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Case Report

# Hemodynamic Change due to Vessel Straightening Immediately after LVIS Jr. Deployment for an Anterior Communicating Artery Aneurysm

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**Objective:** Stent-assisted coil embolization for cerebral aneurysms may lead to straightening of the parent vessel. However, detailed reports documenting the hemodynamic change in bifurcation type aneurysms due to straightening of the parent vessel immediately after stent deployment are scarce.

**Case Presentation:** A 48-year-old woman with a history of polycystic kidney disease underwent aneurysm neck clipping with left frontotemporal craniotomy for a ruptured bifurcation-type anterior communicating artery (AComA) aneurysm. Angiography 18 days after clipping showed a recurrent AComA aneurysm, for which stent-assisted coil embolization was performed. Straightening of the parent vessel immediately after deployment of a low-profile visualized intraluminal support junior (LVIS Jr.) stent from the AComA to the A1 segment of the right anterior cerebral artery was confirmed by working projection angiography. The aneurysm was easily embolized with coils with the support of the stent covering the aneurysm neck. The embolization was finished with a slight dome filling of the aneurysm. The parent vessel angle in 3D angiography changed from 90° before stent deployment to 160° immediately after stent deployment. Angiography 2 months after embolization showed the aneurysm with a complete occlusion and the parent vessel angle of 170° in a 3D image.

**Conclusion:** The hemodynamic change in a bifurcation-type AComA aneurysm due to straightening of the parent vessel immediately after the LVIS Jr. stent deployment led to the covering of the aneurysm neck, resulting in good coil embolization, to which the vessel mobility and the stenting method may have contributed.

**Keywords** ▶ aneurysm, coil embolization, LVIS, hemodynamic change, vessel straightening

## Introduction

Stent-assisted coil embolization for cerebral aneurysms has been reported to straighten the parent vessels over time.[1–6] However, detailed reports documenting the hemodynamic change in bifurcation-type aneurysms due to straightening of the parent vessel immediately after stent deployment are scarce. In a case of subarachnoid hemorrhage (SAH) due to a ruptured bifurcation-type anterior communicating artery (AComA) aneurysm, we performed craniotomy aneurysm neck clipping. We performed a low-profile visualized intraluminal support junior (LVIS Jr.) device (Terumo, Tokyo, Japan) stent-supported coil embolization for the aneurysm that recurred in a short period after the surgery. Herein, we report for the first time a case in which the parent vessel was straightened immediately after stent deployment, and the aneurysm changed hemodynamically.

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## Case Presentation

### History and examination

A 48-year-old woman with a history of polycystic kidney disease presented with headaches and impaired consciousness. The patient had a Glasgow Coma Scale score of 12 and no focal neurological deficits. Head CT showed SAH in the left-dominant basal cistern and sylvian fissure (**Fig. 1A**). 3D-CTA revealed a bifurcation-type AComA aneurysm (dome 1.7 mm, neck 1.8 mm, and height 1.9 mm) in the right A1–A2 junction and a right internal carotid artery aneurysm at the bifurcation of the posterior communicating artery (**Fig. 1B**). A left frontotemporal craniotomy was performed because the AComA aneurysm was judged to have ruptured based on the distribution of SAH. Intraoperative findings also showed that the AComA aneurysm was ruptured. The aneurysm was completely occluded by aneurysm neck clipping (**Fig. 1C**). 3D-CTA 4, 9, and 13 days after clipping showed no apparent recurrence of the AComA aneurysm (**Fig. 1D**). Angiography 18 days after clipping showed a recurrent bifurcation-type AComA aneurysm (dome 3.23 × 2.37 mm, neck 2.46 mm, and height 1.81 mm; **Fig. 2A**). The arterial diameter of the right A1 segment, right A2 segment, AComA, and left A2 segment of the anterior cerebral artery were 2.1 mm, 2.0 mm, 1.6 mm, and 1.6 mm, respectively. Recurrence of the bifurcation-type AComA aneurysm was observed in a short period from aneurysm neck clipping, and we judged that complete occlusion was challenging just by embolizing the coil. Therefore, we attempted stent-assisted coil embolization with the aim of flow diversion to straighten the parent vessel. As a coil-assist stent, LVIS Jr. stent was selected for its effect of straightening the parent vessel and the patient's vessel diameter. Since there was a bend at the left A2 segment–AComA junction, we attempted to deploy the stent from the AComA to the right A1 segment to cover the aneurysm neck. A total of 200 mg of aspirin and 300 mg of clopidogrel were administered orally 21 days after clipping, which was immediately before the endovascular surgery.

## Endovascular surgery

Under general anesthesia, an 8-Fr guiding catheter was placed in the cervical portion of the right internal carotid artery via the right femoral artery and a 6-Fr distal access catheter (Cerulean; Medikit, Tokyo, Japan) in the petrous portion of the right internal carotid artery. A microcatheter (Headway 17; Terumo) was advanced from the right A1 segment via the AComA to the left A2 segment of the anterior cerebral artery for the stent deployment. Working projection angiography showed straightening of the parent vessel from the AComA to the right A1 segment (**Fig. 2B**). Subsequently, another microcatheter (Excelsior SL-10 straight; Stryker, Fremont, CA, USA) was placed in the AComA aneurysm. One loop of Target 360 Nano 2.0 mm × 3.0 cm (Stryker) was placed in the aneurysm to improve the visibility of the microcatheter. An LVIS Jr. 2.5 mm × 17 mm was deployed from the AComA to the right A1 segment using a wire-push procedure, where straightening of the parent vessel occurred and caused the hemodynamic change in the aneurysm, which was confirmed by working projection angiography (**Fig. 2C**). The aneurysm was embolized with one Target 360 Nano 2.0 mm × 3.0 cm, three Target 360 Nano 1.5 mm × 2.0 cm, and one Target Helical Nano 1.5 mm × 2.0 cm using the jailing technique. The embolization was finished with a slight dome filling of the aneurysm (**Fig. 2D** and **2E**). The parent vessel angle in 3D angiography changed from 90° before stent deployment to 160° immediately after stent deployment (**Fig. 3A**–**3C**).

## Postoperative course

The postoperative course was uneventful, and the patient was discharged from the hospital 33 days after the onset without any neurological deficit. Working projection angiography 2 months after embolization, which was performed during the embolization of another aneurysm, showed the parent vessel remaining straight and the complete aneurysm occlusion (**Fig. 2F**). 3D angiography showed the parent vessel angle further straightening to 170° (**Fig. 3D**).

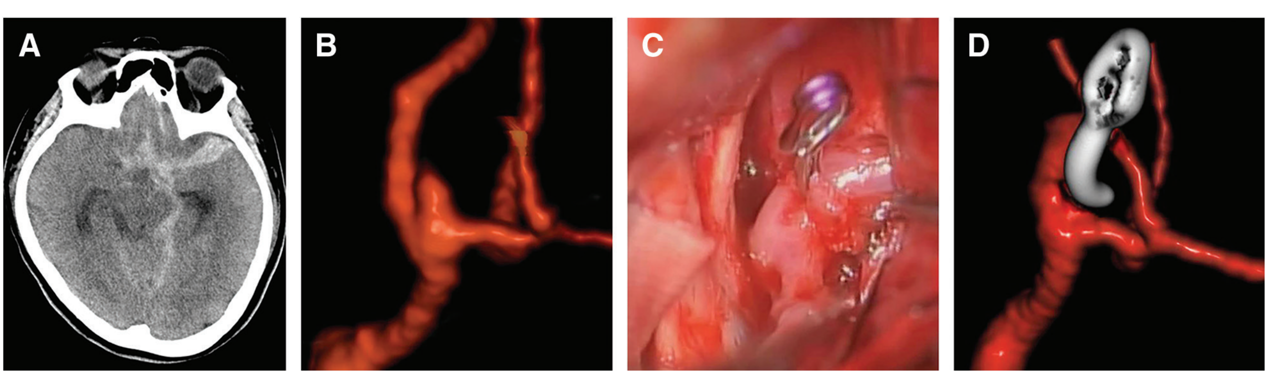


**Fig. 1** (**A**) Head CT at the onset showing SAH in the left-dominant basal cistern and sylvian fissure. (**B**) 3D-CTA at the onset showing a bifurcation-type AComA aneurysm at the right A1–A2 junction of the anterior cerebral artery. (**C**) An intraoperative microscopic image showing complete occlusion of the AComA aneurysm by neck clipping. (**D**) 3D-CTA 4 days after neck clipping showing complete occlusion of the AComA aneurysm. AComA: anterior communicating artery; SAH: subarachnoid hemorrhage

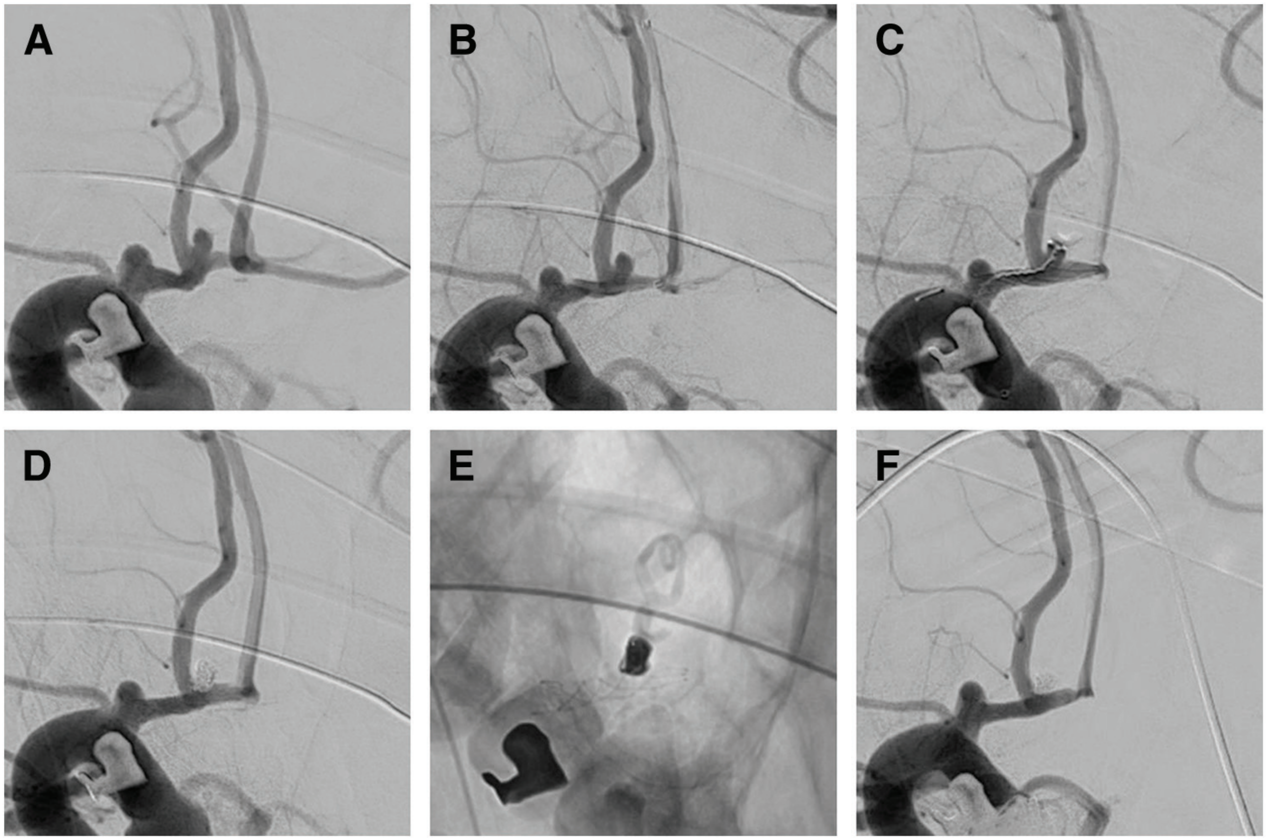


**Fig. 2** Working projection angiography. (**A**) Angiography before embolization showing a recurrent bifurcation-type AComA aneurysm. (**B**) Angiography after guiding a Headway 17 to the left A2 segment showing straightening of the parent vessel from the AComA to the right A1 segment. (**C**) Angiography immediately after deploying an LVIS Jr. 2.5 mm × 17 mm from the AComA to the right A1 segment showing straightening of the parent vessel from the AComA to the right A1 segment. (**D**) Angiography after embolization showing a slight dome filling of the aneurysm. (**E**) Native image after embolization showing a coil mass in the aneurysm and a straightened LVIS Jr. in the parent vessel. (**F**) Angiography 2 months after embolization showing the parent vessel remaining straight and the complete aneurysm occlusion. AComA: anterior communicating artery; LVIS Jr.: low-profile visualized intraluminal support junior

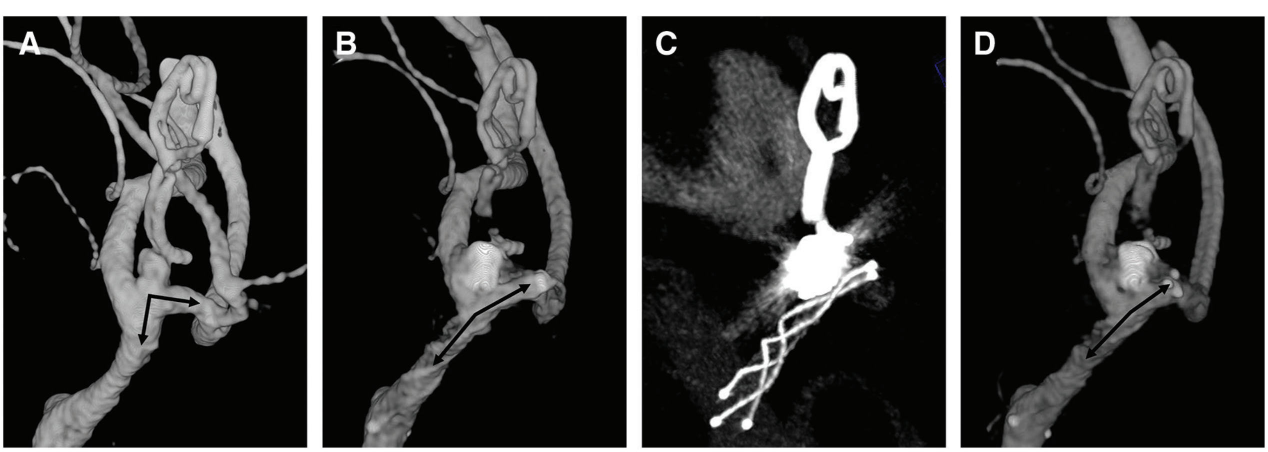


**Fig. 3** Changes in parent vessel angles in 3D angiography. (**A**) The parent vessel angle before stent deployment was 90°. (**B**) The parent vessel angle immediately after deploying LVIS Jr. and embolizing the aneurysm was 160°. (**C**) Cone-beam CT immediately after deploying LVIS Jr. and embolizing the aneurysm reveals that the LVIS Jr. was nearly straight. (**D**) The parent vessel angle 2 months after embolization was 170°. LVIS Jr.: low-profile visualized intraluminal support junior

## Discussion

The hemodynamic changes caused by the straightening of the parent vessel over time due to stent deployment increase the occlusion rate of the aneurysm over time. This effect leads to a decrease in the recanalization rate.[1,4] An investigation using computational fluid dynamics has revealed an increase in hemodynamic parameters due to the vessel deformation caused by stent straightening in bifurcation aneurysms.[7] In the present case, the parent vessel was straightened immediately after stent deployment, which caused a hemodynamic change in the aneurysm. Compared to the case where the parent vessel is not straightened immediately after the stent deployment, the straightening of the parent vessel allows most of the aneurysm neck to be covered with the stent. Therefore, the stent prevented the coils from escaping into the parent vessel and made it easier to fill the coils into the aneurysm in the present case. The aneurysm neck can be covered with the stent by the bulging technique using system-push and wire-push procedures at the aneurysm neck.[8] However, since the angle at which the anterior cerebral artery branches from the internal carotid artery is relatively steep, using the bulging technique for AComA aneurysms may be challenging because the microcatheter can be moved to the middle cerebral artery through the system-push procedure.

In the present case, there were several key factors associated with vessel mobility that may have contributed to straightening of the parent vessel after stent deployment. The smaller the vessel diameter, the more significant the change in the parent vessel angle after stent deployment, and any changes in the parent vessel angle after stent deployment for aneurysms in the AComA are more prominent than those in other sites.[2] Furthermore, since the AComA complex is not fixed by the bone structure, it has high vessel mobility associated with stent deployment.[4] In the present case, the AComA complex was detached from the surrounding tissue during the clipping so that the AComA complex may have been more mobile. In addition, since the patient was relatively young, no arteriosclerotic changes in the AComA complex were observed during the clipping, and the vessel mobility was high. In addition, because the aneurysm size was small, it seems that the AComA complex, including the aneurysm vessel, was highly mobile.

The force of the self-expanding shape memory alloy stent to return to its original stent shape straightens the stent-deployed parent vessel.[2] The force with which the stent expands is called the radial force, and the force required for the stent to bend with respect to the vertical axis is called the axial force.[9] That is, the larger the axial force, the stronger the straightening force of the stent. In the present case, an LVIS Jr. 2.5 mm × 17 mm was selected because the vessel diameters of the AComA and the right A1 segment scheduled for the stent deployment ranged from 1.6 mm to 2.1 mm. The straightening effect of the parent vessel in AComA aneurysm was significantly different between the stents and compared to Neuroform EZ (Stryker, Kalamazoo, MI, USA) and Neuroform Atlas (Stryker, Fremont, CA, USA), Enterprise

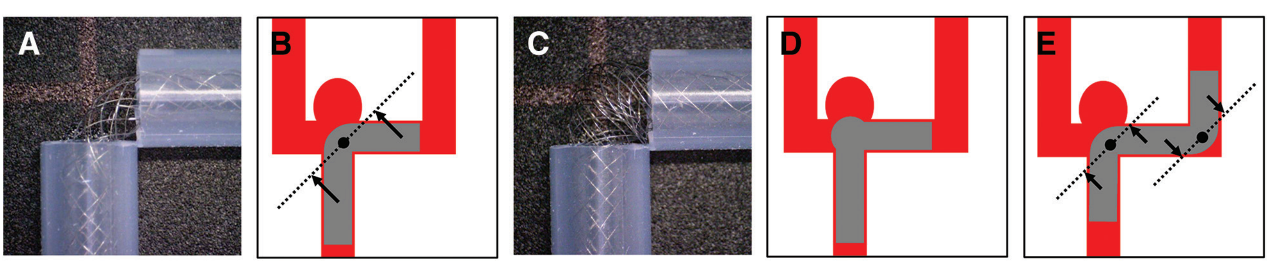


**Fig. 4** Photos and speculative images of LVIS Jr. stent deployment from a bench experiment using a silicone tube. (**A**) When an LVIS Jr. is deployed using a wire-push procedure in a silicone tube flexed 90° in a state where the Headway 17 is easy to kick back, it is deployed at the 90° bend without expanding and shortening. (**B**) B shows a stent-deployed schema like A. It is considered that the force to straighten the stent is applied to the proximal side and the distal side of the bent part (large dot) of the stent. The dotted line shows the position where the stent returns to its original shape with the dot at the fixed center. The arrows show the direction of the force that the stent straightens. (**C**) When an LVIS Jr. is deployed using wire-push and system-push procedures in a silicone tube flexed 90°, it expands and shortens at the 90° bend. (**D**) D shows a stent-deployed schema like C. When the bent part of the stent is fixed in the artery, this part works like a hinge, so little force may be applied in the direction in which the stent is straightened. (**E**) When an LVIS Jr. is deployed from the left A2 segment of anterior cerebral artery, the stent passes through two bends, the left A2 segment—AComA junction and the AComA–right A1 segment junction. The force is applied to the proximal and distal sides of each bend in the direction in which the stent is straightened. Still, the straightening force is applied in the opposite direction to the AComA, so the straightening effect of the AComA may be weakened. The dotted lines show the position where the stent returns to its original shape with the dot at the fixed center. The arrows show the direction of the force that the stent straightens. AComA: anterior communicating artery; LVIS Jr.: low-profile visualized intraluminal support junior

(Cordis Neurovascular Inc., Miami, FL, USA) and LVIS Jr. significantly change the parent vessel angle.[4] In addition, among the self-expanding stents, the nitinol-braided stent had the highest axial force.[9] Therefore, the straightening effect of LVIS Jr. on the parent vessel seems to be relatively strong.

Laser-cut stents from Neuroform Atlas and Enterprise are usually deployed using unsheath procedures. On the other hand, braided LVIS Jr. stent is deployed by combining unsheath, resheath, system-push, system-pull, wire-push, and wire-pull procedures.[10] When an LVIS Jr. is deployed using a wire-push procedure in a state where a Headway 17 is easy to kick back, as in the present case, it is deployed at a 90° bend without expanding and shortening (**Fig. 4A** and **4B**). In the present case, it is considered that the force to straighten the stent is applied to the proximal side and the distal side of the bent part of the stent. Conversely, when an LVIS Jr. is deployed using wire-push and system-push procedures at a bending part of the vessel, it expands and shortens at the 90° bend (**Fig. 4C** and **4D**). When the bending part of the stent is fixed in the artery, this part works as a hinge, so little force may be applied in the direction in which the stent is straightened. In the present case, when an LVIS Jr. is deployed from the left A2 segment of the anterior cerebral artery, the stent passes through two bends, the left A2 segment–AComA junction and the AComA–right A1 segment junction. The force is applied to the proximal and distal sides of each bend in the direction in which the stent is straightened. Still, the straightening force is applied in the opposite direction to AComA, so the straightening effect of AComA may be weakened (**Fig. 4E**).

The factors that predict the degree of straightening of the parent vessel due to stent deployment include age, arterial diameter, degree of arteriosclerotic change, aneurysm-peripheral detachment operation, aneurysm site, pretreatment bifurcation angle, coil size, stent type and size, and stent deployment position and method.[11] In the present case, working projection angiography after guiding the microcatheter for stent deployment had already changed hemodynamically. Therefore, judging from the angiography findings following the microcatheter insertion, straightening the parent vessel immediately after stent deployment can be predicted. It may be an index to determine the stent type, stent size, and stent deployment position, and deployment method to be selected.

## Conclusion

The hemodynamic change in a bifurcation-type AComA aneurysm due to straightening of the parent vessel immediately after LVIS Jr. stent deployment led to the covering of the aneurysm neck, resulting in good coil embolization, to which the vessel mobility and the stenting method may have contributed.

## Consent

Written informed consent was obtained from the patient for publication of this case report and all accompanying images.

## Disclosure Statement

The authors declare that they have no conflicts of interest.

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