective: We report the case of an aneurysm of the recurrent internal carotid artery (ICA)-posterior communicating artery (PCoA) treated using a liquid embolic delivery microcatheter (MC; Marathon).

Case Presentation: A 66-year-old female previously presented with subarachnoid hemorrhage, which had been treated using coil embolization for a ruptured ICA-PCoA aneurysm. She was referred to our hospital because the aneurysm recurred 13 years after treatment. Angiography revealed a de novo lobulated aneurysm at the ICA-PCoA bifurcation with a relatively thickened PCoA branching from the neck of the aneurysm. We performed coil embolization after stent placement with the Neuroform Atlas in the range of the ICA terminus and the PCoA. However, the coils were unequally distributed and it was necessary to navigate the MC to the aneurysm within the stent through the PCoA. We successfully approached the aneurysm using the Marathon. We additionally inserted six ED coils into the aneurysm and achieved favorable embolization.

Conclusion: The Marathon is useful for passage of a stent deployed in a small-caliber artery.

Keywords▶ internal carotid artery-posterior communicating artery aneurysm, Neuroform Atlas, Marathon catheter

Introduction

For coil embolization of cerebral aneurysms, the widespread use of the stent-assisted technique (SAT) has increased the number of patients with broad-neck aneurysm for whom this treatment is indicated.[1)] Furthermore, low-profile neck bridge stents facilitate stenting in small-caliber blood vessels.[2)] Therefore, when navigating a microcatheter (MC) to an aneurysm, there may be a situation in which it must be passed through a stent placed in a small-caliber blood vessel. The distal part of a Marathon catheter (Medtronic, Minneapolis, Minnesota, USA) is flexible, with a smaller diameter than conventional MCs for aneurysm embolization, facilitating navigation to more peripheral lesions or tortuous blood vessels. Several studies have reported coil embolization of aneurysms using a Marathon.[3–5)] We report a patient in whom a Marathon was passed through a stent inserted through the posterior communicating artery (PCoA) for coil embolization of a recurrent wide-neck aneurysm of the internal carotid artery (ICA)-PCoA.

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Case Presentation

A 66-year-old female.
Present illness: In 2006, the patient had presented with subarachnoid hemorrhage. Coil embolization of a ruptured ICA-PCoA aneurysm had been performed at another hospital and she had been discharged. Through the 13-year follow-up, magnetic resonance angiography (MRA) revealed a recurrent aneurysm (**Fig. 1A**), and she was referred to our hospital. For detailed examination, cerebral angiography was performed.
Cerebral angiography findings: On right internal carotid angiography, there was no influx of contrast medium at the previously treated site. At the ICA-PCoA bifurcation, a de

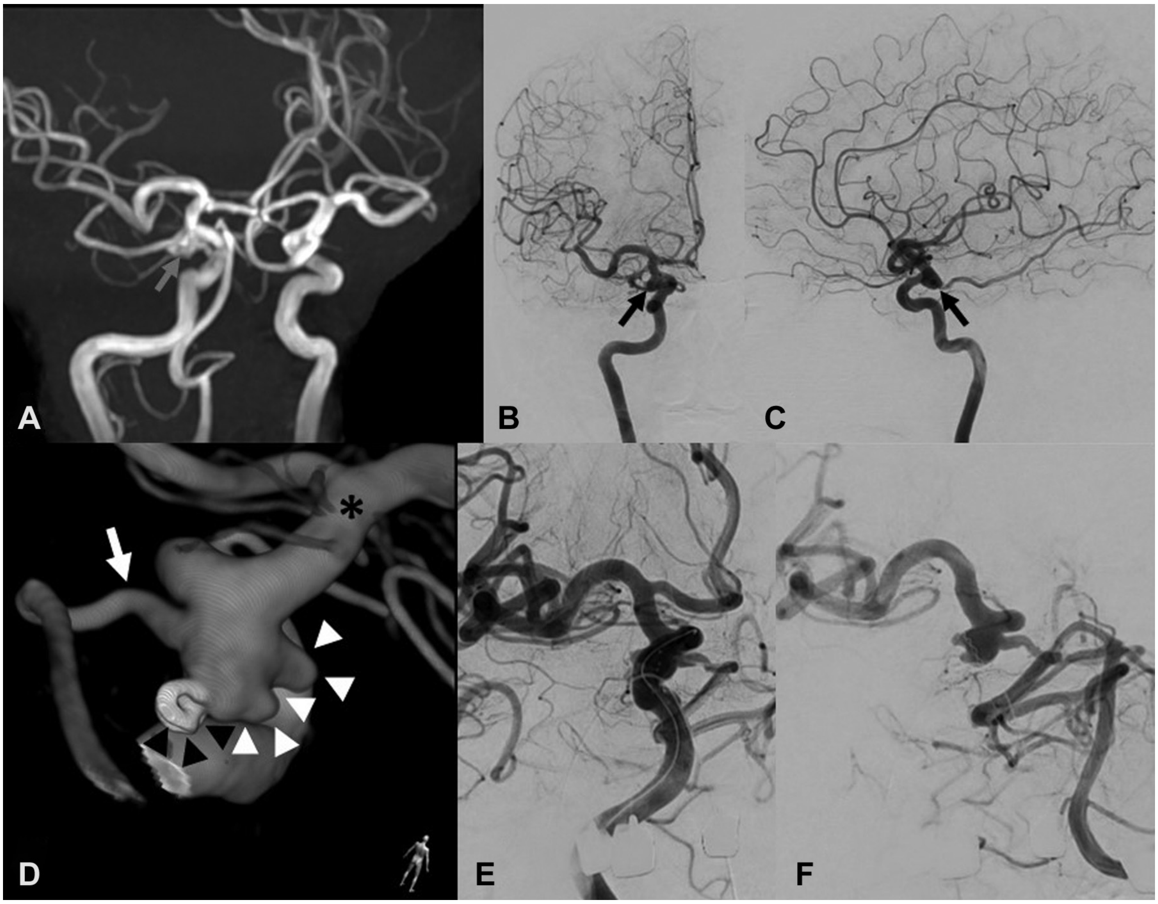

Fig. 1 (**A**) MRA shows the recurrent right ICA-PCoA aneurysm (gray arrow). (**B** and **C**) Right ICA angiography shows the aneurysm (black arrow). (**D**) 3D rotational angiography at the view behind the right ICA shows the aneurysm (white arrowhead: the de novo lobulated aneurysm, black arrowhead: the previously coiled aneurysm, white arrow: PCoA, asterisk: ICA terminus). (**E**) The aneurysm is hidden by the adjacent ICA on right ICA angiography. (**F**) Right VA angiography with interruption of the ICA blood flow by the balloon guiding catheter clearly shows the aneurysm. ICA: internal carotid artery; PCoA: posterior communicating artery; MRA: magnetic resonance angiography; VA: vertebral artery

novo lobulated aneurysm had newly developed (**Fig. 1B** and **1C**). The maximum diameter of the aneurysmal dome was approximately 7 mm and its neck measured approximately 6 mm. The relatively thick (diameter: approximately 1.5 mm) PCoA had branched from the neck like a hairpin curve (**Fig. 1D**).

We attempted the coil embolization of the recurrent aneurysm according to the patient's request. Considering the use of a stent, oral administration of clopidogrel at 75 mg was started 2 weeks before treatment, and aspirin at 200 mg was administered for loading the day before treatment.

Endovascular treatment: Under general anesthesia, an 8French (Fr) sheath was inserted into the right femoral artery and a 5Fr sheath was inserted into the left femoral artery. Systemic heparinization was conducted to achieve an activated clotting time of 300. An 8Fr Optimo (Tokai Medical Products, Aichi, Japan) was inserted into the right ICA and a 5Fr Launcher (Medtronic) was inserted into the left vertebral artery (VA). Although the aneurysm overlapped with the peripheral ICA on internal carotid angiography, the entire aneurysm was clearly visualized on vertebral arteriography, with the ICA blocked by the Optimo balloon (**Fig. 1E** and **1F**). Two SL-10 microcatheters (Stryker, Kalamazoo, MI, USA) were placed in the aneurysm through the ICA, and embolization was attempted using the double catheter technique (DAT). However, this procedure was abandoned due to deviation of the parent blood vessel and poor distribution in one of the two components of the lobulated aneurysms. Therefore, coil embolization using the SAT was selected. A Tactics (Technocrat Corporation, Aichi, Japan) was navigated into the distal left VA as an intermediate catheter and an SL-10 for stent delivery was navigated into the right middle cerebral artery through the PCoA. To avoid excessive intra-aneurysmal bulging, a portion of a Target 3D 5 mm × 10 cm was placed in the aneurysm, and a Neuroform Atlas 4 × 21 mm (Stryker) was

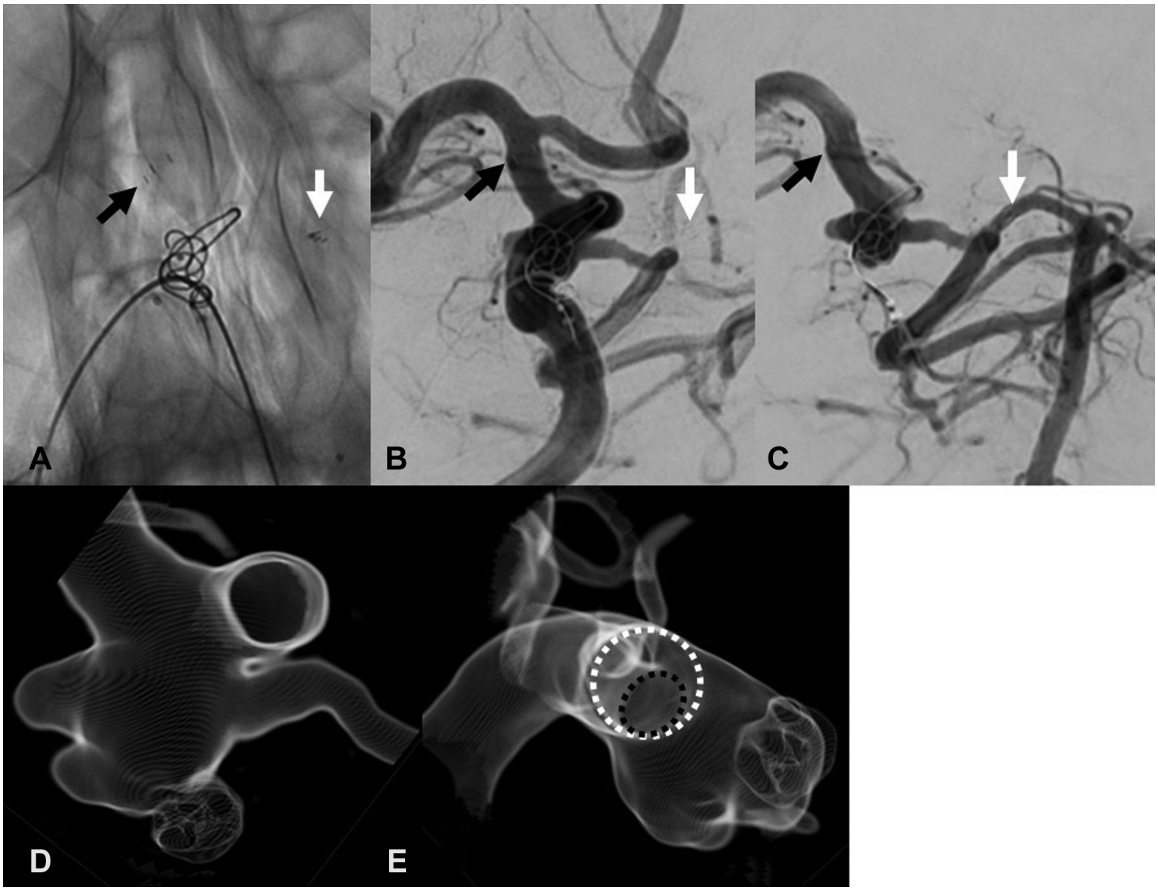

Fig. 2 (**A**) The Neuroform Atlas is placed in the range of the ICA terminus and P1, including the PCoA, after partial placement of the coil in the aneurysm. (**B**) Right ICA angiography confirms patency of the blood flow at the site of stent placement. (**C**) Right VA angiography with interruption of the ICA confirms patency of the blood flow (black arrow: distal marker of the stent, white arrow: proximal marker). (**D** and **E**) We configured the working angles based on 3D rotational angiography after placement of the stent. (**D**: working angle 1, **E**: working angle 2 (tunnel view), white dotted line: the lumen of the ICA, black dotted line: the lumen of the PCoA). ICA: internal carotid artery; PCoA: posterior communicating artery; 3D: three-dimensional

inserted in the range of the ICA terminus and P1 segment (P1) of the right posterior cerebral artery (PCA) including the PCoA (**Fig. 2A, 2B,** and **2C**). After stenting, a satisfactory working angle was established (**Fig. 2D** and **2E**). Using the SL-10 jailed in the aneurysm by this operation, coil embolization was performed, but the coil was unequally distributed in one of the two components of the aneurysm (**Fig. 3A, 3B, 3C,** and **3D**). We considered it necessary to change the position of MC insertion, and planned to navigate another MC into the aneurysm within the stent placed at the PCoA. The true lumen of the stent was captured using a Traxcess 1214 with a J-shaped end (Microvention, Tustin, California, USA) to facilitate SL-10 passage, but the SL-10 was unable to be completely passed. It was exchanged for a Marathon using a Chikai 10 300 cm (Asahi Intecc, Aichi, Japan). The Marathon was successfully passed through the stent relatively readily and inserted into the aneurysm through the stent cell. One ED extrasoft 2 mm × 3 cm and five ED extrasoft 1.5 mm × 1 cm (Kaneka, Kanagawa, Japan) were additionally inserted, and favorable embolization was achieved even in areas where coil distribution had been poor (**Fig. 3E, 3F, 3G,** and **3H**). Treatment was completed.

The postoperative course was favorable and the patient was discharged.

Discussion

A Marathon is a flow-directed catheter. Its end is flexible, with an outer diameter of 1.5 Fr. In addition, its effective length is 165 cm. The ends of conventional MCs for coil embolization of aneurysms measure ≥1.7 Fr in outer diameter and their effective length is 150 cm. Therefore, a Marathon can be navigated to peripheral small-caliber blood vessels or tortuous sites, and is primarily used for the treatment of cerebral arteriovenous malformation (AVM) or

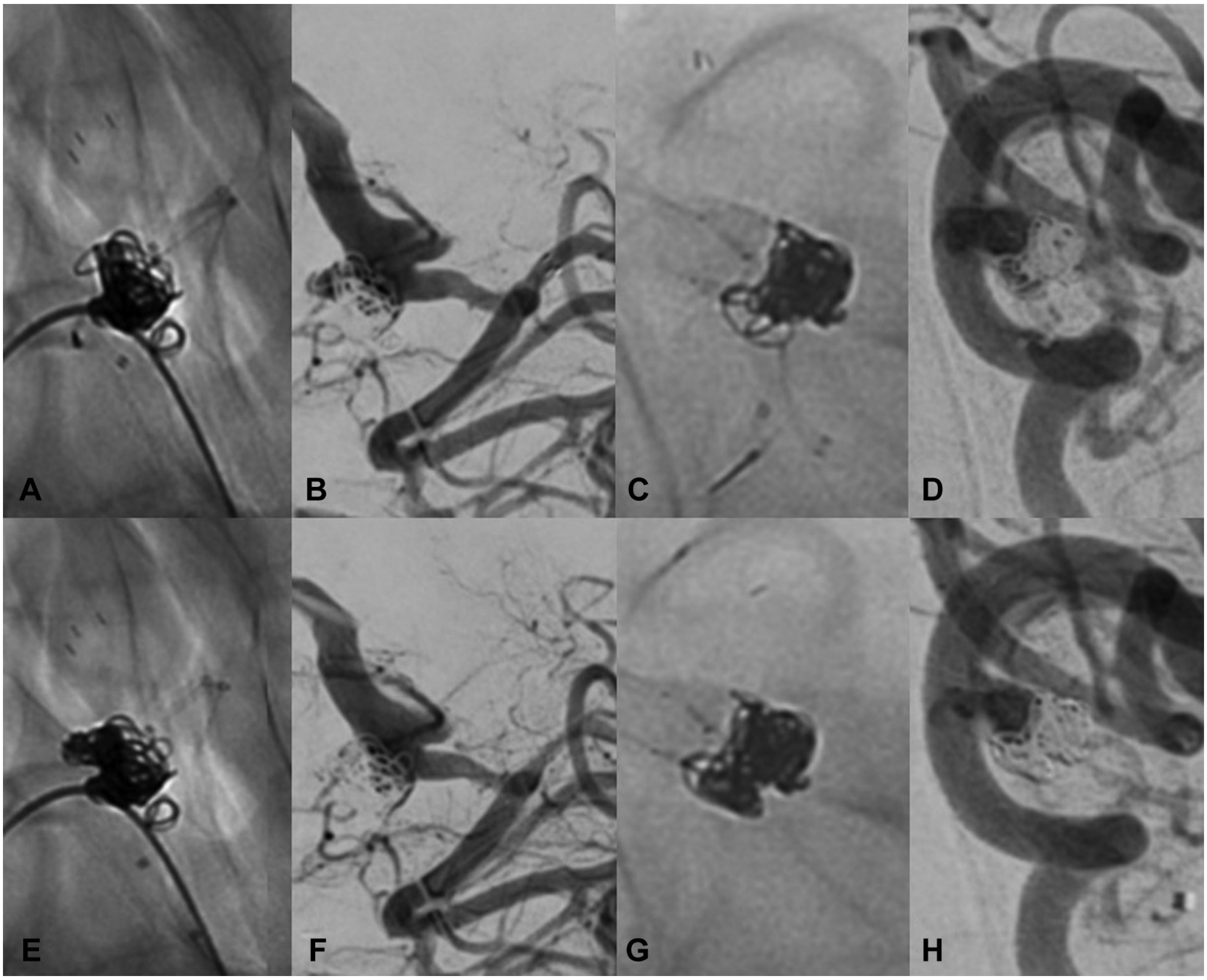

Fig. 3 (**A** and **C**) Unequal distribution of the coil in the aneurysm (**A**: working angle 1, **C**: working angle 2). (**B** and **D**) Right VA angiography shows the remaining blood flow in the aneurysm (**A**: working angle 1, **C**: working angle 2). (**E** and **G**) We inserted additional coils into the aneurysm through the Marathon. (**E**: working angle 1, **G**: working angle 2). (**F** and **H**) Right VA angiography shows favorable embolization (**F**: working angle 1, **H**: working angle 2). VA: vertebral artery

dural arteriovenous fistula (AVF). A liquid is used as the embolic material, such as ONYX (Medtronic) and n-butyl-cyanoacrylate (NBCA).[6,7] The inner diameters of a Marathon at its end and proximal part are 0.013 and 0.015 inches, respectively. According to several studies, coils for embolization of aneurysms, such as a Barricade (Blockade Medical, Irvine, CA, USA), ED extrasoft, Target ultrasoft (Stryker), and Axium (Medtronic), can be inserted. These studies reported coil embolization of AVM, AVF, and cerebral aneurysms using a Marathon.[3–5] Because the Marathon MC facilitates the use of both a liquid embolic material and coil for the same lesion via the same catheter, it is advantageous for reducing the cost and operative time.[3,4]

To our knowledge, three studies involving seven patients have reported the use of a Marathon for embolization of aneurysms[3–5] (**Table 1**). The lesion sites consisted of the anterior communicating artery in two patients, ICA terminus in one, middle cerebral artery in one, anterior inferior cerebellar artery in one, and posterior inferior cerebellar artery in two. Treatment was performed at sites to which conventional MCs were difficult to navigate. Concerning coils, a Barricade was used in four patients, Target ultrasoft in one, and ED extrasoft in two. According to these studies, coil insertion and detachment from a delivery wire were possible without complications. In one patient, stent-assisted coil embolization was performed and an MC was navigated into the aneurysm via a trans-cell route.[5] In another patient, coil embolization alone led to dome filling and NBCA was infused through the same Marathon, resulting in a favorable embolization outcome.[4] In another patient, intra-MC thrombus formation was observed and the Marathon was exchanged, requiring additional navigation.[5]

Table 1 Summary of reported cases and the present case of the use of a Marathon for embolization of aneurysms

Case no.	Authors (year)	Age; sex	Location	Rupture	Coil, diameter (mm)/ length (cm)	Stent	Other embolic material	Complication	Outcome
1	Stidd et al. (2014)	80; male	ACoA	(–)	B, 5/13, 4/7, 3/6, 2.5/6, 2.5/4	(–)	(–)	(–)	Good
2	Stidd et al. (2014)	48; male	ACoA	(+)	B, 3/6, 3/4, 2/4	(–)	(–)	clot collecting within MC	Good
3	Stidd et al. (2014)	48; female	ICA terminus	(–)	T, 3/6, 2/4	Neuroform EZ	(–)	(–)	Good
4	Horie et al. (2015)	31; female	Distal AICA	(–)	E, 16/15*, 16/10*, 1.5/2	(–)	NBCA	(–)	Good
5	Horie et al. (2015)	61; female	Distal MCA	(+)	E, 2.5/6, 1.5/3	(–)	(–)	(–)	Good
6	Beckett et al. (2016)	52; female	PICA	(+)	B, 2/2, 1/2	(–)	(–)	(–)	Good
7	Beckett et al. (2016)	53; male	PICA	ND	B, 3/6, 1.5/2 × 3	(–)	(–)	(–)	Good
8	Our case (2019)	66; female	ICA-PCoA	(–)	E, 2/3, 1.5/1 × 5	Neuroform Atlas	(–)	(–)	Good

*ED Infini extrasoft

ACoA: anterior communicating artery; AICA: anterior inferior cerebellar artery; B: Barricade; E: ED extrasoft; ICA: interanal carotid artery; MC: microcatheter; MCA: middle cerebral artery; PCoA: posterior communicating artery; PICA: posterior inferior cerebellar artery; NBCA: n-butyl-cyanoacrylate; ND: not described; T: Target ultrasoft

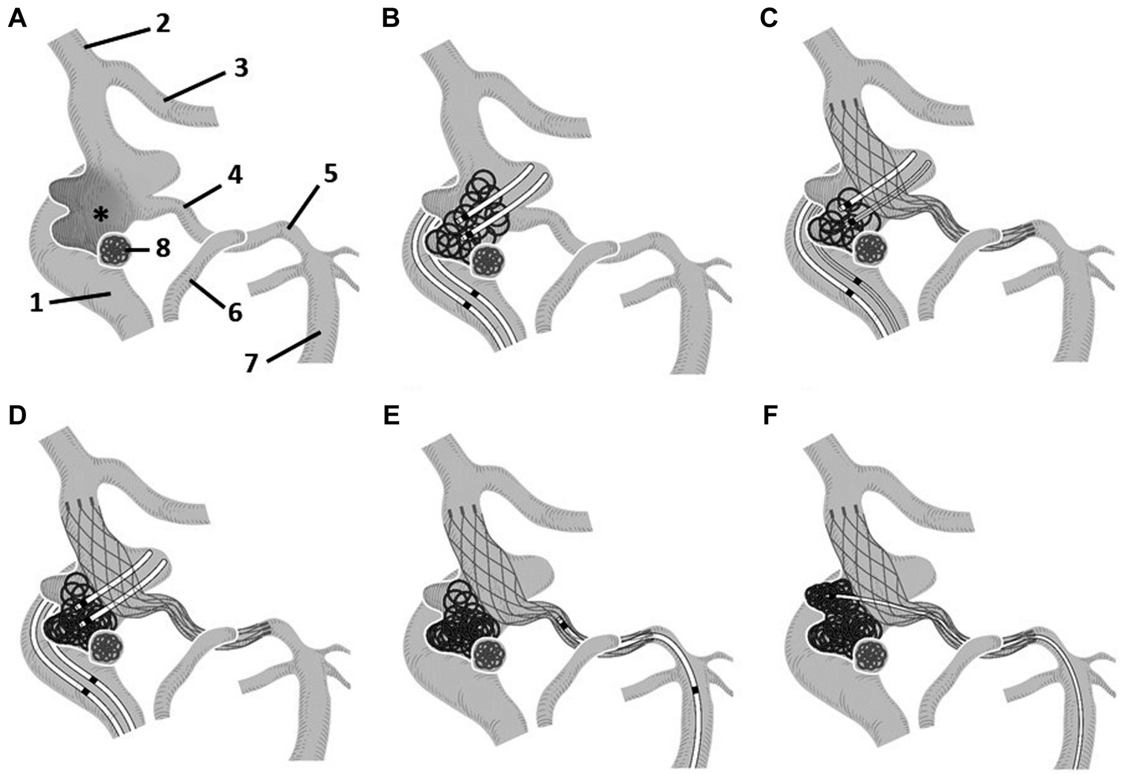

Fig. 4 Schematic illustration of coil embolization in the present case (working angle 1). (**A**) A de novo lobulated aneurysm with a wide neck was present at the ICA-PCoA bifurcation and a relatively thick PCoA branched from the neck of the aneurysm (1: ICA, 2: MCA, 3: ACA, 4: PCoA, 5: P1, 6: P2, 7: BA, 8: previously placed coils, *: the de novo aneurysm). (**B**) There was unequal distribution of the coils even though we performed coil embolization via the double catheter technique. (**C**) The Neuroform Atlas was placed in the range of the ICA terminus and P1, including the PCoA, after partial placement of the coil in the aneurysm. (**D**) There was unequal distribution even though we used the stent-assisted technique. (**E**) We were unable to navigate the SL-10 to the aneurysm within the stent through the PCoA. (**F**) We successfully approached the aneurysm using a Marathon. We inserted six additional ED coils into the aneurysm and achieved favorable embolization. ICA: internal carotid artery; PCoA: posterior communicating artery

In the present case, the following three points were considered as the limitations of coil embolization: (1) when establishing an optimal working angle, the aneurysm overlaps with the peripheral ICA (**Fig. 4A**); (2) it is necessary to embolize the lobulated aneurysm with coils uniformly; and (3) it is necessary to preserve the thick PCoA branching from the neck of the wide-neck aneurysm. The first limitation was overcome by adopting vertebral arteriography findings in an ICA-blocked state as an index when preparing road map images for embolization of the aneurysm. Regarding the second limitation, MCs were navigated to the respective components of the lobulated aneurysms for embolization with DCT. Concerning the third limitation, we considered it necessary to accurately maintain PCoA blood flow using a stent to preserve the perforating branches of the PCoA, although blood flow in the PCA area may be maintained even when sacrificing the PCoA, due to well-developed P1. The PCoA had branched from the neck of the aneurysm like a hairpin curve and MC navigating from the proximal ICA to the PCoA was considered to be difficult. Therefore, we planned to navigate an MC into the distal ICA through the VA and PCoA, and perform stenting involving the ICA terminus to the PCoA.

However, even when adopting the DAT or SAT, it was impossible to accomplish uniform intra-aneurysmal embolization by navigating an MC through the ICA (**Fig. 4B, 4C,** and **4D**). We thus thought it necessary to change the position of MC insertion. Because ICA-mediated insertion might not influence the position or direction of the MC end, we considered it necessary to insert an MC into the aneurysm through the PCoA. A Neuroform Atlas had been placed in the PCoA and it was difficult to pass an SL-10 (**Fig. 4E**), but when it was exchanged for a Marathon, it was passed readily and favorable embolization was achieved (**Fig. 4F**). Recently, the development of low-profile neck bridge stents for embolization of aneurysms has facilitated insertion into smaller-caliber blood vessels.[2] Based on our experience in this case, when an MC needs to pass through a stent placed in a small-caliber blood vessel, the Marathon MC can be useful. Furthermore, in the present case, trans-cell navigating of a Marathon into the aneurysm was readily conducted after PCoA stent passage. Stidd et al. also reported the advantages of trans-cell guiding of a Marathon into an aneurysm.[5] Even if the trans-cell approach into an aneurysm is difficult, the use of a Marathon should be attempted.

The Marathon is a one-marker MC that has no proximal markers at an area 3 cm proximal to its end, and careful operations are required for detecting the detachment point of a coil under fluoroscopic guidance.[3,5] On the other hand, an ED coil facilitates the accurate detection of a detachment point with an alarm sound. It can be readily detached in comparison with other coils when adopting a one-marker MC.[4,8] Regarding the Barricade and Target, when attaching a detachment system of the coil, it is necessary to transiently remove a rotating hemostatic valve (RHV) connected to an MC due to the length of the delivery wire.[3,5] One previous study reported that blood regurgitation into an MC related to RHV removal upon detachment when using a Barricade led to thrombus formation as a complication.[5] An ED coil can be detached without removing an RHV. From this viewpoint, an ED coil in combination with a Marathon is more advantageous than other coils.

In the present case, there was no problem regarding the navigation or insertion of an ED coil through the Marathon in comparison with the use of conventional MCs. The end of a Marathon is flexible and it kinks in tortuous lesions. Its intra-catheter device-guiding capability differs between linear and tortuous lesions. According to the results of an experiment conducted by Beckett et al., it was possible to pass ≤0.013-inch coils through linear lesions, whereas the diameter of a coil that can be passed through tortuous lesions was restricted to 0.012 inches.[3] When navigating a Marathon to a markedly tortuous site, increased resistance to navigation and insertion of a coil must be taken into consideration.

Conclusion

In the present case, stenting involving the ICA terminus to the PCoA for a broad-neck aneurysm was required to preserve the PCoA. Intra-aneurysmal coil distribution was unequal, requiring an approach into the aneurysm through a stent placed in the PCoA. The use of a Marathon facilitated stent passage. When a MC must be passed through a stent placed in a small-caliber blood vessel, the use of a Marathon may be useful.

Disclosure Statement

The authors declare no conflict of interest.

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