Intra-aneurysmal Onyx embolization for distal aneurysms of the cerebellar arteries

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Background: Distal cerebellar artery aneurysms are difficult to treat both surgically and endovascularly. The purpose of this study is to assess the efficacy and safety of intra-aneurysmal Onyx embolization of these lesions with parent artery preservation.

Methods: Ten consecutive patients harboring 10 distal cerebellar aneurysms were treated with intra-aneurysmal Onyx embolization. Locations of the aneurysms were as follows: superior cerebellar artery in three patients, anterior inferior cerebellar artery in two, and posterior inferior cerebellar artery in five. The technical feasibility of the procedure, procedure-related complications, angiographic results, and clinical outcome were evaluated.

Results: In every case, endovascular treatment was achieved. Immediate angiography demonstrated that all of 10 aneurysms were completely occluded, with parent artery preservation in nine of them. Procedure-related complication occurred in one patient with transient neurological sequelae. None of the treated aneurysms experienced rebleeding or recanalization during the follow-up time (mean, 12.7 months).

Conclusion: We found that the intra-aneurysmal Onyx embolization was helpful in the treatment of distal cerebellar aneurysms in which selective occlusion of the aneurysmal sac with coils or open clipping cannot be achieved.

Keywords: Onyx embolization, Distal aneurysm, Posterior inferior cerebellar artery, Anterior inferior cerebellar artery, Superior cerebellar artery

Background

Aneurysms located on distal cerebellar arteries are rare.[1,2] Surgical treatment is considered difficult and is associated with a rather high morbidity/mortality rate.[3,4] The introduction of endovascular methods has added an attractive minimally invasive approach, sparing the patient some of the hazards related to surgical manipulation. The pre-existing literature concerning endovascular treatment of these lesions is limited and controversial.[5–8] Embolization of the aneurysm sac or parent artery with coils is frequently used. On occasion, coiling may be difficult or impossible because of the distal location or the unfavorable configuration of the aneurysm. We present a new method to treat these lesions using Onyx embolization with our preliminary clinical experience and mid-term follow-up.

Patients and Methods

Patients

From July 2007 to December 2010, a total of 10 peripheral cerebellar aneurysms in 10 patients (four men and six women; age range, 44–68 years; mean age, 54.5 years) were treated with Onyx embolization at our institution (Table 1). All patients presented with subarachnoid and/or intracerebellar hemorrhage as the result of rupture of the peripheral aneurysm. According to the Hunt–Hess scale, two patients were grade 1, five patients were grade 2, two patients were grade 3, and one patient was grade 4. Locations of the aneurysms were as follows: superior cerebellar artery (SCA) in three patients, anterior inferior cerebellar artery (AICA) in two, and posterior inferior cerebellar artery (PICA) in five. All of them were small aneurysms (diameter <10 mm). In two of the 10 patients, a small arteriovenous malformation, supplied by the affected vessel, was apparent but considered asymptomatic according to the computerized tomography (CT) scan.

Endovascular treatment procedures

Therapeutic alternatives were discussed between neurosurgical and neurointerventional teams. All procedures were performed under general anesthesia after giving informed consent. All patients received systemic heparinization to raise the activated clotting time at about 300 seconds during the procedure. In patients

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DOI 10.1179/1743132811Y.0000000076

who presented with acute subarachnoid hemorrhage (SAH), heparinization started after catheterization. A 6F guiding catheter was guided into the vertebral artery via the transfemoral route. Under road-mapping, the tip of the Marathon microcatheter (MTI-ev3, Irvine, CA, USA) was gently introduced into the aneurysm. After the microcatheter was flushed with 0.25 ml of dimethyl sulfoxide, injection of Onyx-18 or 34 proceeded and was closely monitored under subtracted fluoroscopy (blank road-mapping). When the aneurysm was completely occluded, the injection was ended. Selective embolization of the aneurysm sac with parent artery preservation was preferred. Otherwise the distal parent artery was partially occluded, but was not sacrificed. The reflux of Onyx into the proximal vessel was strictly controlled. After the procedure, the patient was monitored in a neurosurgery intensive care unit for at least 24 hours and received low-molecular weight heparin calcium 4000 IU/12 hours for the next 3 days.

Follow-up

Angiographic follow-up was performed at 3–20 months (mean, 7.6 months). Clinical follow-up data were collected at 6–20 months (mean, 12.7 months) by clinic visitation, or telephone interview, and clinical outcome was graded according to modified Rankin score (mRS). More attention was paid to rebleeding of embolized aneurysms and any stroke in the territory of the treated artery.

Results

Angiographic data

Results are summarized in Table 1. In the acute stage after SAH, endovascular treatment was performed successfully in all 10 patients included in the present study. Final angiogram showed disappearance of the aneurysm in all patients, and preservation of the parent vessel was accomplished in nine of them. In the remaining patient (patient 7), parent vessel occlusion was inevitable owing to the configuration of the aneurysm, and both the aneurysm and parent vessel were occluded with Onyx. All patients had a follow-up angiogram 3–20 months after the procedure. There was no recanalization of the embolized aneurysm on any of the follow-up studies.

Clinical data

All patients survived the hospital admission period. At last follow-up, the mRS assessment showed mRS 0–1 in seven patients, mRS 2 in two, and mRS 4 in one. The patient (patient 9) with mRS 4 was attributable to the severity of his initial hemorrhage. None of the patients had an episode of rebleeding after treatment. One complication related to procedure occurred due to infarction in the territory of the treated artery (patient 8, see illustrated cases section). Small areas of cerebellar infarction were detected by magnetic resonance imaging (MRI) in two patients (patients 4 and 7), without any significant clinical sequelae.

Table 1 Summary of relevant clinical and angiographic data in 10 patients

Patient	Age (years)/ sex	Hunt–Hess grade	Location	Additional vascular disease	Endovascular treatment	Adverse events	Angiographic result	Modified Rankin score	Angiographic follow-up
1	55/M	1	L. PICA		Aneurysm occlusion		Complete	0	Unchanged (11 mo.)
2	52/M	2	L. PICA		Aneurysm occlusion		Complete	0	Unchanged (6 mo.)
3	49/F	2	R. AICA	AVM cerebellum	Aneurysm occlusion		Complete	1	Unchanged (20 mo.)
4	50/F	2	L. SCA		Aneurysm occlusion	Silent cerebellar infarction	Complete	0	Unchanged (6 mo.)
5	68/F	3	L. SCA		Aneurysm occlusion		Complete	2	Unchanged (6 mo.)
6	50/M	2	L. AICA		Aneurysm occlusion		Complete	0	Unchanged (8 mo.)
7	44/F	2	R. PICA	AVM cerebellum	Aneurysm occlusion + parent artery occlusion	Silent cerebellar infarction	Complete	0	Unchanged (4 mo.)
8	48/F	1	L. PICA		Aneurysm occlusion	Cerebellar infarction, hydrocephalus	Complete	1	Unchanged (6 mo.)
9	68/M	4	L. PICA		Aneurysm occlusion		Complete	4	Unchanged (6 mo.)
10	61/F	3	R. SCA		Aneurysm occlusion		Complete	2	Unchanged (3 mo.)

Note: M, male; F, female; PICA, posterior inferior cerebellar artery; AICA, anterior inferior cerebellar artery; SCA, superior cerebellar artery; AVM, arteriovenous malformation; mo., month; L, left; R, right.

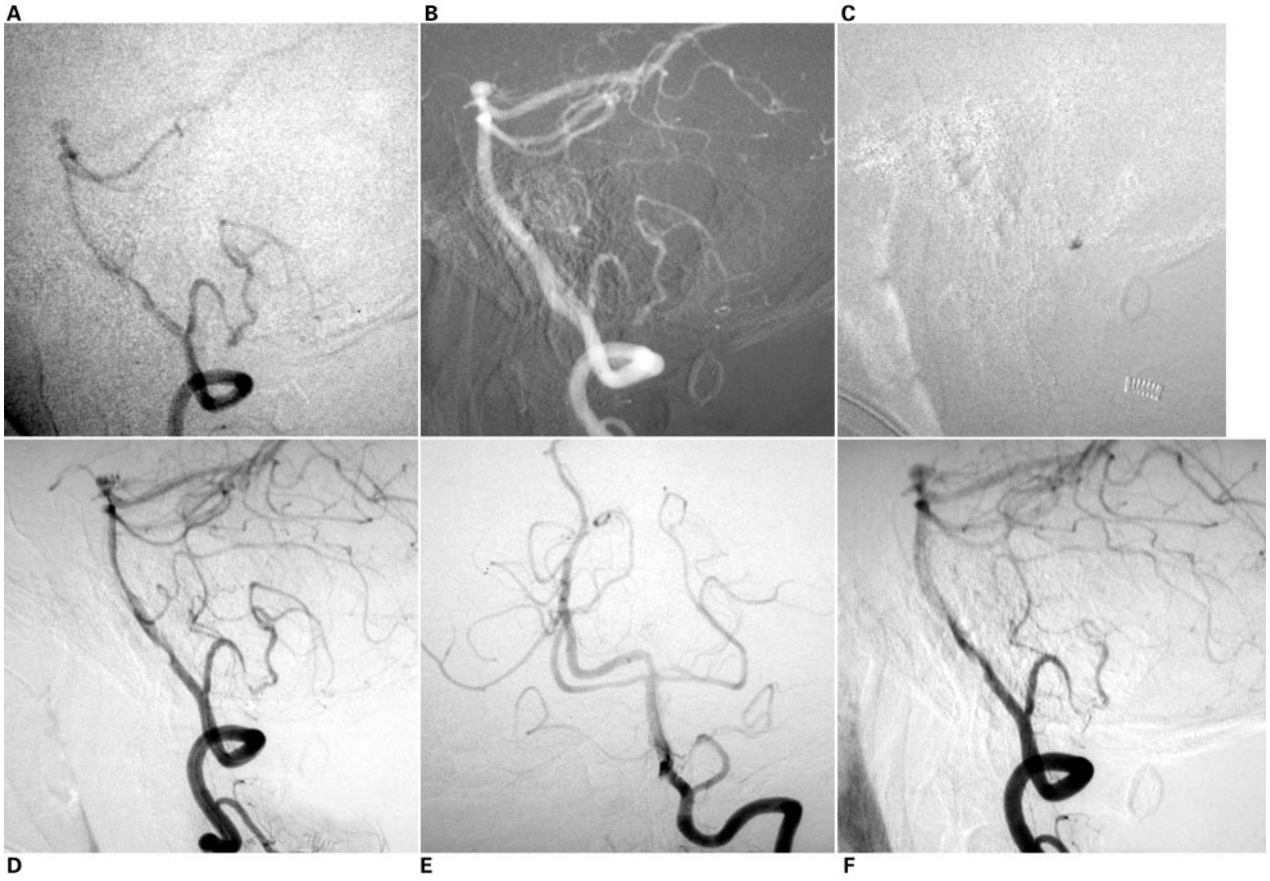

Figure 1 Angiography of patient 2, a 52-year-old man, showed an aneurysm located at the caudal loop of the left PICA (A). A Marathon microcatheter was brought into the aneurysm, and then Onyx-18 was injected (B, C). Post-procedural (D) and follow-up (E, F) angiogram revealed complete occlusion of the aneurysm with the parent artery preservation.

Illustrated cases

Patient 2

A 52-year-old man presented with sudden onset of severe headache. On admission, he was drowsy and had neck stiffness (Hunt–Hess grade 2). A CT scan showed SAH in the ambient cistern, pontine cistern, and cerebellomedullary cistern. Angiography revealed an aneurysm located at the caudal loop of the left PICA. Initially, coil embolization was considered; however, owing to the wide neck, protrusion of the first coil resulted in the occlusion of the distal segment of PICA. Consequently, we changed the strategy. A Marathon microcatheter was brought into the aneurysm. Onyx-18 of 0.3 ml was injected. Control angiography showed occlusion of the aneurysm with preservation of the parent artery and normal flow to the distal PICA. The patient was completely asymptomatic at discharge, and 6-month follow-up confirmed the good result (Fig. 1).

Patient 8

A 48-year-old woman presented with temporary, sudden loss of consciousness. On neurological examination disclosed a stiff neck ((Hunt–Hess grade 1). A CT scan showed the fourth intraventricular hemorrhage. Cerebral angiography revealed an aneurysm located at posterior medullary segment of the left PICA. By injection of 0.4 ml Onyx-18, the aneurysm was occluded with parent artery patent. Three days later, she developed vertigo, nausea, and vomiting, followed by decreased level of consciousness. Emergent MRI scan showed cerebellar infarct, with compression of the fourth ventricle, and hydrocephalus. An external ventricular drain was placed. She gradually recovered completely and is independent in daily activities. Follow-up angiography showed complete occlusion of the aneurysm with parent artery preservation (Fig. 2).

Discussion

Cerebral aneurysms located in the distal vessels are rare.[9] The overall incidence of distal aneurysms in the anterior cerebral artery distribution is between 7 and 9%, followed by 2–7% for the middle cerebral artery location, and only 5% for the posterior circulation. Aneurysms of the vertebrobasilar system comprise fewer than 10% of all intracranial aneurysms.[10] Aneurysms of the cerebellar arteries are also rare and represented 0.8% of 2349 single bleeding aneurysms in the series presented by Locksley.[1] Among them, aneurysms located distal to the cerebellar arteries are particularly rare. Approximately 0.1 and 0.2% of cerebral aneurysms are located on the anterior inferior cerebellar artery[11,12] and superior cerebellar

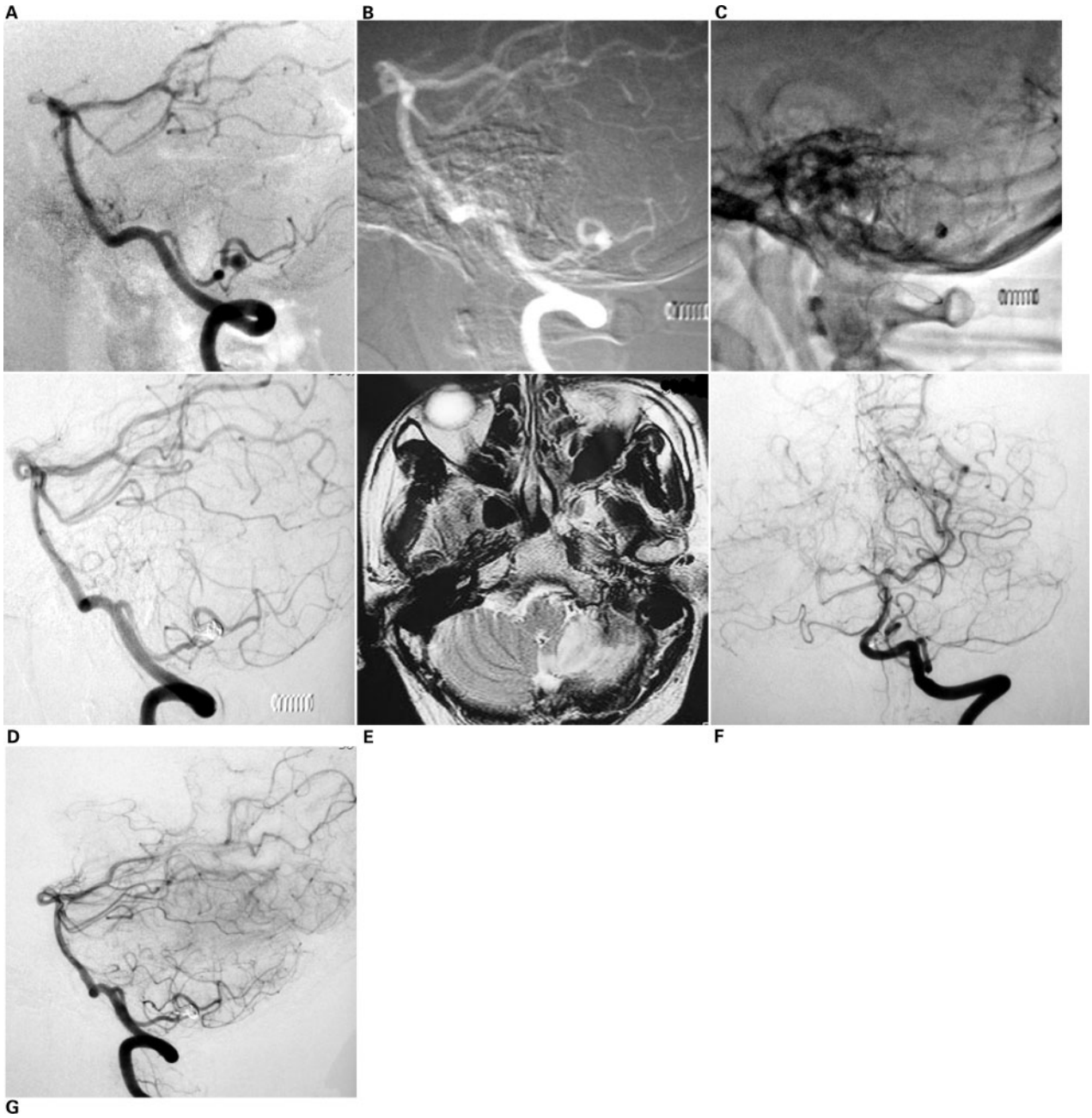

Figure 2 Lateral angiogram (A) of patient 8, a 48-year-old woman, showed an aneurysm located at posterior medullary segment of the left PICA. By injection of Onyx-18, the aneurysm was occluded (B, C). Post-procedural (E) angiogram revealed that the aneurysm was completely occluded and the parent vessel was patent. MRI scan (E) showed cerebellar infarct with compression of the fourth ventricle. Follow-up angiography (F, G) showed complete occlusion of the aneurysm with parent artery preservation.

artery, respectively. Gacs *et al.*[13], in a surgical series of 910 vertebrobasilar aneurysms, reported six distal aneurysms of the SCA (0.7%) and eight aneurysms of the PICA (0.9%). Due to the rarity of these lesions, pre-existing literature concerning their treatment is limited. In this article, we provide our clinical experience with a novel method, intra-aneurysmal Onyx embolization, to treat these leisions, which is a possible alternative and, we believe, a safe technique.

The natural history of patients with untreated ruptured aneurysms of the posterior circulation is grim because they are associated with high rebleeding rate with 30-day survival rate reported to be as low as 11%.[9,14] Treatment is generally considered because of this poor prognosis. However, there is little consensus regarding treatment. Surgical treatment of cerebellar artery aneurysms is considered difficult and is associated with high morbidity and mortality rates,[3,4,15] because surgery is often complicated by cranial nerve dysfunction, in view of the intimate relationship of the cerebellar arteries with cranial nerves III–X. In addition, because most distal cerebellar artery aneurysms seem secondary to arterial dissection, and involve the circumference of the small parent vessel,[16] clipping with sparing of the parent artery is mostly impossible. Endovascular

coiling has become the preferable method for the management of unclippable intracranial aneurysms. However, contrary to typical saccular aneurysms, distal cerebellar artery aneurysms usually have a fusiform shape or a very wide neck, making endosaccular coiling with parent artery preservation difficult or even impossible. In addition, the small caliber of the parent artery does not allow the use of remodeling techniques, such as temporary balloon inflation or stent deployment. Although parent artery occlusion (PAO) has been reported as an alternative treatment in these cases, the potential risk of ischemia in the parent vessel territory is relatively high. We reviewed the results from the most recent series focusing on aneurysms of the cerebellar arteries that were treated by PAO. Rates of transient neurologic deficits in PICA, AICA, and SCA territory were 21.7, 30, and 27.7%, respectively. Additionally, there was a permanent neurologic deficit rate of 20% in AICA territory.[17] Many authors advocated the idea that the endovascular approach allows functional invention of the artery and its distal territory before occlusion and suggested amobarbital test or balloon test occlusion.[7] In our department, we use this test before PAO as well and find it useful to assess the leptomeningeal collateral supply. However, it should not be critical for treatment planning because it may give false-positive or false-negative results and because, in many cases, the patients cannot cooperate in the acute stage. In our experience, occlusion of the aneurysm with parent artery patent is an acceptable alternative in exceptional cases.

Selective occlusion of the aneurysm of the distal cerebellar arteries by means of injection of glue has been reported to be a safe and efficient method.[6] There have been significant improvements in neurovascular technology and implants over the past decade. The multicenter study on Onyx embolization of intracranial aneurysms was published in 2004.[18] In this study, 97 patients with 100 aneurysms were treated. At the 1-year follow-up, there was complete occlusion in 93% of the small aneurysms, in 77% of the large aneurysms, and in 57% of the giant aneurysms, with an overall aneurysm occlusion rate of 79%. Retreatment was necessary in 10% of patients, with 2% mortality and 8% permanent morbidity. Struffert *et al.* reported histologic results of Onyx embolization in experimental aneurysm model showing that an intima will develop over the Onyx cast.[19] Onyx of lower density was also used in intranial aneurysm embolization. In 2005, Lubicz *et al.* published a series of 41 aneurysms treated with Onyx 34 with a good result. In our series, we used Onyx 34 to treat distal aneurysms instead of glue. In contrast to other embolic material, Onyx 18 or 34 can offer a more prolonged and controlled injection, and it is a less adhesive liquid, which eliminates the risk of gluing the catheter to the vessel wall. The result was encouraging. All of 10 aneurysms were completely occluded, with parent artery preservation in nine of them. Not a single one of treated aneurysms experienced recanalization or rebleeding during the follow-up time.

Compared to other techniques, Onyx embolization has several advantages according to our experience. First, it increases the rate of parent artery preservation, which could minimize the risk of ischemic complications. Second, it allows easy and safe catheterization of an aneurysm with Marathon catheter. Third, the risk of aneurysm rupture during procedure is low, because no manipulation of coils is required. Last, compared to glue, Onyx is easier to control and visualize, which reduces the risk of distal migration or proximal reflux of the agent.

In our series, one procedure-related complication with transient neurological sequelae occurred, and a small area of silent cerebellar infarction was found in one patient by follow-up MRI scan, though no occlusion was observed intra-operatively, and parent arteries appeared anatomically patent in both cases. These adverse events are probably caused by distal migration of Onyx into the normal branches, which has to be acknowledged as the main drawback of this technique. Therefore, Onyx-34 is preferred, if flow to the aneurysm is rapid. Though the procedure-related complication rate in this series is low, the procedure must be performed very cautious, because the small caliber of the parent artery does not allow the use of balloon to seal the aneurysm. Reflux must be strictly controlled, and any reflux proximal to the caudal loop is not permitted to avoid fatal basilar artery occlusion. Increased fluoroscopy time, potential adverse effects of dimethyl sulfoxide are also some disadvantages of the technique.

We acknowledge that this study has several limitations: (1) it was not designed as a prospective clinical trial, allowing the results to be confounded by physician's bias on patient selection; (2) because no randomization to other therapeutic approaches including surgical procedure, coil embolization, our data cannot directly address the relative superiority or inferiority of an approach to these lesions and only portray a snapshot of current technique and its associated results; and (3) the small number of patients makes the estimation of adverse event rate imprecise.

Conclusion

Angiographic and clinical results of our series indicate that intra-aneurysmal Onyx embolization of distal cerebellar aneurysms with parent artery preservation is probably an effective option with acceptable morbidity and mortality in exceptional

cases in which selective occlusion of the aneurysmal sac with coils or open clipping cannot be achieved. Nevertheless, further experience is necessary to determine complication rate and suitable selection of patients for this new technique.

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