Three Cases with Wide-necked Cerebral Aneurysms in Whom the T-stent Technique Was Useful

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Purpose: We report three patients with wide-necked cerebral aneurysms in whom the T-stent technique with a low-profile visualized intraluminal support (LVIS) Jr. was useful, and review its usefulness and tips.

Case Presentations: Case 1: A 75-year-old male with a left internal carotid-posterior communicating (IC-PC) aneurysm (maximum diameter: 11 mm, neck diameter: 7.0 mm). The posterior communicating (P-com; 2.3 mm) had branched from the aneurysmal dome. Stent-assisted coil embolization (SACE) was performed by inserting an LVIS Jr. 3.5 × 28 on the fetal-type posterior cerebral artery (PCA). P-com side and an LVIS Jr. 3.5 × 18 on the internal carotid artery (ICA) side (T-stent technique).

Case 2: An 80-year-old female with a right IC-PC aneurysm (maximum diameter: 6.0 mm, neck diameter: 5.4 mm). The P-com (2.2 mm) had branched from the aneurysmal dome. SACE was performed by inserting an LVIS Jr. 2.5 × 13 on the fetal-type PCA. P-com side and a Neuroform Atlas 4.5 × 21 on the ICA side.

Case 3: A 61-year-old female with a left vertebral artery (VA)-posterior inferior cerebellar artery (PICA) aneurysm (maximum diameter: 6.4 mm, neck diameter: 5.6 mm, PICA diameter: 2.2 mm). SACE was performed by inserting an LVIS Jr. 2.5 × 13 on the PICA side and an LVIS Blue 4.5 × 23 on the VA side.

Conclusion: The T-stent technique with an LVIS Jr. was useful for achieving neck formation for a wide-necked aneurysm directly branching from an aneurysm or preserving branches measuring ≥2 mm in diameter. We reported its tips.

Keywords ▶ T-stent technique, stent-assisted coil embolization, large broad-necked aneurysm

Introduction

Recently, adjunctive techniques of endovascular treatment, such as the stent and balloon technique,1 Y-configuration technique,2,3 and kissing Y-configuration technique,4 for wide-necked cerebral aneurysms, which are difficult to treat using simple techniques, have been developed.5 According to several case reports, the T-stent technique facilitated coil embolization of cerebral aneurysms at the internal carotid artery-posterior communicating (IC-PC) artery bifurcation.6 In this study, we report three patients with wide-necked cerebral aneurysms in whom the T-stent technique using a low-profile visualized intraluminal support (LVIS) Jr. (Terumo Corporation, Tokyo, Japan) on the branching vessel side was useful, and review the details of this procedure and tips.

Case Presentations

Case 1: A 75-year-old male.

Present illness: MRI for detailed examination of old cerebral infarction revealed an unruptured cerebral aneurysm at the left IC-PC. Its maximum and neck diameters were 11 and 7.0 mm, respectively. The posterior communicating (P-com) artery measuring 2.3 mm in diameter had branched from the double-lobular aneurysmal dome. It was necessary to preserve the P-com with the fetal-type posterior cerebral artery (PCA) (Fig. 1A).

Course after admission: The possibility that stent-assisted coil embolization (SACE) may be selected when coil
Fig. 1  DSA during operation for Case 1. (A) Preoperative left internal carotid angiogram shows a large broad-necked artery P-com aneurysm. P-com is arising from the aneurysmal dome. (B) Angiogram after LVIS Jr. 3.5 × 28 deployment. Arrow: proximal marker of the stent. (C) Angiogram after LVIS Jr. 3.5 × 18 deployment. Arrow: proximal marker of the stent. (D) Final angiogram shows neck remnant of the aneurysm. (E) Postoperative angiogram at 13 months shows no recurrence of the aneurysm. LVIS: low-profile visualized intraluminal support; P-com: posterior communicating
embo\lization with a simple technique is difficult was explained to the patient and his family. After obtaining informed consent, the administration of aspirin at 100 mg and clopidogrel at 75 mg was started 1 week prior to endovascular surgery. To evaluate platelet responsiveness, the aspirin-reaction unit (ARU), P2Y12 reaction unit (PRU), and % inhibition were measured using a VerifyNow system (Accumetrics, Inc., San Diego, CA, USA) the day before surgery, and the values were confirmed to be within the effective ranges in reference to previous studies.\textsuperscript{7–9)}

Endovascular treatment: Under general anesthesia, puncture was performed through the right brachial artery, and a 6 Fr Roadmaster (Goodman Co., Ltd., Aichi, Japan) was inserted into the distal right internal carotid artery (ICA). Subsequently, an Excelsior SL-10 J-shaped (Stryker, Fremont, CA, USA) was guided into the P-com using a GT12 double angle guidewire (Terumo Corporation), and an LVIS Jr. 3.5 × 28 was deployed. At this point, positioning was carefully conducted so that a portion of the radiopaque marker of the stent’s proximal flare might appear on the ICA side, considering stent shortening (Fig. 1B). Subsequently, an Echelon10 (Medtronic, Minneapolis, MN, USA) was guided into the lateral double-lobular aneurysm using a GT12 90° guidewire (Terumo Corporation), and coil embolization with an AXIUM 3D (Medtronic) was performed. As coil deviation to the ICA side was observed during this procedure, the coil was removed, and the T-stent technique was selected. Arteriosclerosis was marked, making it difficult to guide a new microcatheter. Therefore, the above Echelon10 was guided into the middle cerebral artery (MCA) using a GT12 guidewire so that it might wait for an LVIS Jr. 3.5 × 18. In addition, the above Excelsior SL-10 J-shaped was guided into the medial double-lobular aneurysm using a GT12 guidewire, and an LVIS Jr. 3.5 × 18 was inserted on the ICA side so that the aneurysmal neck might be covered, with 1-loop coil deployment (Fig. 1C). Lastly, an additional coil was inserted into the medial aneurysm using the jail technique, facilitating coil embolization. The neck remnant (NR) was favorable. Surgery was completed (Fig. 1D).

Postoperative course: The postoperative course was favorable. During surgery, systemic heparinization was conducted. After stent deployment, ozagrel sodium at 80 mg was administered. Cilostazol at 200 mg was additionally administered from the day after surgery, and triple antiplatelet therapy (TAPT) was continued for 6 weeks after surgery. After 6 months, it was switched to dual-antiplatelet therapy (DAPT). After 1 year, it was switched to simple antiplatelet therapy (SAPT). There has been no recanalization during the 13-month postoperative follow-up (Fig. 1E).

Case 2: An 80-year-old female.

Present illness: MRI for detailed examination of headache revealed an unruptured cerebral aneurysm at the right IC-PC. Its maximum and neck diameters were 6.0 and 5.4 mm, respectively. The P-com measuring 2.2 mm in diameter had branched from the aneurysmal dome. It was necessary to preserve the P-com with the fetal-type PCA (Fig. 2A).

Course after admission: The possibility of selecting SACE was explained to the patient and her family, as described for Case 1. After obtaining informed consent, DAPT was started 1 week before surgery. The ARU and PRU were within the effective ranges the day before surgery.

Endovascular treatment: Under general anesthesia, puncture was conducted through the right femoral artery. A 6 Fr Roadmaster was inserted into the distal right ICA, and a 5 Fr Guider Softip (Boston Scientific, Marlborough, MA, USA) was inserted through the left femoral artery. Initially, a Headway17 (Terumo Corporation) was guided into the P-com using a CHIKAI14 microguidewire (Asahi Intecc Co., Ltd., Aichi, Japan) so that it might wait for an LVIS Jr. 2.5 × 13. After guiding an Echelon10 into the aneurysm using a GT12 guidewire, an Excelsior XT-17 (Stryker) was guided into the MCA so that it might wait for a Neuroform Atlas 4.5 × 21. Initially, an LVIS Jr. 2.5 × 13 was inserted on the P-com side. At this point, positioning was carefully conducted so that a portion of the radiopaque marker of the stent’s proximal flare might appear on the ICA side, considering stent shortening (Fig. 2B). Subsequently, a Neuroform Atlas 4.5 × 21 was inserted on the ICA side (T-stent technique) (Fig. 2C).

Using the jail technique, coil embolization with an AXIUM 3D was performed. The NR was favorable. Surgery was completed (Fig. 2D).

Postoperative course: The postoperative course was favorable. During surgery, systemic heparinization was conducted. After stent deployment, ozagrel sodium at 80 mg was administered. Cilostazol at 200 mg was additionally administered from the day after surgery, and TAPT was continued for 6 weeks after surgery. After 6 months, it was switched to DAPT. There has been no recanalization during the 7-month postoperative follow-up (Fig. 2E). Switching to SAPT after 1 year is being scheduled.

Case 3: A 61-year-old female.

Present illness: MRI for detailed examination of vertigo revealed an unruptured cerebral aneurysm at the left vertebral artery (VA)-posterior inferior cerebellar artery bifurcation (PICA). Its maximum and neck diameters
Fig. 2  DSA during operation for Case 2. (A) Preoperative 3D-DSA shows a large broad-necked P-com artery aneurysm. P-com is arising from the aneurysmal dome. (B) Angiogram after LVIS Jr. 2.5 × 13 deployment. Arrow: proximal marker of the stent. (C) Angiogram after Neuroform Atlas 4.5 × 21 deployment. Arrow: proximal marker of the stent. (D) Final angiogram shows neck remnant of the aneurysm. (E) Postoperative angiogram at 7 months shows no recurrence of the aneurysm. LVIS: low-profile visualized intraluminal support; P-com: posterior communicating
Tips of the T-stent Technique with an LVIS Jr.

For Case 1. After obtaining informed consent, DAPT was started 1 week before surgery. The ARU and PRU were within the effective ranges the day before surgery.

Endovascular treatment: Under general anesthesia, puncture was conducted through the right femoral artery. A 6 Fr
Roadmaster was inserted into the distal left VA. Using a GT12 guidewire, an Echelon10 was guided to an area distal to the cranial loop of the PICA so that it might wait for an LVIS Jr. 2.5 × 13. Subsequently, a Headway21 (Terumo) was guided into the VA union using a CHIKAI14 microguidewire so that it might wait for an LVIS Blue 4.5 × 23. To perform the T-stent technique, an LVIS Jr. 2.5 × 13 was initially deployed on the PICA side. At this point, positioning was carefully conducted so that a portion of the radiopaque marker of the stent’s proximal flare might appear on the VA side, considering stent shortening. Subsequently, an LVIS Blue 4.5 × 23 was partially deployed on the VA side so that it might cover the aneurysmal neck (partial T stenting) (Fig. 3B). After guiding the above Echelon10 into the aneurysm from the LVIS Jr. side using the semi-jail technique, the LVIS Blue 4.5 × 23 on the VA side was completely deployed, with 1-loop AXIUM 3D coil deployment (complete T stenting) (Fig. 3C). Lastly, coil embolization was performed by inserting an additional coil into the aneurysm, and the NR was favorable. Surgery was completed (Fig. 3D).

Postoperative course: The postoperative course was favorable. During surgery, systemic heparinization was conducted. After stent deployment, ozagrel sodium at 80 mg was administered. Cilostazol at 200 mg was additionally administered from the day after surgery, and TAPT was continued for 6 weeks after surgery. After 6 months, it was switched to DAPT. There has been no recanalization during the 10-month postoperative follow-up (Fig. 3E). Switching to SAPT after 1 year is being scheduled.

Discussion

In our hospital, there are no criteria for indicating the T-stent technique for wide-necked aneurysms, but the multiple stent technique is adopted for patients with wide-necked aneurysms, characterized by vessels to be preserved branching from aneurysms in whom it may be impossible to preserve branching vessels using double catheter or balloon-assisted techniques. Among these patients, the T-stent technique is considered for those in whom it is possible to guide a microcatheter into a branching vessel.

In the T-stent technique, there is no stent overlapping in comparison with multiple stent techniques, such as the Y-configuration technique. This technique is advantageous in that there is no strat deformity. However, it may cause stent-interference-related blood flow disorder or thromboembolism; therefore, positioning should be carefully conducted, considering stent shortening.6) In addition, favorable T-stent grounding was achieved by radially deploying the proximal stent end on the branching vessel side, as demonstrated in Case 2, deploying a closed-cell stent that is available as a re-sheath, LVIS Jr. so that a portion of the radiopaque marker may appear in the parent blood vessel, and deploying an autodilation-type stent with marked adhesion to blood vessels, Neuroform Atlas, on the parent blood vessel side. When selecting a stent on the branching vessel side, an open-cell stent, which does not shorten, Neuroform Atlas, may also be useful. However, re-sheathing or re-insertion is impossible after the start of stent deployment although the positioning of open-cell stents is relatively easy in comparison with closed-cell stents; therefore, we have not used any open-cell stent.

In Case 1, it was possible to guide a 10 catheter alone for stenting on the ICA side due to marked arteriosclerosis, and a Neuroform Atlas could not be used on the parent blood vessel side. However, a braided stent with a high metallic covering rate, LVIS Jr., was used on the parent blood vessel side so that flow-diversion-effect-mediated aneurysmal thrombosis might occur. In Case 3, the aneurysm had crossed over the VA side, and an LVIS stent was used to achieve flow diversion effects.10) Fortunately, favorable T-stent grounding was achieved despite the use of an LVIS stent on the parent blood vessel side in both Cases 1 and 2. With respect to perioperative antiplatelet management in consideration with perioperative complications related to SACE, such as ischemic or hemorrhagic complications, a study indicated that an adequate postoperative DAPT period was ≥9 months after surgery.11) However, a consensus has not been reached. In our hospital, as perioperative antiplatelet therapy, DAPT with aspirin at 100 mg and clopidogrel at 75 mg is started 1 week before surgery, and TAPT12) with intraoperative heparin, ozagrel sodium at 80 mg, and cilostazol at 200 mg (from the day after surgery) is administered for 6 weeks after surgery through assessment with a VerifyNow system.7–9) After 6 months, it is switched to DAPT. After 1 year, it is switched to SAPT. In the three patients, there has been no recurrence although the follow-up period was short. The T-stent technique using an LVIS Jr. on the branching vessel side may be useful. In the future, long-term follow-up will be conducted.

Conclusion

The T-stent technique with an LVIS Jr. was useful for achieving neck formation for a wide-necked aneurysm.
directly branching from an aneurysm or preserving branches measuring ≥2 mm in diameter. We reported its tips.

**Disclosure Statement**

There is no conflict of interest regarding this article for the main author or coauthors.

**References**
