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Flow diverter treatment for internal carotid artery aneurysm following management of distal cerebral aneurysms: Technical note

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ABSTRACT

Background: In recent years, the effectiveness of flow diverters (FDs) for the treatment of intracranial aneurysms has been reported. While FDs are effective, their deployment involves advancing a delivery wire distally, which may pose a risk if a distal aneurysm exists within the same artery. In such cases, the delivery wire could potentially perforate the distal aneurysm. Here, we present two cases of tandem aneurysms in which an internal carotid artery (ICA) aneurysm was treated with an FD following the treatment of a distal cerebral aneurysm.
Case description: A 44-year-old woman and a 67-year-old woman underwent magnetic resonance imaging for headache or abducens nerve palsy. In both cases, two aneurysms were revealed: one at the ICA and the other either at the middle cerebral artery or the top of the ICA. Due to the risk of perforation by the delivery wire during FD deployment, the distal aneurysms were treated first—either with surgical neck clipping or stent-assisted coil embolization. One month after the initial treatment, FD placement for the ICA aneurysm was performed as planned without complications in either case.
Discussion: This is the first report where tandem aneurysms were successfully treated with treatment for distal cerebral aneurysms, followed by FDs for proximal ICA aneurysms. We emphasize the potential risk of perforation of the distal aneurysm by the delivery wire during FD placement.
Conclusion: Treatment of distal cerebral aneurysms beforehand can help ensure the safe and effective use of FDs in patients with tandem aneurysms.

1. Introduction

Historically, various surgical treatments have been employed for cavernous carotid aneurysms (CCAs).[1] In recent years, flow diverters (FDs) have emerged as a promising alternative, gradually replacing conventional treatments for CCA.[2,3] Initially in Japan, FD use was approved for internal carotid artery (ICA) aneurysms measuring 10 mm or more in maximum diameter and 4 mm or more in neck width, specifically located at the petrous segment. More recently, the efficacy of FDs for smaller, intradural aneurysms has also been reported.[4,5] Consequently, the approved indications for FD use in Japan have expanded to include aneurysms measuring 5 mm or more in diameter with wide necks located in the ICA, proximal anterior cerebral artery (ACA), middle cerebral artery (MCA), and vertebral artery (VA).

While FDs have demonstrated clinical effectiveness, their deployment requires distal advancement of the delivery wire, which poses a risk of perforation if a distal aneurysm is present within the same vascular territory. In this report, we present two cases of tandem aneurysms in which an ICA aneurysm was successfully treated with an FD following prior treatment of a distal cerebral aneurysm. This study was

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approved by the Institutional Review Board of Okayama University Hospital (1911-023), and informed consent was obtained from all patients.

2. Case description

2.1. Case 1

A 44-year-old woman with a family history of subarachnoid hemorrhage (SAH) underwent magnetic resonance imaging (MRI) due to headaches. MRI revealed two aneurysms: one at the anterior wall of the left ICA (IC-AW) and the other at the MCA. Digital subtraction angiography (DSA) demonstrated that the IC-AW aneurysm had two domes, with a maximum diameter of 6.2 mm and a neck width of 5.1 mm (Fig. 1A–C). The MCA aneurysm also had two domes, each measuring between 1 and 3 mm in diameter (Fig. 1D). The IC-AW aneurysm was situated near the anterior clinoid process.

2.2. Treatment plan

Treatment options for the IC-AW aneurysm included FD placement, stent-assisted coil embolization, and surgical neck clipping. Given the reported effectiveness of FDs, we initially planned to treat the IC-AW aneurysm using an FD. However, the advancement of the delivery wire during FD or stent placement raised concerns about potential perforation of the distal aneurysm. The MCA aneurysm had two domes with a short dome and a wide neck, making it unsuitable for endovascular treatment. Therefore, to avoid the risk of perforation during FD deployment, we decided to surgically clip the MCA aneurysm in advance, followed by FD treatment of the IC-AW aneurysm. Surgical neck clipping of the MCA aneurysm was performed first (Fig. 1E and F). During the operation, the anterior clinoid process was drilled to expose the IC-AW aneurysm. The aneurysm was found to be in close proximity to the oculomotor nerve, and the posterior aspect of the aneurysm could not be fully visualized. Given these findings, neck clipping of the IC-AW aneurysm was deemed high risk, and we opted to proceed with the original plan of FD placement. One month later, the IC-AW aneurysm was treated with FD placement along with one coil embolization as planned. Pipeline embolization device (PED; Medtronic Inc, Dublin, Ireland) sized 3.75 × 16 mm was applied. During the procedure, the delivery wire was advanced to a position near the previously clipped MCA aneurysm (Fig. 1G). Although it is not officially described, the length of the stent within the catheter is approximately two times as long as its fully deployed length. When 15.8 mm of the stent was deployed prior to full deployment, the delivery wire advanced approximately 22.2 mm from the distal end of the stent on cone-beam CT. No complications were observed during or after the procedure (Fig. 1H). At five-month follow-up, complete occlusion of the IC-AW aneurysm was confirmed.

2.3. Case 2

A 67-year-old woman underwent MRI for evaluation of abducens nerve palsy. MRI revealed two aneurysms: one was the CCA and the other was at the top of the ICA (Fig. 2A and B). DSA showed that the maximum diameter of the CCA was 19.5 mm (Fig. 2C), while the aneurysm at the top of the ICA measured 2.6 mm in maximum diameter with a neck width of 1.8 mm (Fig. 2D).

2.4. Treatment plan

We chose to treat the CCA with an FD. However, considering the movement of the delivery wire during FD placement, there was concern about potential perforation of the aneurysm at the top of the ICA. Therefore, we planned to perform stent-assisted coil embolization for the aneurysm at the top of the ICA in advance. Stent-assisted coil embolization was performed first (Fig. 2E). One month later, FD placement for the CCA was carried out as planned. PED sized 3.5 × 35 mm

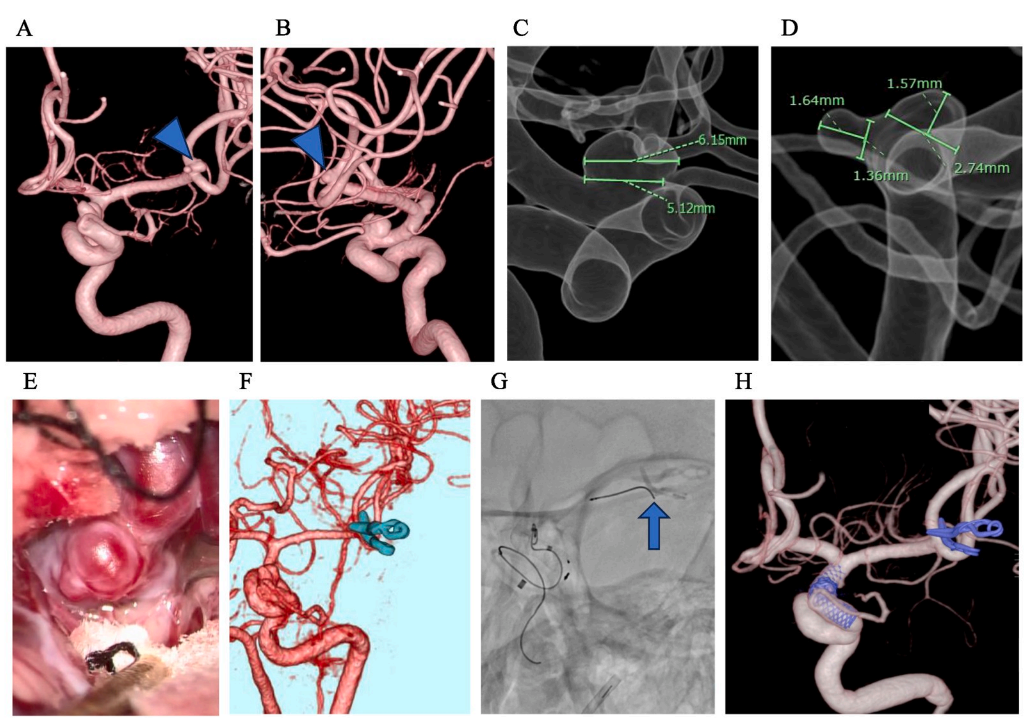

Fig. 1. (A,B) DSA revealed two aneurysms: one at the IC-AW and the other at the MCA. An arrowhead shows the MCA aneurysm (C) The IC-AW aneurysm had two domes, with a maximum diameter of 6.2 mm and a neck width of 5.1 mm (D) The MCA aneurysm also had two domes, each measuring between 1 and 3 mm in diameter (E) Intraoperative view of the MCA aneurysm (F) Surgical neck clipping of the MCA aneurysm was performed first (G) During FD placement for the IC-AW aneurysm, the delivery wire was advanced to a position near the previously clipped MCA aneurysm. An arrow shows the tip of the delivery wire (H) Treatment with FD and one coil placement for the IC-AW aneurysm was accomplished as planned.

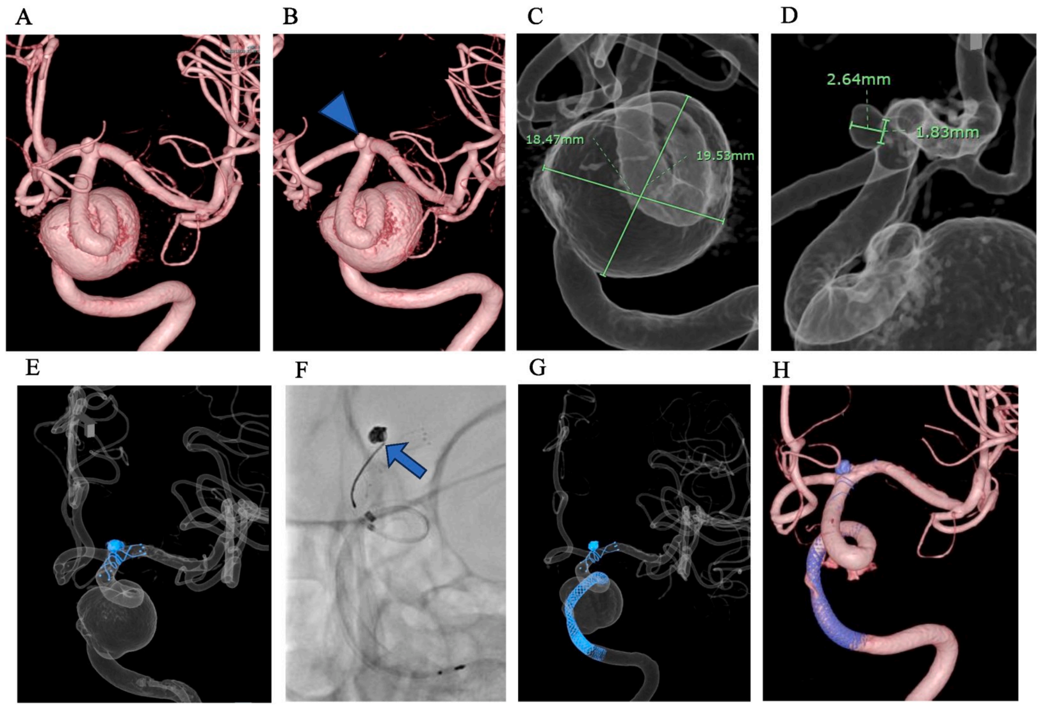

Fig. 2. (A,B) DSA revealed two aneurysms: one was the CCA and the other was at the top of the ICA. An arrowhead shows the top of the ICA aneurysm (C) DSA showed that the maximum diameter of the CCA was 19.5 mm (D) The aneurysm at the top of the ICA measured 2.6 mm in maximum diameter with a neck width of 1.8 mm (E) Stent-assisted coil embolization was performed first for the aneurysm at the top of the ICA (F) During the FD placement for the CCA, the delivery wire was advanced close to the aneurysm at the top of the ICA. An arrow shows the tip of the delivery wire (G) Treatment with FD for the CCA was accomplished as planned (H) At 11-month follow-up, DSA revealed a significant reduction in blood flow to the CCA and complete occlusion of the aneurysm at the top of the ICA.

was applied. During the procedure, the delivery wire was advanced close to the previously treated aneurysm at the top of the ICA (Fig. 2F). When 31.5 mm of the stent was deployed prior to full deployment, the delivery wire advanced approximately 25.6 mm from the distal end of the stent on cone-beam CT. No complications occurred during or after the procedure (Fig. 2G). At 11-month follow-up, DSA revealed a significant reduction in blood flow to the CCA and complete occlusion of the aneurysm at the top of the ICA (Fig. 2H).

3. Discussion

Here we present two cases where tandem aneurysms were successfully treated with either clipping or coiling for distal cerebral aneurysms followed by FDs for proximal ICA aneurysms. We emphasize the potential risk of perforation of the distal aneurysm by the delivery wire during FD placement. Preceding treatment of the distal aneurysm would provide a safe procedure.

Despite the proven benefits of FD, several complications have been documented, including ischemic stroke, aneurysm rupture, stenosis, hematoma, transient ischemic attack, and death.[6] In addition, various mechanical or device-related complications during FD placement have been reported, such as poor stent opening, inadequate wall apposition, prolapse into the aneurysm, and device migration.[7–9] These complications may result in incomplete aneurysm occlusion, ischemic stroke, or the need for additional FD deployment. These facts highlights the importance of careful FD placement.

Although a wide range of complications has been reported, perforation of a distal cerebral aneurysm by the delivery wire has not yet been described.

FD placement is performed by carefully pushing and pulling the microcatheter to optimize the mesh density of the device.[6] Advancing and withdrawing the delivery wire and microcatheter allows for better conformation of the FD along the vessel curves. It is recommended that the tip of the microcatheter be positioned at least 20 mm distal to the aneurysm. Since the delivery wire moves distally during FD deployment, the presence of an aneurysm in the distal segment of the same artery poses a risk of perforation by the delivery wire.

The length of the stent varies depending on the density of the mesh, and the advance of the delivery wire is also influenced by the position to start deploying the stent. Whlie it is difficult to argue in general, careful consideration of the position and the length of the stent is crucial. Such preparation may help avoiding the perforation of the aneurysm.

Multiple cerebral aneurysms are observed in approximately 10–30 % of patients,[10,11] with a higher incidence in women than in men. The presence of multiple aneurysms is associated with increased vulnerability and dysplastic changes in the parent artery. Although the incidence of vasospasm after SAH does not significantly differ between patients with single and multiple aneurysms, outcomes following SAH tend to be more severe in patients with multiple aneurysms.

In cases of multiple aneurysms, it is crucial to identify which aneurysm is most likely to rupture. Shojima et al reported that the largest aneurysm among multiple lesions carries the highest risk of rupture, with a sensitivity of 0.76 and specificity of 0.86.[12] They concluded that aneurysm size is a more important predictor of rupture risk than location or morphology. Therefore, treatment typically prioritizes the largest aneurysm due to its higher rupture risk. However, as demonstrated in our cases, where treating the larger aneurysm posed certain risks, it may be advisable to consider treating the smaller aneurysm first.

Treatment of tandem aneurysms presents challenges for both surgical and endovascular approaches.[13] Surgical intervention is often complicated by the dysplastic nature of the parent artery, while endovascular treatments such as coil embolization carry a risk of aneurysm perforation due to the multiple catheterizations required. Additionally, stent placement for one aneurysm may impede treatment of the adjacent lesion. Recently, FD treatment has been reported as a safe and effective option for adjacent tandem aneurysms, largely because it involves a simpler procedural approach.[14]

This report has several limitations. First, the sample size is small, which limits the generalizability of our findings. Second, the follow-up period of the patients were relatively short, which may not fully evaluate the long term outcome.

Although perforation of a distal cerebral aneurysm by the delivery wire has not been previously reported, the possibility of encountering multiple aneurysms during FD treatment does exist. In our cases, distal cerebral aneurysms were treated in advance, which effectively prevented perforation by the delivery wire during FD deployment for the proximal aneurysm. When an aneurysm is present in the distal segment of the same artery, preemptive treatment of the distal aneurysm should be considered.

4. Conclusion

We reported two cases of tandem aneurysms in which an ICA aneurysm was treated with an FD following prior treatment of a distal cerebral aneurysm. During FD placement, the delivery wire advances distally; therefore, if an aneurysm is present in the distal segment of the same artery, there is a risk of perforation by the delivery wire. Preemptive treatment of the distal cerebral aneurysm can help ensure a safer overall procedure in such cases.

CRediT authorship contribution statement

Yuichi Hirata: Writing – original draft, Data curation. **Masafumi Hiramatsu:** Writing – review & editing, Writing – original draft, Supervision, Project administration. **Kenji Sugiu:** Writing – review & editing, Supervision, Project administration, Conceptualization. **Fukiko Baba:** Writing – review & editing. **Juntaro Fujita:** Writing – review & editing, Data curation. **Yuta Sotome:** Writing – review & editing, Data curation. **Masato Kawakami:** Writing – review & editing, Data curation. **Ryu Kimura:** Writing – review & editing, Data curation. **Yuki Ebisudani:** Writing – review & editing, Data curation. **Jun Haruma:** Writing – review & editing, Supervision. **Tomohito Hishikawa:** Writing – review & editing, Supervision. **Shota Tanaka:** Writing – review & editing, Supervision, Project administration.

Generative AI

Generative AI and AI-assisted technologies were NOT used in the preparation of this work.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Kenji Sugiu reports a relationship with Medtronic Japan, Terumo Corp., and Kaneka Medical Products that includes: speaking and lecture fees. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Abbreviations

FD: flow diverter
ICA: internal carotid artery
CCA: cavernous carotid aneurysm
ACA: anterior cerebral artery
MCA: middle cerebral artery
SAH: subarachnoid hemorrhage
MRI: magnetic resonance imaging
AW: anterior wall
DSA: digital subtraction angiography
PED: Pipeline embolization device
CT: computed tomography