Prioritized Venous Coiling Facilitating Endovascular Treatment of Brain Arteriovenous Malformations with a Fistulous Component

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■ BACKGROUND: **Brain arteriovenous malformation (AVM) with a fistulous component presents a treatment challenge. The presence of the fistulous component may be related to either a complication from endovascular treatment, perioperative hemorrhagic events during surgical resection, or incomplete obliteration after radiosurgery.**

■ CASE DESCRIPTION: **From December 2010 to May 2014, 7 consecutive patients (3 men, 4 women, average age, 28.7 years; age range, 11 months to 67 years) with AVMs with a high-flow fistulous component were treated at our institute with venous coiling before transarterial liquid embolization. One AVM was grade I based on the Spetzler–Martin grading system, 1 was grade II, 3 were grade III, and 2 were grade IV. The nidus size ranged from 1.7 to 6.0 cm. Four patients had pure fistulous-type lesions, and 3 had lesions of the mixed fistulous-plexiform type. All AVMs shared a common feature of a high-flow fistulous component with a large venous pouch emerging from the nidus. After endovascular embolization of the AVMs, 3 patients had complete occlusion, 3 patients had near-complete occlusion, and 1 patient had significant reduction in volume. There was no immediate complication after embolization, but 1 patient experienced delayed hemorrhage 3 days after the procedure.**

■ CONCLUSIONS: **Prioritized transarterial venous coiling is feasible for the embolization of AVMs with a high-flow fistulous component and the procedure had an acceptable complication rate.**

INTRODUCTION

Current treatment modalities of brain arteriovenous malformation (AVM) include endovascular embolization, neurosurgical resection, radiosurgery, and a combined approach. Most treatment is multidisciplinary, and endovascular treatment usually aims to reduce the size of the nidus to facilitate surgical resection or radiosurgery. For the endovascular treatment of AVM, the most frequently used embolic agents during the last 15 years have included N-butyl cyanoacrylate (NBCA) and ethylene-vinyl alcohol copolymer (Onyx). NBCA is an adhesive embolic agent with a rapid polymerization property, which makes penetrating the AVM nidus deeply difficult. Previous studies regarding the efficacy of NBCA in AVM embolization revealed a complete occlusion rate between 2.4% and 33.3%, greater than 50% nidus reduction of between 67.7% and 88.8%, and a morbidity and mortality rate of between 1.6% and 14.9%.[1–3]

Onyx is a cohesive and nonadhesive embolic agent that solidifies much slower than NBCA. This property allows for injection of Onyx in a slow, "pause and restart" fashion, providing better control and improved penetration of the nidus. Angiographic evaluation can be performed during the period between injection "pause" and "restart," which allows for adjustment of the embolization strategy during the procedure.

Numerous studies of AVM embolization in which the investigators used Onyx have reported a complete occlusion rate of 4.1%–28%, mean nidus reduction of between 74.1% and 84%, and a morbidity and mortality rate of 4%–26.3%.[2,4–8] Complications associated with the use of Onyx include a rate of hemorrhagic complications that ranges from 0% to 15%.[2,4–7,9–15] and a rate ischemic of complications of 0% to 17%.[4,5,9,10,12,13] A few studies[5,11,16] have reported extraordinarily high complete occlusion rates of between 51% and 96%, with a morbidity and mortality rates from 0% to 8.5%.

Key words
- Arteriovenous malformation
- Brain
- Endovascular treatment
- Fistulous component
- Prioritized venous coiling

Abbreviations and Acronyms
AVM: Arteriovenous malformation
ICH: Intracerebral hemorrhage
NBCA: *N*-butyl cyanoacrylate
Onyx: Ethylene-vinyl alcohol copolymer
S-M grade: Spetzler–Martin grade

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A prospective, multicenter, randomized trial to compare the efficacy of Onyx versus NBCA for AVM embolization[17] showed that the use of Onyx led to more than 50% volume reduction in 96% cases compared with 85% of cases in which NBCA was used (although the difference was not significant); adverse effects were similar in both groups. That study suggested that Onyx was equivalent, but not superior, to NBCA in reducing AVM volume. Since its approval by the Food and Drug Administration in 2005, Onyx has been used widely in AVM embolization, and because of its better controllability and nidus penetration, there is a trend towards shifting the goal of endovascular treatment from presurgical or preradiosurgical treatment to curative treatment by embolization alone.[18,19]

Certain angiographic architectural features of AVM are more favorable for curative embolization or high-volume reduction rate, including (1) superficial location; (2) small-to-medium size; (3) small number of arterial feeders of large size, accessible for microcatheters, allowing 2–3 cm of Onyx reflux; and (4) single and superficial draining vein whose proximal part (emerging from the nidus) is recognizable.[7,13,15] Treating a brain AVM with a fistulous component with the use of liquid embolization, however, is always a challenge. Such a fistulous component usually will form a venous pouch just distal to the nidus, and this venous pouch might receive abnormal flow from more than one compartment within the AVM.

We hypothesized that precedent venous pouch coiling in a brain AVM with a fistulous component can appropriately increase outflow resistance, prevent migration of liquid embolic agents to other parts of the cerebral venous system, increase penetration of the nidus, and allow more control and greater reduction in volume. The goal of this study was to present our experience with endovascular embolization of brain AVMs with a fistulous component by using venous-side coiling, which was prioritized during the embolization procedure.

MATERIALS AND METHODS

Patients

From December 2010 to May 2014, 7 consecutive patients (3 men, 4 women; average age, 28.7 years; age range, 11 months to 67 years) with AVMs with a high-flow fistulous component were treated at our institute with venous coiling before transarterial liquid embolization (Table 1). One patient presented with intracerebral hemorrhage (ICH), 2 patients with headache, 2 patients presented with seizure, and 2 patients had AVMs that were found incidentally. Patient 6 had a first-ever ICH 16 years ago and had undergone 4 endovascular treatments; the last session was performed 11 years ago. Partial occlusion of the lesion was noted at that time. He presented with ICH again and was included as part of our study.

One patient had an AVM of Spetzler–Martin grade (S-M grade) I, 1 AVM was S-M grade II, 3 were grade III, and 2 were grade IV. The nidus size ranged from 1.7 to 6.0 cm, with a mean nidus size of 3.22 cm. Four patients had pure fistulous-type lesions, and 3 had lesions of the mixed fistulous-plexiform type. All AVMs shared a common feature of a high-flow fistulous component with a large venous pouch emerging from the nidus.

Treatment

The goal of treatment was curative treatment by endovascular embolization alone or volume reduction in preparation for further surgical resection or radiosurgery. All procedures were performed with the patient under general anesthesia in a biplane angiography suite. The right femoral artery was accessed with a 6-Fr sheath, and 6-Fr guiding catheters were used. Pre-embolization angiography was performed via ipsilateral or contralateral internal carotid artery, vertebral artery, or external carotid artery according to AVM location and preoperative findings on computed tomography or magnetic resonance imaging.

In the 7 patients who underwent endovascular treatment, the first priority was to reduce shunt flow by venous pouch coiling, followed by an attempt at nidus obliteration during the embolization procedure. Microangiography of the different compartments (including fistulous and non-fistulous compartments) was performed by superselective catheterization of different feeding arteries to evaluate flow dynamics. A microcatheter (Echelon-10; ev3, Irvine, California, USA; or Excelsior SL-10; Stryker, Cork, Ireland) was then navigated through the fistulous arterial feeder, with the tip advanced to the venous pouch just distal to the nidus. Loose coil packing (Matrix 2/GDC-10; Stryker) was then performed

Table 1. Demographics and Angioarchitectural Data of the 7 Patients Who Underwent Endovascular Treatment of Brain Arteriovenous Malformations with a Fistulous Component

Patient No.	Age/Sex	Presentation	Nidus Size/Type	Location	Arterial Feeders	S-M Grade
1	40 years/F	Incidental	3.55 cm/fistulous	Rt parietal	Rt MCA	3
2	15 months/F	Seizure	2.75 cm/fistulous	Rt frontal	Rt MCA, bil. ACA	1
3	7 years/F	Incidental	1.67 cm/fistulous	Rt cerebellar	Rt PCA	3
4	49 years/M	Headache	3.34 cm/mixed	Rt parieto-occipital	Rt PCA, MCA, MMA, OA	4
5	36 years/F	Headache	3.54 cm/mixed	Rt temporal	Rt MCA, AChoA, PCA, IMA, MMA	3
6	67 years/M	ICH	5.93 cm/mixed	Rt occipital	Rt ICA, ACA, MCA, PCA, Lt MMA	4
7	11 month/M	Seizure	1.73 cm/fistulous	Rt frontal	Rt MCA	2

S-M, Spetzler–Martin grade; F, female; Rt, right; MCA, middle cerebral artery; bil, bilateral; ACA, anterior cerebral artery; PCA, posterior cerebral artery; M, male; MMA: middle meningeal artery; OA, occipital artery; AchoA, anterior choroidal artery; IMA, internal maxillary artery; ICH, intracerebral hemorrhage; ICA, internal carotid artery; Lt, left.