

Endovascular intervention with a low-profile visualized intraluminal support stent for ruptured, very small, wide-necked, intracranial aneurysms

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Abstract

Objective: To evaluate patients treated for ruptured, very small, wide-necked aneurysms using low-profile visualised intraluminal support alone or with stent-assisted coiling.

Method: The retrospective study was conducted at the Department of Neurosurgery, First Affiliated Hospital of Bengbu Medical College, China, and comprised data of patients who presented with ruptured, very small, intracranial aneurysms between March 2015 and May 2019 who were treated using low-profile visualised intraluminal support alone or with stent-assisted coiling. Outcomes from radiology and clinical assessments were obtained related to the time the patients were discharged and their subsequent mid-term examination.

Results: Of the 10 patients, 6(60%) were males and 4(40%) were females. The overall mean age was 47.70 ± 10.22 years (range: 23-62 years). In the sample, 7(70%) patients experienced total occlusion and 3(30%) had nearly complete occlusion. All the 10(100%) patients had uneventful recoveries. Progressive thrombosis to complete occlusion occurred in 3(30%) aneurysms that had initially presented with Raymond grade II. There was no case of stenosis or occlusion.

Conclusion: Treatment of ruptured, very small, wide-necked intracranial aneurysms with stent-assisted coiling and low-profile visualised intraluminal support provided superior technical outcomes.

Keywords: Coiling, Stent-assisted coiling, Small intracranial aneurysms, Low-profile stent. (JPMA 71: 1972; 2021)

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Introduction

Very small cerebral aneurysms are usually those with diameters <3mm.¹ Because the aneurysm is very small, there is risk associated with direct surgical clipping and endovascular embolisation. Endovascular therapy of small aneurysms has become an optional treatment modality with specialised interventional materials and techniques. Intracranial stents are widely used. The low-profile visualised intraluminal support (LVIS) stent (MicroVention Terumo, Tustin, CA, USA) is a self-expanding, flexible, braided, single-wire, nitinol device, and its safety and effectiveness with respect to treatment of cerebral aneurysms have been described previously.²⁻⁴

The current study was planned to examine the efficacy and safety of embolisation using LVIS and stent-assisted coils (SACs) to treat very small, ruptured, wide-necked intracranial aneurysms.

Materials and Methods

The retrospective study was conducted at the Department of Neurosurgery, First Affiliated Hospital of Bengbu Medical College, China, and comprised data of patients who presented with ruptured, very small, intracranial aneurysms between March 2015 and May 2019 who were treated using LVIS alone or with SAC. Data was retrieved

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after approval from the institutional ethics review board from radiology and clinical assessments that had been obtained at the time the patients were discharged and on their subsequent mid-term examination. Data of those having undergone microsurgical clipping was excluded.

Each patient had a follow-up 3-24 months. Those included were diagnosed to have acute subarachnoid haemorrhage (SAH), which was identified by head tomography analysis and consistent with the position of aneurysms identified by computed tomography angiography (CTA). The patients were classified using the Hunt and Hess (H&H) grading system⁵ on the basis of digital subtraction angiography (DSA).

Endovascular surgeries started with the use of general anaesthesia. Guiding catheter of size 6F was passed into the femoral arterial sheath to access specific regions of the internal carotid artery (ICA), which depended on the aneurysm location. Rotational angiography and three-dimensional (3D) reconstruction was performed to visualise the configuration and shape of each of the aneurysms and the anatomical association between the aneurysm and its parent artery, as well as to ascertain the appropriate stent placement and coiling projection. A Headway 21 microcatheter (MicroVention, Tustin, CA, USA) was placed at the distal aneurysm neck using a 0.014-inch Synchro microwire (Stryker, West Valley City, UT, USA). The tip of the Headway 17 microcatheter was steam-shaped to

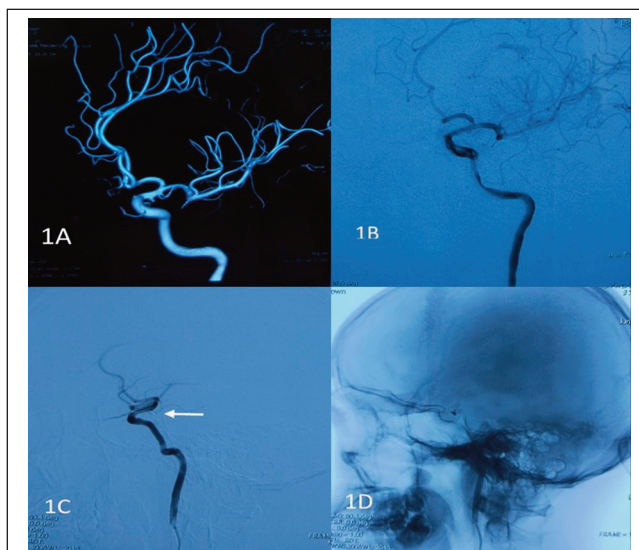


Figure 1: Digital subtraction angiography (DSA) of a ruptured posterior communicating artery (PCA) aneurysm images before and after low-profile visualised intraluminal support (LVIS) stent-assisted coiling embolisation in a 23-year-old male who presented with a sudden headache, nausea and vomiting, and was hospitalised due to the onset of spontaneous subarachnoid haemorrhage. (A) Three-dimensional (3D) reconstruction of the aneurysm. (B) Successful occlusion of the aneurysm immediately post-procedure. The degree of occlusion was Raymond grade I. (C-D) Five-month follow-up angiography demonstrating complete occlusion of the aneurysm (white arrow), and the LVIS stent completely expanded.

conform to the anatomy of the specific aneurysm and was positioned in the aneurysmal sac. LVIS was inserted and moved to the head of the Headway 21 microcatheter with an outlet release.

Aneurysm coiling was conducted using coils with sizes and lengths that were appropriate for the specific aneurysm. When the aneurysmal cavity had been filled with one or more coils, the stent was partially deployed and covered the aneurysm neck only in part. Then the stent was fully

deployed after the last coil was stabilised and isolated (Figure 1). Procedures using semi-deployment of stents were used in all patients in line with literature.⁶ Two hours prior to surgery, patients were given oral dual anti-platelet therapy comprising 300mg aspirin and 300mg clopidogrel. Starting 24 hours post-surgery, the patients received oral, dual anti-platelet medications 100mg/d aspirin and 75mg/d clopidogrel for six weeks after which clopidogrel was discontinued. The patients continued to take aspirin for two years post-surgery. Twenty-four hours after surgery, routine head computed tomography (CT) scans were done to rule out any post-procedural haemorrhage or brain infarction. All patients were assessed using angiography on follow-up.

Raymond Classification Scale⁷ (RCS) was used to evaluate immediate post-operative angiography, while Modified Rankin Scale⁶ (mRS) was used to assess the patients' clinical outcomes.

Results

There were 241 patients with 247 intracranial aneurysms. Of them, 137(55.5%) were treated surgically and 110(44.5%) endovascularly. Among these, 21(8.5%) patients had very small ≤ 3 mm, ruptured, wide-necked cerebral aneurysms, and 11(4.5%) of them had undergone microsurgical clipping. The remaining 10(48%) patients were treated using endovascular coil embolisation with LVIS device and formed the sample for the current study. The mean follow-up was 9.42 ± 5.57 months (range: 3-24 months). There were 6(60%) males and 4(40%) females with an overall mean age of 47.70 ± 10.22 years (range: 23-62 years).

Of the total, 3(30%) patients were classified as H&H grade I, and 7(70%) as grade II. Both types of aneurysms were detected in the anterior cerebral circulation. The mean size of the aneurysms was 2.47 ± 0.47 mm (range: 1.0-3.0mm). All aneurysms presented with a wide neck and the dome-

Table: Clinical and radiologic details of patients with ruptured, very small, wide-necked, intracranial aneurysms.

No.	Age/sex	H-H grade	Sub location of Aneurysm	Maximal diameter(mm)	D/N ratio	The number of coils	Dimensions of stents(mm)	Occlusion Degree (Raymond scale)	Follow-up Time(months)	Follow-up Result (Raymond scale)	Modified Rankin Scale (mRS)
1	46/M	II	A.Ch.A	2.0	1.3	2	4.5*15	II	6	I	0
2	47/F	I	Ophth. A	2.3	1.2	4	4.5*15	I	3	I	0
3	62/M	I	P.Co.A	3.0	1.0	4	3.5*20	I	5	I	0
4	53/M	II	A.Co.m	3.0	1.1	4	3.5*20	I	10	I	0
5	42/M	II	Ophth. A	3.0	1.1	3	4.5*20	I	7	I	1
6	48/M	II	Ophth. A	2.8	0.8	3	3.5*20	II	13	I	0
7	23/M	II	Ophth. A	1.7	1.1	2	3.5*20	I	9	I	0
8	51/F	II	M.C.A	2.0	1.3	0	3.5*20	II	6,16	I	1
9	54/F	II	P.Co.A	2.3	1	3	4.5*15	I	6,24	I	0
10	51/F	I	P.Co.A	2.6	1.3	3	4.5*15	I	8	I	1

H-H: Hunt and Hess, mRS: Modified Rankin scale, M: Male, F: Female. A.Ch.A: Anterior choroidal artery, Ophth.A.: Ophthalmic segment, P.Co.A: Posterior communicating artery, A.Co.m: Anterior communicating artery, M.C.A: Middle cerebral artery, D/N ratio: Dome-to-neck ratio

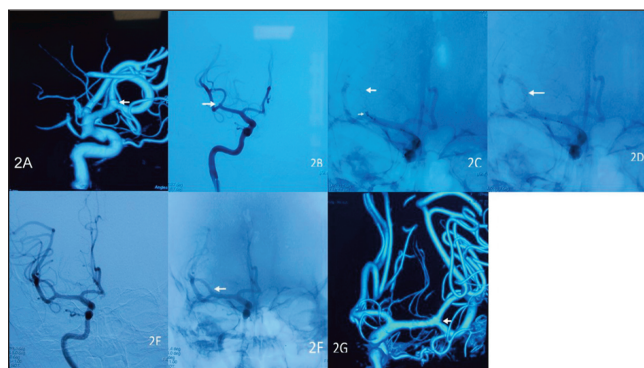


Figure-2: Digital subtraction angiography (DSA) of a ruptured middle cerebral artery (MCA) aneurysm images before and after low-profile visualised intraluminal support (LVIS) stent-assisted coiling embolisation in a 51-year-old female who presented with a sudden headache, nausea and vomiting, and was hospitalised due to the onset of spontaneous subarachnoid haemorrhage. (A) Three-dimensional (3D) reconstruction of the aneurysm (white arrow). (B) The aneurysm in the working projection before treatment and the aneurysm (white arrow). (C) The microcatheter (thin arrow) was in place, stent was partially released (thick arrow), the superior trunk of the MCA was no longer visible. (D) The aneurysm was embolised with sole LVIS stent, the superior trunk of the MCA was unobstructed. The degree of occlusion was Raymond grade II (E). Six-month follow-up angiography revealed decreasing size of the aneurysm and the parent artery was obvious without stenosis (F). Six-month follow-up angiography revealed the parent artery was patent without any stenosis (white arrow). (G) Three-dimensional (3D) angiographic reconstruction at six-month follow-up revealed decreasing size of the aneurysm (white arrow).

to-neck (DN) ratio was <1.5 . Aneurysm location was anterior communicating artery (ACA) 1(10%), posterior communicating artery (PCA) 3(30%), middle cerebral artery (MCA) 1(10%), ophthalmic artery (OA) 4(40%) and anterior choroid artery (AChA) 1(10%) (Table).

One aneurysm was embolised using the stent alone. When the microcatheter was in position, the upper middle cerebral artery trunk was not visible, and it was decided not to insert the coils (Figure 2).

All the 10 patients received endovascular treatment within 0-5 days after the subarachnoid haemorrhage occurred, and no re-rupture was observed. Immediate post-operative angiography revealed that 7(70%) patients had Raymond grade I, and 3(30%) had grade II. Shortly following embolisation, the 3 grade II aneurysms showed increasing thrombosis with full occlusion. No movement or misplacement of stents or coils was observed, and there was no stenosis or occlusion in the parent arteries. On follow-up examination, all 10(100%) patients were found to have recovered without relapse.

Discussion

The incidence of very small aneurysms in ruptured

intracranial aneurysm is low, and the degree of rupture between small and large aneurysms is not markedly different.^{8,9} Because of their size, treatment of very small, wide-necked aneurysms is difficult. When very small aneurysms are clipped directly, the clips are likely to fall off. Endovascular therapy also is more difficult since the space in the aneurysm sac, as well as the wide neck of the aneurysm, are also very small, the coils are not well-secured, and the aneurysm walls may be easier to get punctured.

Literature indicates that stent-assisted coiling used to treat intracranial aneurysms is both effective and safe.¹⁰ The use of SAC to treat cerebral aneurysms is based on the "fence-like" property of stents in which the endothelialisation of stents in blood vessels takes place, which produces the potential flow displacement effect. The microcatheter is secured using a stent, which avoids the so-called "kick-back" phenomenon. The safety of patients during treatment and the efficacy of coiling in very small intracranial aneurysms have increased through the development of new materials, including smaller coils, improved microcatheters, and steerable soft microguide wires. The use of endovascular coiling to treat very small cerebral aneurysms is reported to have significantly lower risk levels at approximately 3-4%.¹¹

Due to the very small sizes involved, it was challenging in our experience to adequately place the microcatheter during the procedure. Perforation of the arterial wall could be induced by the forward movement of the microguide wire and microcatheter. Therefore, we referred to the 3D reconstructions of the aneurysms to shape the head of microcatheter to match the shape of the aneurysm as accurately as possible to allow the microcatheter to slip into the aneurysm sac.

LVIS devices are made from titanium and nickel. They are auto-expanding, flexible devices that are constructed using a single wire. LVIS can be used by a single person with an appropriate delivery mechanism. The LVIS has an exceedingly small cell diameter of 1.0mm, which can boost stream displacement, and guard against the protrusion of the coil. Thus, the risk of escape of the coil is virtually eliminated. Wang et al. examined the cardiovascular effects of using LVIS with stents on intracranial aneurysms and reported that the Pipeline device produced increased flow reduction compared to LVIS, but the use of LVIS resulted in more flow reduction when compared to the double-Enterprise stent.¹² When considering intravascular treatment for aneurysms, LVIS was compared with predicate laser-cut Nitinol microstents, which are based on hypotubes (Neuroform stent; Stryker Neurovascular, Fremont, CA, USA), Enterprise stent (Codman

Neurovascular, Raynham, MA, USA), and Solitaire stent (Medtronic Neurovascular, Irvine, CA, USA)). LVIS is constructed as a braided stent that does not just carry out a "fencing function", but also inhibits coils from protrusion out of the aneurysm into the originating or "parent" artery, and it is also possible to accurately position the LVIS to obtain greater metal surface coverage (LVIS 23%) as well as to create a drum-like extension at the aneurysm neck.^{13,14}

Based on published reports, Flow Diverter (FD) stents are more commonly used than LVIS in patients with large or complex aneurysms due to the haemodynamic effects, as FD stents have a great potential for branch occlusion, which could lead to serious complications.^{15,16} FD stents have not been used in patients with ruptured aneurysms, but, in clinical practice, some physicians use FD stents to treat large and complex aneurysms, such as subarachnoid haemorrhage.¹⁷ In general, LVIS, at an equitable cost, has a broader range of possible applications, not only for anterior circulation aneurysms, but also for posterior circulation aneurysms.

The semi-deployment technique for stents was used in the procedures for all the patients in the current study. When the coils were placed in the aneurysm sac, the microcatheter could be pushed into the parent artery. Thus, it was important to appropriately adjust the microcatheter to avoid this from occurring.

Due to its high metal coverage, we do not assume that the aneurysm sac was densely packed with coils when the stent-assisted procedure was used to treat very small aneurysms. After some time, the follow-up examinations also indicated satisfying results. Lu et al. reported similar views.¹⁸ For the one ruptured aneurysm that occurred in the current study, after using the stent semi-deployment, we stopped injecting coils into the sac, because we were not able to visualise the upper portion of the MCA, so the only option was to deploy just one stent.

Conclusion

Initial experience indicated that LVIS devices were both effective and safe to treat very small aneurysms. However, the single-stent technique needs additional research to determine how successful it is in causing aneurysm occlusion.

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Conflict of Interest: None.

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References

1. Brinjikji W, Lanzino G, Cloft HJ, Rabinstein A, Kallmes DF. Endovascular treatment of very small (3 mm or smaller) intracranial aneurysms: Report of a consecutive series and a meta-analysis. *Stroke* 2010; 41: 116-21.
2. Poncyljusz W, Biliński P, Safranow K, Baron J, Zbrozarczyk M, Jaworski M, et al. The LVIS/LVIS Jr. stents in the treatment of wide-neck intracranial aneurysms: multicentre registry. *J Neurointerv Surg* 2015; 7: 524-9.
3. Iosif C, Piotin M, Saleme S, Barreau X, Sedat J, Chau Y, et al. TRAIL Investigators: Safety and effectiveness of the Low Profile Visualized Intraluminal Support (LVIS and LVIS Jr) devices in the endovascular treatment of intracranial aneurysms: results of the TRAIL multicenter observational study. *J Neurointerv Surg* 2018; 10: 675-81.
4. Fiorella D, Boulos A, Turk AS, Siddiqui AH, Arthur AS, Diaz O, et al, LVIS investigators. The safety and effectiveness of the LVIS stent system for the treatment of wide-necked cerebral aneurysms: final results of the pivotal US LVIS trial. *J Neurointerv Surg* 2019; 11: 357-61.
5. Greenberg MS. *Handbook of Neurosurgery*. 7th ed. New York: Thieme Medical Publishers; 2010, Pp 1511.
6. Zhang J, Wang D, Li X. Solitaire AB stent-assisted coiling embolization for the treatment of ruptured very small intracranial aneurysms. *Exp Ther Med* 2015; 10: 2239-44.
7. Raymond J, Guilbert F, Weill A, Georganos SA, Juravsky L, Lambert A, et al. Long-term angiographic recurrences after selective endovascular treatment of aneurysms with detachable coils. *Stroke* 2003; 34: 1398-403.
8. van Rooij WJ, Keeren GJ, Peluso JP, Sluzewski M. Clinical and Angiographic Results of Coiling of 196 Very Small (<or =3 mm) Intracranial Aneurysms. *AJNR Am J Neuroradiol* 2009; 30: 835-9.
9. Liu Y, Wang F, Fu X, Liu Y, Zhang G, Xu K. Clinical and angiographic outcomes following endovascular treatment of very small (3mm or smaller) intracranial aneurysm: A single-center experience. *Medicine* 2017; 96: e7457.
10. Chalouhi N, Jabbour P, Singhal S, Drueding R, Starke RM, Dalyai RT, et al. Stent-Assisted Coiling of Intracranial Aneurysms: Predictors of Complications, Recanalization, and Outcome in 508 Cases. *Stroke* 2013; 44: 1348-53.
11. Yamaki VN, Brinjikji W, Murad MH, Lanzino G. Endovascular treatment of very small intracranial aneurysms: meta-analysis. *AJNR Am J Neuroradiol* 2016; 37: 862-7.
12. Wang C, Tian Z, Liu J, Jing L, Paliwal N, Wang S, et al. Flow diverter effect of LVIS stent on cerebral aneurysm hemodynamics: a comparison with Enterprise stents and the Pipeline device. *J Transl Med* 2016; 14: 199.
13. Fiorella D, Boulos A, Turk AS, Siddiqui AH, Arthur AS, Diaz O, et al, LVIS investigators. The safety and effectiveness of the LVIS stent system for the treatment of wide-necked cerebral aneurysms: final results of the pivotal US LVIS trial. *J Neurointerv Surg* 2019; 11: 357-61.
14. Park SY, Oh JS, Oh HJ, Yoon SM, Bae HG. Safety and Efficacy of Low-Profile, Self-Expandable Stents for Treatment of Intracranial Aneurysms: Initial and Midterm Results-A Systematic Review and Meta-Analysis. *Interv Neurol* 2017; 6: 170-82.
15. Fischer S, Vajda Z, Perez MA, Schmid E, Hopf N, Bätzner H, et al. Pipeline embolization device (PED) for neurovascular reconstruction: initial experience in the treatment of 101 intracranial aneurysms and dissections. *Neuroradiology* 2012; 54: 369-82.
16. Dornbos D, Karras CL, Wenger N, Priddy B, Youssef P, Nimjee SM, et al. Pipeline embolization device for recurrence of previously treated aneurysms. *Neurosurg Focus* 2017; 42: E8.
17. Giacomini L, Piske RL, Baccin CE, Barroso M, Joaquim AF, Tedeschi H. Neurovascular reconstruction with flow diverter stents for the treatment of 87 intracranial aneurysms: Clinical results. *Interv Neuroradiol* 2015; 21: 292-9.
18. Lu J, Liu JC, Wang LJ, Qi P, Wang DM. Tiny intracranial aneurysms: endovascular treatment by coil embolisation or sole stent deployment. *Eur J Radiol* 2012; 81: 1276-81.