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Small ruptured and unruptured complex cerebral aneurysms: Single center experience of low-profile visualized intraluminal support stent

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ABSTRACT

Objectives: Even though low-profile visualized intraluminal support (LVIS) device is used extensively currently and provide intraluminal support in complex cerebral aneurysm embolization, only few studies have reported its clinical results. This study presents the results of patients treated with LVIS.

Patients and methods: Cerebral aneurysms with an undefined neck, fusiform shape, and blood blister-like aneurysms that were treated with LVIS between May 2017 and May 2019 were reviewed retrospectively.

Results: Overall, 112 aneurysms in 104 patients were treated using LVIS, and 105 LVISs were placed. Of these, 101 aneurysms (90%) were small (< 10 mm) in size, 17 were fusiform aneurysms, and 3 were blood blister-like aneurysms. Overall, 39 patients suffered a subarachnoid hemorrhage and 65 had no bleeding history. 2 patients died of internal carotid artery (ICA) thrombosis, resulting in 1.9% mortality rate. Follow-up angiography was obtained in 68 patients (65%), and the complete obliteration rate was 98.5% in 6–12 months.

Conclusion: The LVIS is a safe and effective treatment for small ruptured or unruptured complex intracranial aneurysms.

1 Introduction

The low-profile visualized intraluminal support (LVIS; MicroVention, Aliso Vajo, USA) device is a braided and self-expanding device, which has been used to treat broad-neck, complex cerebral aneurysms [1–13]. In a systematic review of the use of braided stents in early studies (2006–2017) involving 35 studies comprising 1426 patients [14], the overall successful stent delivery and complete aneurysm occlusion rates were 97% and 88.3%, respectively. The rate of procedure-related complications of using LVIS was 7.4%, and the morbidity rate was 1.5%, which were statistically associated with the location of the posterior circulation, peripheral location, as well as with fusiform, dissecting, and circumferential aneurysms. However, in these studies, thromboembolic
and hemorrhagic complications were noted to decrease to 1.4% and 0.7%, respectively, with the accumulation of experience [15]. In this study, we presented our single center LVIS experience in a series of 112 aneurysms in 104 patients.

2 Patients and methods

This retrospective study comprised 104 consecutive patients (mean age, 58.5 years; age range, 27–87 years) with 112 aneurysms treated using LVIS between May 2017 and May 2019 (Table 1). Of these, 66 patients were women, and 38 were men. Cerebral aneurysms with undefined neck, blood blister-like aneurysms, and fusiform aneurysms were treated using the LVIS. The patients consented to the procedure, and these cases were approved by the ethics committee of Beijing Tsinghua Changgung hospital, China.

Table 1 112 aneurysms in 104 patients treated using LVIS.

| Variable               | Number of patients |
|------------------------|--------------------|
| Female                 | 66 (63.5%)         |
| Male                   | 38 (36.5%)         |
| Ruptured               | 39 (37.5%)         |
| Unruptured             | 65 (62.5%)         |
| Aneurysm locations     |                    |
| ICA                    | 82 (73.2%)         |
| VA-BA                  | 15 (13.4%)         |
| Acoma                  | 4 (3.6%)           |
| MCA                    | 4 (3.6%)           |
| A1                     | 1 (0.9%)           |
| P1                     | 1 (0.9%)           |
| Aneurysm size          |                    |
| Small, < 10 mm         | 101 (90.2%)        |
| Large, 10-25 mm        | 10 (8.9%)          |
| Giant, > 25 mm         | 1 (0.9%)           |
| Aneurysm classification|                    |
| Saccular               | 92 (82.1%)         |
| Fusiform               | 17 (15.2%)         |
| Blood blister-like     | 3 (2.7%)           |

ICA, internal carotid artery; VA-BA, vertebral artery-basilar artery; Acoma, anterior communicating artery; MCA, middle cerebral artery; A1, A1 segment of the anterior cerebral artery; P1, P1 segment of the posterior cerebral artery.

2.1 Endovascular treatment

All procedures were performed under general anesthesia in all patients. The working angle was chosen based on the 3D reconstruction of rotational angiography in every patient. The length and diameter of the parent artery were measured using a 2D working angle angiogram. In every patient, a 6 French guiding catheter (Envoy, Cordman Neurovascular, Miami Lakes, Florida) was placed into the internal carotid or vertebral artery. The Headway21 microcatheter (MicroVention, Aliso Vajo, USA) was advanced distally to the aneurysm over a 0.014 microguidewire (Traxcess14, MicroVention, USA). The most common size of the LVIS was 3.5 mm in diameter and 15 mm or 20 mm in length. In few cases, LVIS of 4.5 mm in diameter was chosen. The LVIS was released to cover the targeted landing zone by using techniques of microcatheter unsheathing, delivery-wire advancement, and microcatheter resheathing. Notably, the releasing process needs to be performed as slowly as possible to deploy the LVIS accurately. A single LVIS and coils were placed in most cases (Figs. 1–3). Additional LVIS was necessary when coils were not added.

2.2 Medication

In the acute stage of subarachnoid hemorrhage (SAH), the patient was premedicated with a loading dose of 300 mg aspirin and 300 mg clopidogrel 3 hours before the procedure, followed by 100 mg aspirin and 75 mg clopidogrel every day. For unruptured aneurysm, the patient was premedicated with 100 mg aspirin and 75 mg clopidogrel daily for 3–5 days before the procedure. Heparin was given routinely through the continuous flushing. After the procedure, a dose of 100 mg aspirin, and 75 mg clopidogrel was maintained for 3 months, and clopidogrel was discontinued, but the aspirin continued for 6 months.
Fig. 1  (A) 3D reconstruction of the left internal carotid artery (ICA) angiography showed two aneurysms of the left middle cerebral artery (MCA). (B) Post-operative image showed the single LVIS (3.5 mm × 20 mm) placed in the left MCA and complete coiling of the two aneurysms. (C) Post-procedure angiography showed complete obliteration of the two aneurysms and reconstruction of the MCA.

Fig. 2  (A) 3D reconstruction of the left ICA angiography showed a very wide-neck posterior communicating artery (PComA) aneurysm. (B) The post-operative angiogram showed the PComA aneurysm completely embolized with patent PComA. (C) Fluoroscopic image after additional coil placement.

Fig. 3  (A) Frontal angiogram showed a large cavernous ICA aneurysm. (B) The fluoroscopic image showed the LVIS and coil mass. (C) Angiography after coil placement showed complete obliteration of the aneurysm and reconstruction of the ICA.
3 Results

Overall, 73 aneurysms were unruptured, and 39 patients had a previous history of SAH. Notably, 82/112 (73.2%) aneurysms were located in the internal carotid artery (ICA), 15/112 (13.4%) in the vertebral artery-basilar artery (VA-BA), 4/112 (3.6%) in the anterior communicating artery (Acoma), 4/112 (3.6%) in the middle cerebral artery (MCA), 1 (0.9%) in A1 segment of the anterior cerebral artery, and 1 (0.9%) in P1 segment of the posterior cerebral artery. One (0.9%) aneurysm was giant (> 25 mm), 10/112 (8.9%) were large (10–25 mm), and 101/112 (90.2%) were small (< 10 mm). Furthermore, 92/112 (82.1%) aneurysms were wide-necked saccular, 17/112 (15.2%) were fusiform, and 3 (3.6%) were blood blister-like.

In 104 patients, 112 aneurysms were successfully treated using 105 LVISs. One LVIS was used to treat one aneurysm in 96 patients, and one LVIS treated two aneurysms in 7 patients. In one patient, a second LVIS was necessary to cover the neck of a tiny aneurysm.

Two patients (1.9%) died because of thrombus formation in the ICA, resulting in massive infarction. Follow-up angiography was obtained in 68 patients (65%) at the 6- to 12-month time point. According to the control angiograms, 67 of 68 aneurysms were occluded with a total obliteration rate of 98.5%, and one giant ICA aneurysm did not exhibit occlusion on the 6-month follow-up angiography. The overall mortality rate was 1.9%.

4 Discussion

In this series, the angiographic obliteration rate of small complex cerebral aneurysms treated using LVIS stent was 98.5% at follow-up, which was comparable with the findings of the previous LVIS series [16]. We did not deliver the LVIS through the double-lumen balloon catheter, and the “combined remodeling technique” was not applied to avoid extra maneuvers [17]. For blood blister-like aneurysms, the overlapping stents were not used [18], and we generally used single stent-assisted coiling. In a meta-analysis involving 384 patients with 390 aneurysms, the overall technical success rate of LVIS was 96.8% [19]. The aneurysmal complete obliteration rate was 54.6% on immediate control and 84.3% on follow-up angiograms. Procedure-related morbidity and mortality rates were 1.4% and 0, respectively, at follow-up. The thromboembolic and hemorrhagic complication rates were 4.9% and 2.1%, respectively. The risk of thromboembolic complications associated with LVIS stent is not negligible.

For small bifurcating aneurysms, the LVIS Jr is technically effective with promising results [20]. For ruptured and unruptured vertebral artery dissecting aneurysms, no procedure-related mortality was observed by using the LVIS technique, with complete occlusion noted in 76.7% cases. Notably, previous studies had observed 76% to 92.4% complete aneurysm occlusion by using LVIS stents (Table 2). Overall, the treatment-related complications were 0 to 13%. Treatment-related morbidity and mortality were 0 to 5.2%. The most common complications were periprocedural thromboembolism in retrospective and prospective studies [21]. Thromboembolic events may occur during or after the procedure, during the early follow-up, and in the late phase [16], because of the following possible causes: 1) low response or resistance of antiplatelet drugs, 2) poor stent opening or poor apposition to the vessel wall, and 3) endothelium injuries. LVIS and LVIS Jr promote excellent progressive complete aneurysmal occlusion but seem to cause more common intra-procedural stent-related thrombotic events [15, 19].

Safe and definite aneurysm treatment with LVIS stent and assisting coiling needs precise image guidance. Endovascular procedures in complex
cases rely on manipulating stents that involve accurate sizing, positioning, and wall apposition. Technical complications can be caused by poor visualization during stent deployment. In our patients, real-time image guidance enabled precise device positioning, excellent wall apposition, and dense coil packing. Notably, incomplete wall apposition because of poor visualization under traditional fluoroscopy can cause thrombotic complications with LVIS techniques. During percutaneous coronary interventions, cardiologists use X-ray images to optimize real-time image guidance to improve stent placement, expansion, and wall apposition. Even we used this method in our patients to enhance visualization during LVIS deployment and avoid poor visualization of pre-deployment under traditional fluoroscopy. Our experience of using this method during the stent deployment provided improved image guidance and stent deployment in technically challenging cases, including coil embolization of small aneurysms and deployment of intracranial flow-diverting stents. The X-ray images not only improved stent visualization but also decreased the radiation exposure to the physician and patient compared with traditional fluoroscopy. The Pipeline embolization devices are proven to be extremely effective in treating complex aneurysms; however, they cannot be used during the acute stage or aneurysmal rupture, as well as are expensive in China [22].

5 Conclusion

The LVIS is a safe and effective treatment for small ruptured or unruptured complex intracranial aneurysms.

Conflict of interests

The authors declare no conflict of interests in this paper.

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