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Technical Note

Intentional Stent Herniation Technique Using Neuroform Atlas Stent System for Embolization of a Wide-Necked Basilar Tip Aneurysm

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Objective: Endovascular treatment for complex wide-necked basilar tip aneurysms is challenging. Multiple stenting may be an option to deal with such aneurysms; however, the risk of ischemic complications is reported to be relatively high. Here, we report a case of unruptured basilar tip aneurysm treated using the intentional stent herniation technique to preserve the aneurysmal neck branches.

Case Presentation: A 65-year-old woman presented with a growing unruptured basilar tip aneurysm associated with bilateral posterior cerebral arteries (PCAs) arising from the aneurysmal dome. We intentionally selected a large-sized Neuroform Atlas stent (Stryker, Kalamazoo, MI, USA) compared to the parent artery and deployed it along the right PCA to the basilar artery. The stent was herniated into the aneurysmal dome near the origin of the left PCA, resulting in the preservation of the left PCA. Successful coil embolization was achieved with acceptable obliteration.

Conclusion: The intentional stent herniation technique may be an effective approach to treat complex wide-necked basilar tip aneurysms.

Keywords cerebral aneurysm, coil embolization, stent herniation technique, Neuroform Atlas stent

Introduction

In wide-necked basilar tip aneurysms, bilateral posterior cerebral arteries (PCAs) and superior cerebellar arteries usually arise around the aneurysm's neck or dome. Performing dense coil embolization while preserving these vessel branches can be challenging. Although embolization with stent-assisted techniques is a promising strategy, wide-necked aneurysms with complex shapes that cannot be addressed with a single stent may require complex stenting, such as Y-configured stenting. However, careful consideration is required when applying such complex techniques due to a potential risk of thromboembolic complications.[1)]

The Neuroform Atlas (Stryker, Kalamazoo, MI, USA) stent is a self-expandable, open cell-type stent characterized with good wall apposition.[2)] Interestingly, the Neuroform Atlas stent can be herniated inside the aneurysm using a stent that is larger than the vessel's diameter.

In this report, we focus on the technical aspects of a case in which we obtained a successful coil embolization by intentionally herniating a Neuroform Atlas stent inside a wide-necked basilar tip aneurysm with bilateral PCAs arising from the dome.

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Case Presentation

Case: 65-year-old woman.
Medical history: Hypertension, type 2 diabetes, transient ischemic attack.
Current disease history: Eight years prior, the patient was hospitalized to treat a transient cerebral ischemic attack caused by the left internal carotid artery occlusion. MRI incidentally revealed a small cerebral aneurysm at the tip of

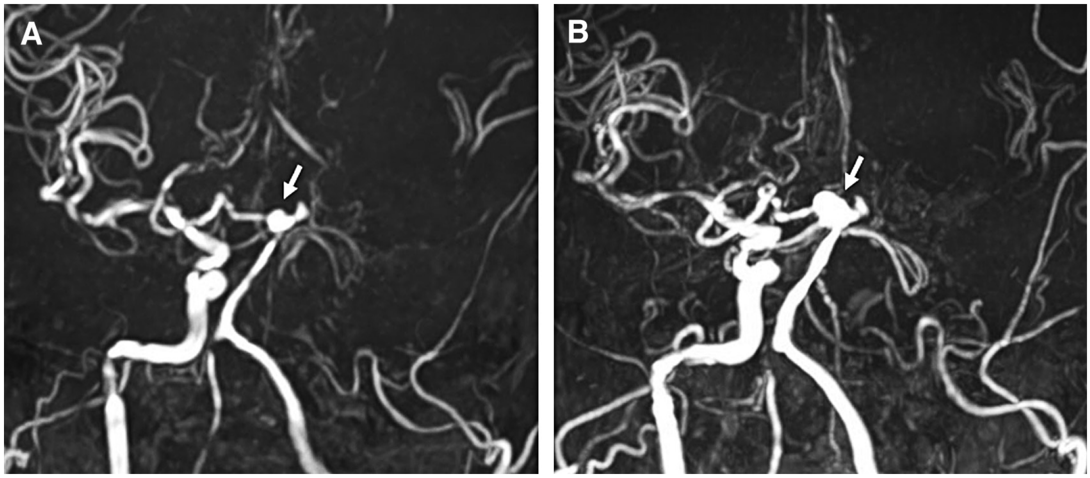

Fig. 1 Head MRA images from 8 years prior (**A**) and the current report (**B**). The basilar tip aneurysm had grown from a previous diameter of 3 mm to 7 mm in the recent image (arrows).

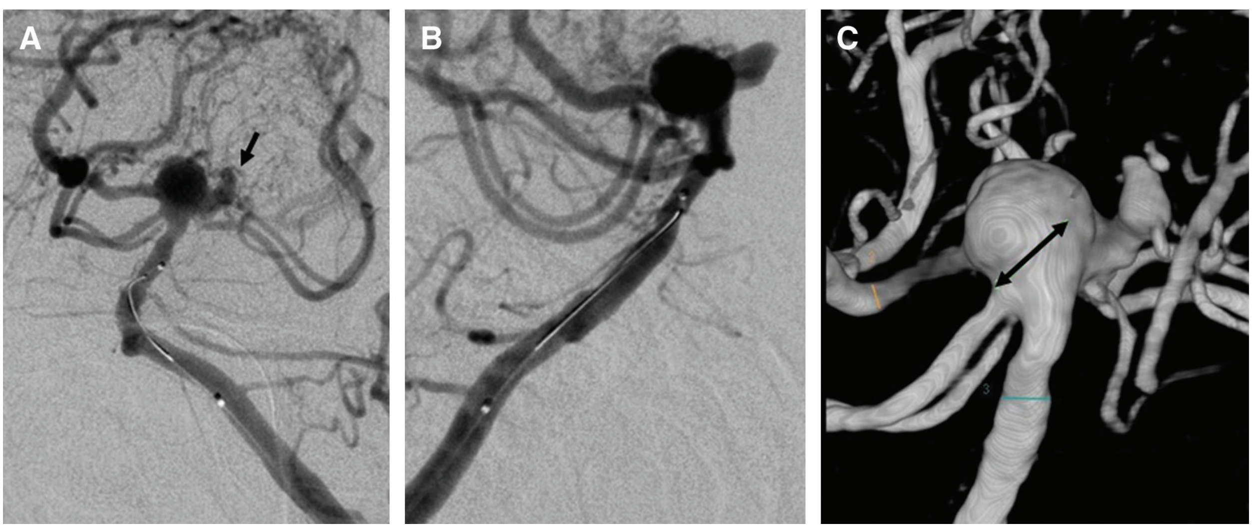

Fig. 2 Frontal (**A**) and side views (**B**) of the left vertebral artery. A wide-necked aneurysm is seen at the tip of the basilar artery, with bilateral PCAs arising from the dome. Severe stenosis is seen at the transition of the left P1-P2 segment and the origin of a dilated posterior thalamoperforating artery is observed (arrow). (**C**) 3D cerebral angiography image. The distance between the arrows is 4.5 mm (double arrow).

the basilar artery (**Fig. 1A**). Follow-up MRI showed the basilar tip aneurysm to be growing over time (**Fig. 1B**), and we decided to perform endovascular therapy for the aneurysm.

On admission: No signs of neurological deficit.

Neuroradiological findings: Cerebral angiography showed a 7.2 × 6.5 × 4.8 mm aneurysm at the tip of the basilar artery (**Fig. 2**). The aneurysm was wide-necked with bilateral PCAs arising from the dome. The right PCA branched from the dome more to the cranial side than the left PCA. Severe stenosis was observed in the transition of the left P1-P2 segment and the origin of a dilated posterior thalamoperforating artery was observed. As indicated by the previous MRI, there was an occlusion of the left cervical internal carotid artery, and the territory of the left internal carotid artery was perfused mainly via cross-flow from the anterior communicating artery. Evaluation of the posterior communicating artery (including the Allcock test) was performed; however, the artery was not visualized on both sides.

Endovascular therapy: Based on the above findings, we diagnosed the patient with an unruptured basilar tip aneurysm and left internal carotid arterial occlusion. We decided to perform stent-assisted coil embolization for the growing unruptured basilar tip aneurysm.

Endovascular therapy was performed under local anesthesia. After placing a 6-Fr sheath (Asahi Intecc, Aichi, Japan) in the right femoral artery, a 6-Fr Fubuki catheter (Asahi Intecc) was used as a guiding catheter, which was placed in the left vertebral artery (V2 segment). After deploying a Neuroform Atlas stent from the right PCA to the basilar artery, we planned to perform coil embolization with the jailing technique. First, an Excelsior SL-10 J (Stryker) microcatheter was introduced into the right PCA (P2 segment) to place the stent. Next, another Excelsior SL-10 J was placed in the aneurysm for coil embolization. The diameter of the right P1 was 1.2 mm and that of the basilar artery was 2.3 mm. Normally, a 3.0 × 30 mm Neuroform Atlas stent is chosen for this vessel diameter; however, we intentionally selected an oversized 4.5 × 30 mm stent. The aim of this was to preserve the origin of the left PCA at the dome by pushing up the neckline and herniating the stent inside the aneurysm. The 4.5 × 30 mm Neuroform Atlas stent was deployed from the right P2 segment to the middle of the basilar artery (**Fig. 3A**). Cone-beam CT confirmed herniation of the stent inside the aneurysm as planned and protection of the origin of the left PCA (**Fig. 3B**). A Target 360 Ultra 4.5 mm × 10 cm coil (Stryker) was used to form the framing, and a total of seven coils were used. The final imaging showed disappearance of the aneurysm and preservation of the bilateral PCAs (**Fig. 3C, D**).

The postoperative course was unremarkable with no neurological findings. No cerebral infarction was found by MRI the day after embolization. Seven days after surgery, the patient was discharged with a modified Rankin scale grade of 0.

Discussion

Morbidity of surgical clipping of basilar tip aneurysms is reported to be relatively high[3]; however, safer treatment is now possible thanks to remarkable progress in endovascular therapy. That being said, many basilar tip aneurysms have a wide-necked shape with a low aspect ratio (dome/neck ratio) and often require coil embolization with some kind of adjunctive technique. In particular, cases such as the present one, with a complex shape and multiple vessels branching off from the dome (PCA, superior cerebellar artery), are often difficult to treat with the usual balloon-assisted technique or the stent-assisted technique using a single stent. Y-configured stenting and other forms of complex stenting have been reported to be useful in such cases,[4] as it is possible to create a scaffold for coil embolization while preserving the branch vessels. This not only ensures placement of the coil inside the aneurysm, but it has been reported that the stent itself has a flow diversion effect and that changing the geometry of the blood vessel modifies blood flow into the aneurysm.[5] However, problems with these techniques include the complexity of the procedure and potential complications. The rate of thromboembolic complications has been reported to be over 10%,[6] which means the indications and use of these techniques should be considered carefully. Another treatment option is a collaborative approach with an extracranial–intracranial bypass, which reduces the number of vessels branching from the aneurysm that need to be preserved during endovascular treatment.[7] However, the deep bypass surgeries performed in this method are generally quite challenging.

The Neuroform Atlas stent is an open cell-type stent released in February 2017 in Japan as an improved form of the Neuroform EZ stent (Stryker). The Neuroform Atlas stent has the characteristics of lower profile delivery, better scaffolding due to smaller cell sizes, improved trackability, and higher conformability to the vessel wall than the Neuroform EZ stent. The Neuroform Atlas stent is easily deployed, can be placed simply by unsheathing a microcatheter, and has good wall apposition. By taking advantage of these features and intentionally selecting a stent larger than the parent vessel's diameter, it is possible to herniate the stent inside the aneurysm. The advantage of this intentional stent herniation technique is that cerebral aneurysms with complex shapes can be treated using a single stent, which is expected to reduce the risk of thromboembolic complications. If two branch vessels need to be preserved, the stent size should be selected by measuring the distance from the branch vessel on the side the stent is to be placed to the origin of the contralateral branch (**Fig. 2C**). On the side of the branch where the stent is to be placed, it is advantageous to select a branch that originates from a higher point on the dome of the aneurysm, which would protect the opposite branch originating from the lower point on the aneurysmal dome thanks to the herniated stent. Indeed, in the present case, we were able to preserve the origin of the contralateral PCA from the dome using a Neuroform Atlas stent herniated inside the aneurysm. On the other hand, there are a few limitations of this technique. Since Neuroform Atlas cannot be resheathed, it is difficult to perform repositioning of the stent during the deployment. The drawback of deployment of oversized stent for a smaller artery remains to be evaluated. In addition, the future studies are needed to clarify the long-term results of this technique.

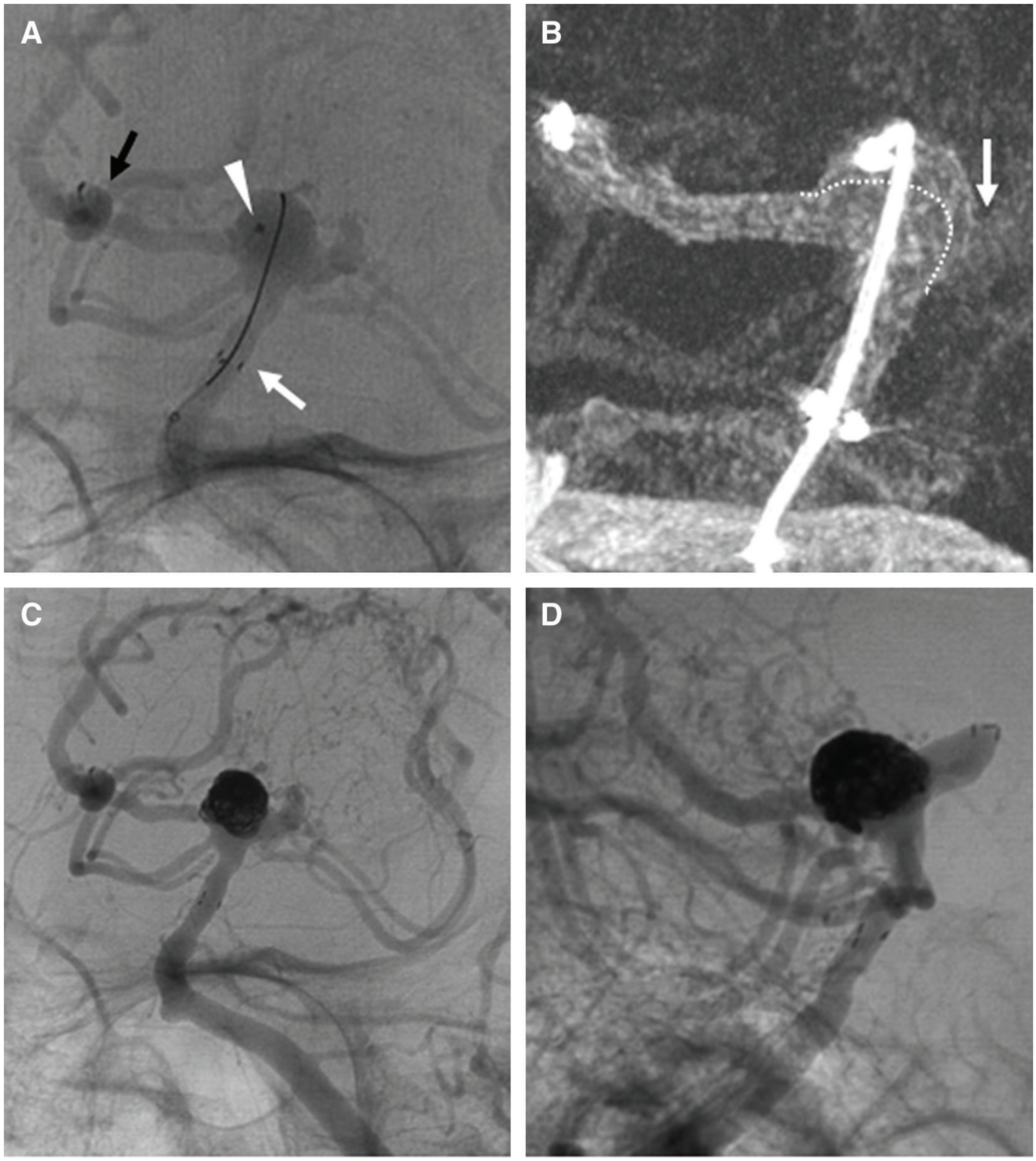

Fig. 3 (**A**) Frontal view of left vertebral artery. A 4.5 × 30 mm Neuroform Atlas stent was deployed from the right P2 segment to the middle of the basilar artery (white arrow, proximal stent tip; black arrow, distal stent tip). An Excelsior SL-10 J microcatheter was placed in the aneurysm for coil embolization (arrowhead). (**B**) Cone-beam CT. Herniation of the Neuroform Atlas stent in the aneurysm (broken line) protects the origin of the left PCA (arrow). Frontal (**C**) and side (**D**) views of left vertebral artery after coil embolization. Embolization inside the aneurysm is good and both PCAs are preserved. PCAs: posterior cerebral arteries

Several cases have recently illustrated the effectiveness of the stent herniation technique similar to our methods (**Table 1**).[8–12] Kuramoto et al. reported using Neuroform EZ stent to treat an internal carotid artery aneurysm with a posterior communicating artery branching from the dome.[11] This intentional stent herniation technique would be also possible with an LVIS braided stent (Terumo, Tokyo, Japan).[8] Visibility of the LVIS braided stent allows easy confirmation of complete stent opening and wall apposition of the stent. In addition, LVIS braided stent is resheathable and repositionable. Inoue et al.[10] described the so-called bulging technique using LVIS Jr. stent (Terumo). After pulling the microcatheter and place it in a shortcut line, the LVIS Jr. stent can be expanded by pushing the stent and the microcatheter together. Although the bulging technique using the LVIS Jr. stent would be effective, it should be noted that the deployment technique is more involved than the Neuroform Atlas stent which can be deployed by simply unsheathing the microcatheter. Furthermore, some studies have reported the higher risk of thromboembolic

Table 1 The cases of coil embolization using the intentional stent herniation technique

Author (year)	Age/Sex	Location	Size (mm)	Presentation	Stent	Branch preservation	Occlusion result	Complications
Darflinger et al. (2015)[8]	NA	MCA	8.4	Unruptured	LVIS Jr.	Yes	Neck remnant	NA
Du et al. (2016)[9]	60s/NA	ICA	12	Unruptured	LVIS Jr.	Yes	Body filling	None
	60s/NA	Basilar tip	8	Unruptured	LVIS Jr.	Yes	Body filling	None
	40s/NA	Basilar tip	11	Unruptured	LVIS Jr.	Yes	Neck remnant	None
	50s/NA	ICA	7.7	Unruptured	LVIS Jr.	Yes	Neck remnant	None
	50s/NA	AcomA	5	Unruptured	LVIS Jr.	Yes	Neck remnant	None
	40s/NA	AcomA	6	Unruptured	LVIS Jr.	Yes	Neck remnant	None
	50s/NA	Basilar tip	3	Ruptured	LVIS Jr.	Yes	Body filling	None
	50s/NA	AcomA	9	Unruptured	LVIS Jr.	Yes	Neck remnant	None
Inoue et al. (2018)[10]	74/F	Basilar tip	4.3	Ruptured	LVIS Jr.	Yes	Complete occlusion	None
Kuramoto et al. (2019)[11]	78/F	PcomA	8.3	Unruptured	Neuroform EZ	Yes	Neck remnant	None
Yamashita et al. (2020)[12]	74/F	Basilar-SCA	11	Unruptured	LVIS	Yes	Neck remnant	None
Present case	65/F	Basilar tip	7.2	Unruptured	Neuroform Atlas	Yes	Neck remnant	None

AcomA: anterior communicating artery; ICA: internal carotid artery; MCA: middle cerebral artery; NA: not available; PcomA: posterior communicating artery; SCA: superior cerebellar artery

complications than the Neuroform Atlas stent.[13] Therefore, we recommend to use the LVIS braided stent in case the distance between the orifice of the branch and the opposite wall is over 4.9 mm because the maximum opening of the Neuroform Atlas stent is 4.9 mm in contrast to 5.5 mm with the LVIS stent. Otherwise, we recommend to choose the Neuroform Atlas to accomplish the intentional stent herniation technique in consideration of the easy deployment and presumably lower risk of thromboembolic complications.

Conclusion

We believe intentional stent herniation using a Neuroform Atlas stent can be an effective treatment strategy for wide-necked basilar tip aneurysms with complex shapes, since treatment can be performed with a single stent.

Disclosure Statement

The authors declare that they have no conflicts of interest.

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