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Case Report

Transarterial Balloon-assisted Onyx Embolization of Intracranial Arteriovenous Malformations Using a Dual-lumen Balloon Microcatheter: Two Case Reports

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The Onyx system has been well established in recent years as a very important material in the treatment of arteriovenous malformations (AVMs). When using the Onyx, it is essential to wait for the creation of a plug around the tip of the catheter, which enables the effective forward penetration of Onyx. Recent reports have shown that the introduction of a dimethyl sulfoxide compatible dual-lumen balloon microcatheter improves the efficiency of AVM embolization. We report our recent experience of two cases of intracranial AVM embolization using Onyx and the transarterial balloon-assisted technique. In both cases, the procedures were successfully performed and the nidus of the AVM was totally occluded in a relatively short time. This technique may enable immediate forward flow and penetration of Onyx without concern about reflux. It may also reduce the procedure time and increase the angiographic occlusion rate. Navigation of the dual-lumen balloon microcatheter nevertheless remains a challenge.

Keywords Arteriovenous embolization, Onyx, Scepter XC Balloon

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INTRODUCTION

The Onyx liquid embolic agent (ethylene vinyl alcohol copolymer; Covidien/ev3, Irvine, CA, USA) is a permanent, non-adhesive polymer for the management of vascular malformations. Onyx has been well established in recent years as a very important material in the treatment of arteriovenous malformations (AVMs). The angiographic cure rate of AVM using Onyx varies from 20% to 94.1%.[1)10)13)21)] When using the Onyx, it is essential to wait for the creation of a plug around the tip of the catheter, which enables the effective forward penetration of Onyx. However, proper creation of the plug is difficult as it can be a time-consuming and unpredictable process.

Recent reports show that the introduction of dimethyl sulfoxide (DMSO)-compatible dual-lumen balloon microcatheters improves the efficiency of AVM embolization.[8)12)] In this article, we present our initial experiences with transarterial balloon-assisted Onyx embolization of intracranial AVMs using the dual-lumen balloon microcatheter.

CASE REPORT

Case 1

A 49-year-old man was admitted to the Neurosurgery Department in our hospital a few hours after experi-

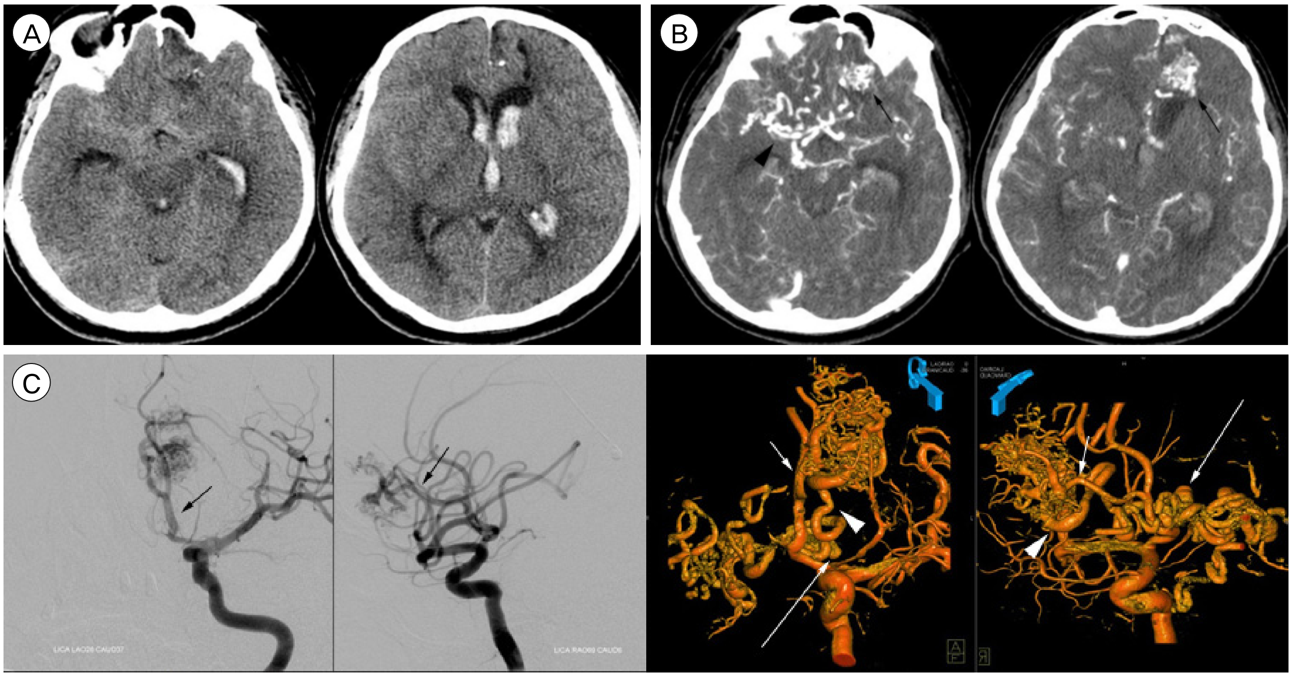

Fig. 1. A 49-year-old male patient with ruptured AVM. (A) Brain CT scan revealed diffuse SAHs in basal cisterns and large IVHs in the entire ventricles and enlarged ventricles. (B) Brain CTA showed AVM (arrows) at left lower frontal region, which was drained by enlarged veins(arrow head). (C) Conventional cerebral angiography showed AVM, which was supplied by left frontopolar artery (black and white short arrows) and the single drainage vein(white arrow heads) showed the severe ectasia, tortuosity and even varix (white long arrows). AVM = arteriovenous malformation; CT = computed tomography; CTA = computed tomography angiography.

encing sudden severe dizziness and mental deterioration. He denied any history of hypertension or diabetes. His family and medical histories were non-contributory. On neurological examination, he was drowsy but had no focal neurological deficits. A non-contrast-enhanced computed tomography (CT) head scan showed diffuse subarachnoid hemorrhages (SAHs) in the basal cisterns and large intraventricular hemorrhages (IVHs) throughout the ventricles (Fig. 1A). The ventricles were also enlarged. Three-dimensional CT angiography and conventional cerebral angiography showed an AVM in the left lower frontal region, which was supplied by the left frontopolar artery and drained by the ventricular vein to the sigmoid sinus via the straight and transverse sinuses (Fig. 1B and Fig. 1C). The single drainage vein showed severe ectasia, tortuosity, and a varix, which was suspected to have ruptured (Fig. 1C).

First, we performed extraventricular drainage to relieve the acute hydrocephalus. As the angiography revealed a single feeder (left frontopolar artery) with a diameter of about 3 mm, we planned to perform balloon-assisted Onyx embolization. We performed AVM embolization using 2.8 mL of Onyx assisted by the Scepter XC balloon (Microvention, Inc., Tustin, California, USA) of 4 × 10 mm in size. The duration of the procedure was 20 minutes and it was successful, i.e. the nidus of the AVM was totally occluded (Fig. 2). After the procedure, the patient was managed conservatively. Three weeks after the hemorrhages, the patient showed mild memory impairment and was referred to the rehabilitation department. At two months after the hemorrhages, a non-contrast-enhanced CT head scan showed no abnormal findings (Fig. 3A) and the patient showed signs of improvement in memory. Seven months after the hemorrhages cerebral angiography revealed that the AVM nidus remained totally occluded (Fig. 3B).

Case 2

A 37-year-old man was admitted to the neuro-

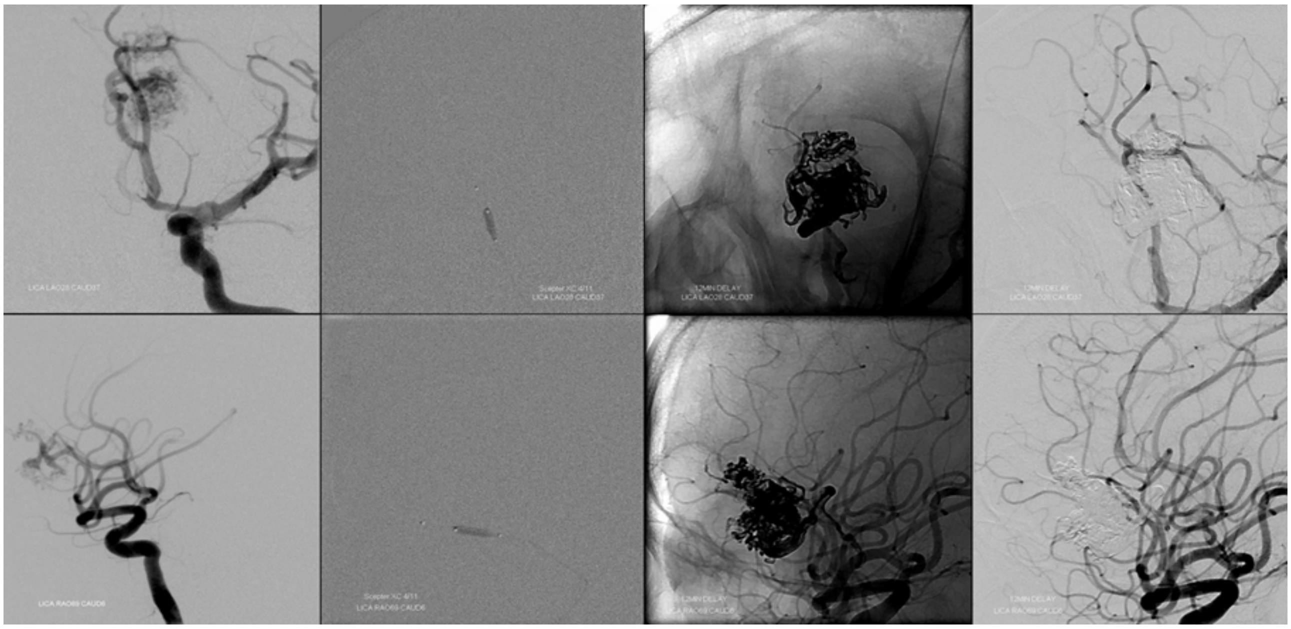

Fig. 2. Transarterial balloon-assisted Onyx embolization of intracranial AVM using dual-lumen balloon microcatheter. First column to the left: Working view anteriorposterior and lateral view, Second column: Ballooning, Third column: After completion of Onyx injection, and Fourth column: Angiography after Onyx embolization revealed the total occlusion of the AVM. AVM = arteriovenous malformation.

surgery department in our hospital a few hours after experiencing sudden syncope. He denied any history of hypertension or diabetes. His family and medical histories were non-contributory. On neurological examination, he was alert and did not show any focal neurological deficits. A non-contrast-enhanced CT head scan showed mild hyperdense lesions at the right medial frontal base (Fig. 4A). Brain magnetic resonance imaging (MRI) and angiography (MRA) and conventional cerebral angiography showed an AVM at the right frontal pole, which was supplied by the right medial orbitofrontal and frontopolar arteries and drained by the superficial cerebral vein to the superior sagittal sinus (Fig. 4B, C).

As the angiography revealed that the diameter of the feeder vessel was about 2 mm, we planned to perform balloon-assisted Onyx embolization. One of the feeder vessels, the right medial orbitofrontal artery, was very tortuous (Fig. 5A); the exchange technique was therefore used. This involved the introduction of a 45-degree preshaped Echelon 010 microcatheter into the right medial orbitofrontal artery close to the AVM nidus. A Transcend 014 300 cm microwire was inserted into the Echelon 010 microcatheter and the Echelon microcatheter was withdrawn, leaving the Transcend microwire in situ. The Scepter XC balloon was then introduced into the right medial orbitofrontal artery along the Transcend 014 300 cm microwire. Endovascular embolization of the right medial orbitofrontal artery was performed using 2.8 mL of Onyx assisted by the Scepter XC balloon (4 × 10 mm). The duration of the procedure was 30 minutes and it was successful, i.e. the lower two thirds of the AVM nidus was occluded (Fig. 5A). Angiography of the right frontopolar artery revealed that the upper one third of the AVM remained, and that the artery was also very tortuous. (Fig. 5A). We used the same equipment and exchange technique, with which the Scepter XC balloon was introduced into the right frontopolar artery at the region close to the residual AVM nidus. Endovascular embolization of this artery was performed using 1.3 ml of Onyx assisted by the Scepter XC balloon (4 × 10 mm). The procedure lasted 15 minutes and was successful with the nidus of AVM being totally oc-

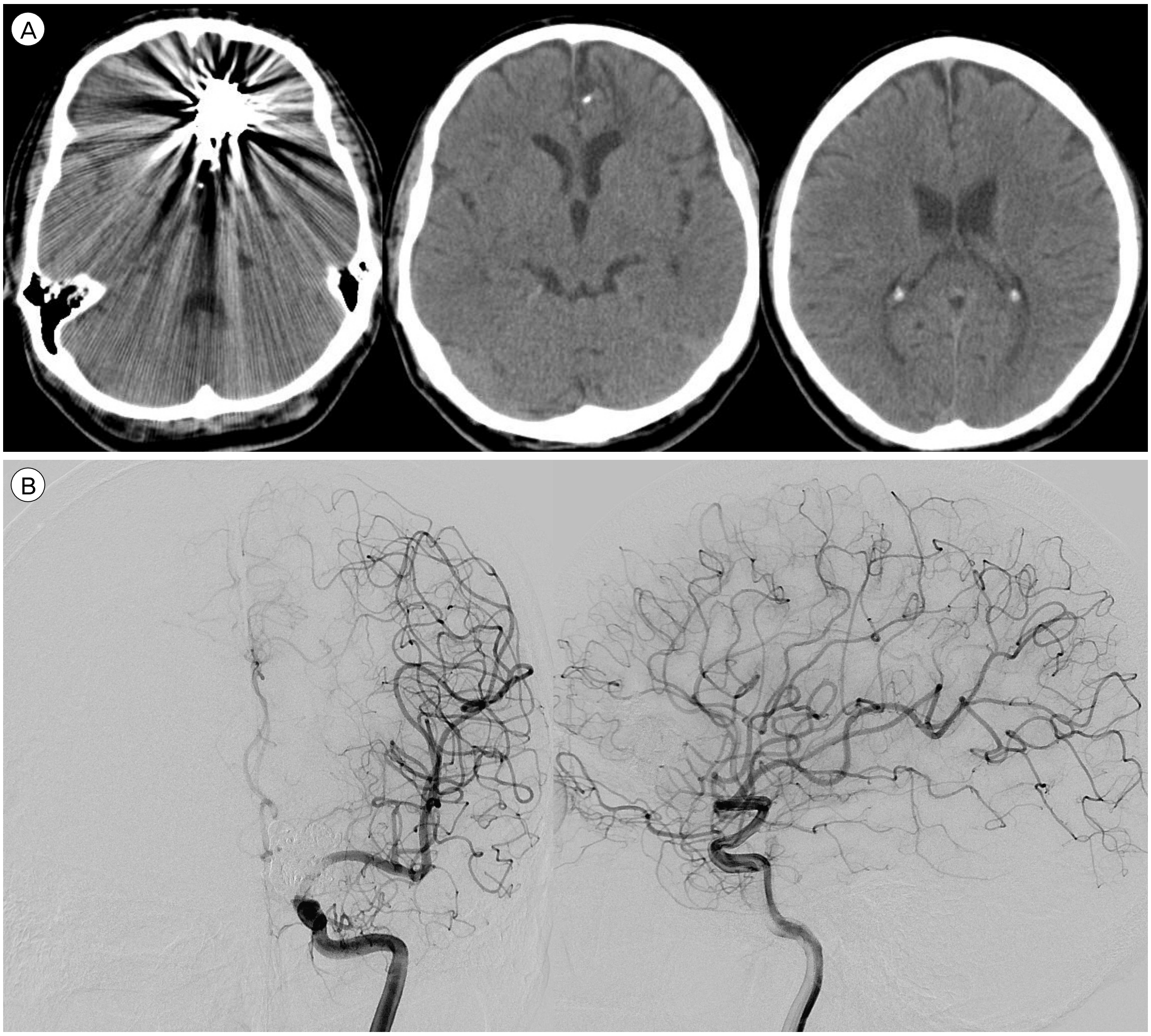

Fig. 3. Follow-up brain CT and angiograpy. (A) At two months after the hemorrhages, a brain CT scan showed no abnormal findings. (B) Seven months after the hemorrhages, the patient underwent cerebral angiography which revealed the AVM nidus remained totally occluded. CT = computed tomography; AVM = arteriovenous malformation.

cluded (Fig. 5B). After the procedure, the patient was managed conservatively and was discharged uneventfully several days later.

DISCUSSION

In recent years, the Onyx system has been used extensively for AVM embolization with an improved rate of angiographic occlusion. When using the Onyx, it is important to wait for the creation of a plug around the tip of the catheter because the plug allows the forward flow of the Onyx.[21] The plug is formed through the reflux of Onyx at the tip of the catheter and it may require time for proper plug formation because Onyx penetration is very variable. If unintended reflux occurs, the Onyx injection should be stopped for 1-2 minutes, prolonging the procedure time. Unintended early reflux is one of the main caus-

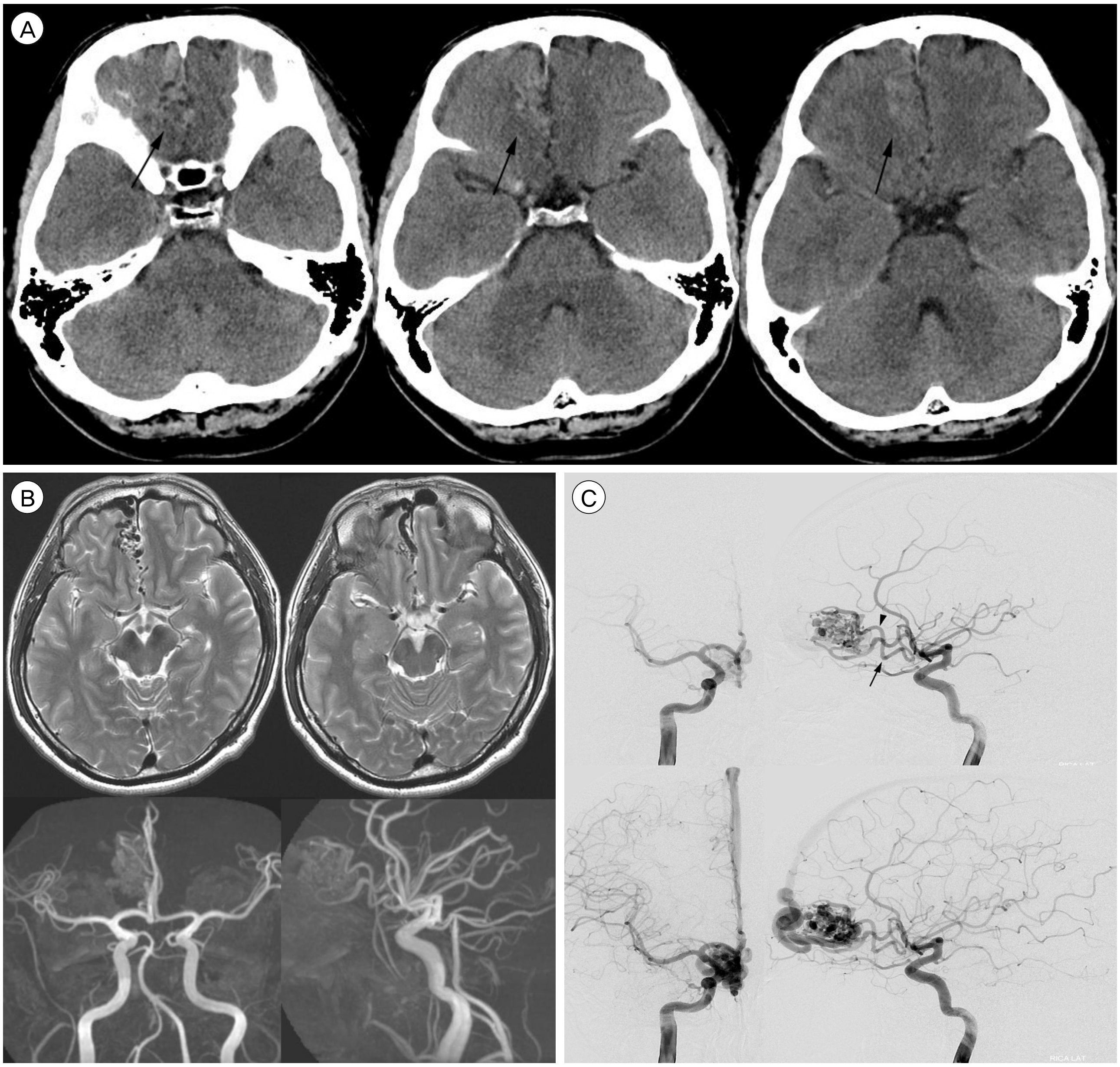

Fig. 4. A 37-year-old male patient with unruptured AVM. (A) A brain CT scan revealed mild hyperdense lesion at right medial frontal base (black arrows). (B) Brain MRI and MRA showed AVM at right frontal pole region. (C) Conventional cerebral angiography showed AVM at right frontal pole region, which was supplied by right medial oribitofrontal (black arrow) and frontopolar arteries (arrowhead) and drained by superficial cerebral vein to superior sagittal sinus. CT = computed tomography; MRI = magnetic resonance imaging, MRA = magnetic resonance angiography; AVM = arteriovenous malformation.

es of incomplete AVM embolization and one of the causes of some complications such as cerebral infarction due to reflux of the liquid to proximal normal branches,[20] stuck microcatheters that could not be removed and arterial rupture during the catheter removal procedures.[21]

In our cases, the Scepter XC balloon microcatheter acted as a plug making it possible to accomplish immediate forward flow of Onyx. Because there was no reflux of Onyx, we improved the angiographic embolization rate of AVM without the proximal branch occlusion or stuck microcatheters. Arrest of blood due to the Scepter XC balloon microcatheter allowed us to control the Onyx penetration rate more precisely and

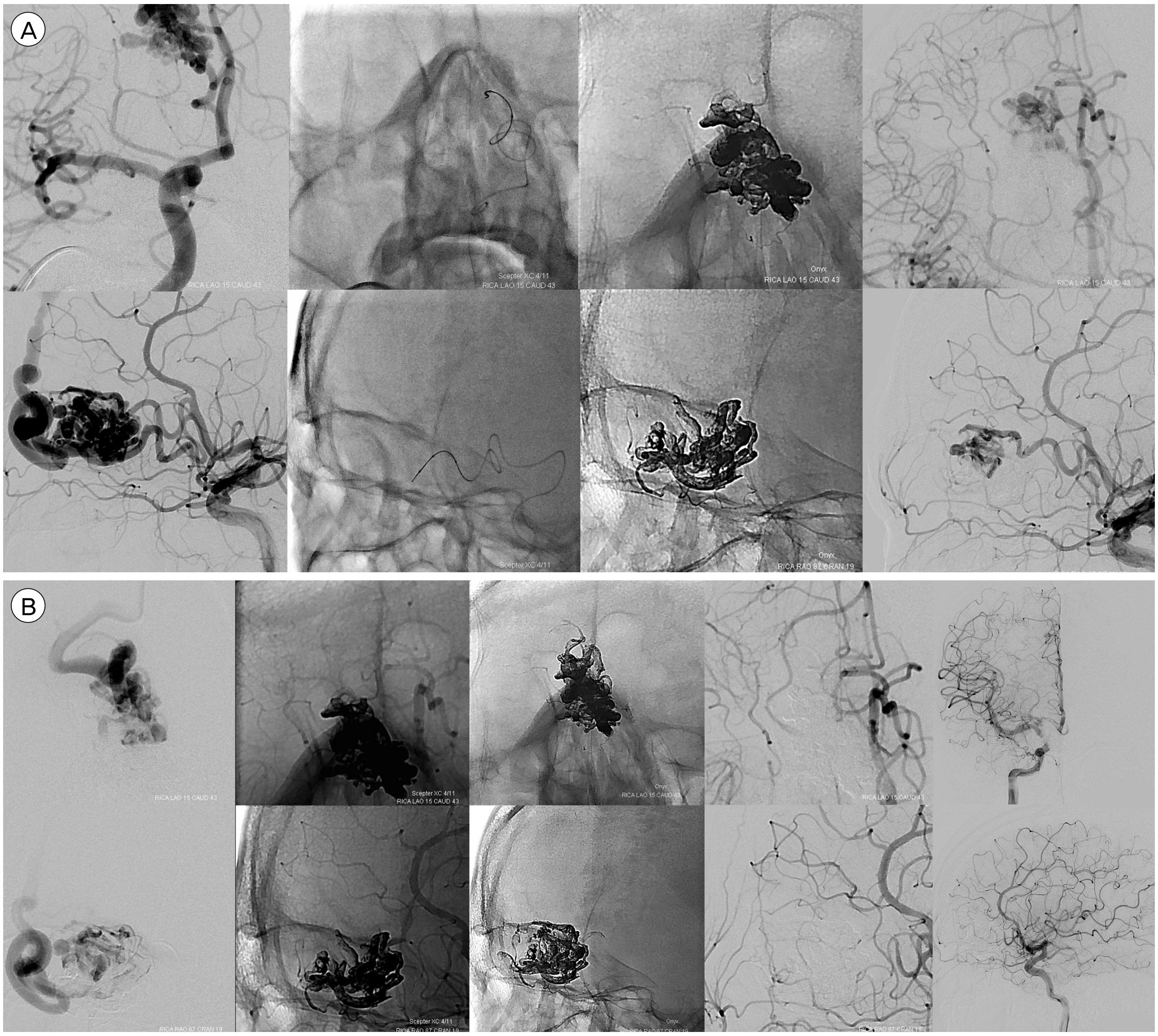

Fig. 5. Transarterial balloon-assisted Onyx embolization of intracranial AVM using dual-lumen balloon microcatheter. (A) Via the right medial orbitofrontal artery. First column to the left: Working view anteriorposterior and lateral view, Second column: After balloon catheter insertion, Third column: After completion of Onyx injection, and Fourth column: Angiography after Onyx embolization revealed the occlusion of lower two thirds of the AVM nidus. (B) Via the right frontopolar artery. First column to the left: Working view anteriorposterior and lateral view, Second column: After balloon catheter insertion, Third column: After completion of Onyx injection, Fourth column: After completion of Onyx injection, and Fifth column: Angiography after Onyx embolization revealed the total occlusion of the AVM nidus. AVM = arteriovenous malformation.

allowed us to protect the early occlusion of drainage veins. As a result, it took a shorter time than that done without Scepter SC balloon microcatheter to perform the AVM embolization, and total occlusion of AVMs was obtained without any complications.

Initially a detachable balloon was used as the permanent embolic device.[3,9,14,17-19] Thereafter, a single-lumen balloon-assisted embolization using Onyx was used for dural AVF.[2,6,11,15,16] They applied a single-lumen balloon microcatheter followed by a conventional DMSO compatible microcatheter (proximal balloon and distal microcatheter) into the feeding artery and performed the ballooning of a single-lumen balloon microcatheter followed by Onyx injection via the

DMSO compatible microcatheter, during which the microcatheter was jailed against the vessel wall. This jailing technique might not completely prevent Onyx reflux. With the advent of the dual-lumen balloon microcatheter, dual-lumen balloon-assisted embolization using Onyx has been used for dural AVF[4)5)] and for extracranial AVMs.[7)12)]

Recently, dual-lumen balloon-assisted embolization using Onyx has also been used for intracranial AVMs.[8)] In Jagadeesan's report, embolization using Onyx was performed in four intracranial AVMs.[8)] In all cases there was immediate antegrade flow and adequate penetration of Onyx with satisfactory angiographic occlusion rates. In one case, however, arterial rupture occurred and this was successfully managed using balloon, Onyx infusion, and surgical removal of the hemorrhage. The authors emphasized the importance of paying strict attention to matching the balloon inflation to the size of the vessel on the roadmap, as well as designation of one operator to balloon inflation and deflation throughout the procedure.

In both our cases, there was immediate forward flow and adequate penetration of Onyx and complete angiographic cures were achieved. There were no ischemic or hemorrhagic complications. However, there were some difficulties in the procedures. The most important factor was the navigation of the dual-lumen balloon microcatheter to the appropriate position of the feeding artery. Usually feeding arteries are relatively wide, but become tortuous in the AVM. The experience in our cases was similar. The lumens of A3 size were about 2-3 mm but they were very tortuous, which made navigation of the dual-lumen balloon microcatheter difficult. We overcame the difficulty by using microcatheter microwire exchange techniques as described above. Although we succeeded with this technique, it is not always possible. Therefore, when planning dual-lumen balloon-assisted embolization, it is very important to assess the route of the vessel to determine the type of technique to use. Another difficulty is rupture of the balloon. In order to prevent this complication, we matched the balloon inflation to the size of the vessel on the roadmap. We experienced no ruptures in our cases.

CONCLUSION

In keeping with other cases reported in the literature, we successfully performed transarterial Onyx embolization of intracranial AVMs using DMSO compatible dual-lumen balloon microcatheters. In the procedure of Onyx embolization for AVMs, reflux of Onyx is central. The Scepter XC balloon microcatheter acted as a plug, which enables immediate forward flow and penetration of Onyx without issues of reflux. It may also reduce the procedure time and increase the rate of angiographic occlusion. Navigation of the dual-lumen balloon microcatheter, however, remains challenging.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

REFERENCES

1. Abud DG, Riva R, Nakiri GS, Padovani F, Khawaldeh M, Mounayer C. Treatment of brain arteriovenous malformations by double arterial catheterization with simultaneous injection of Onyx: retrospective series of 17 patients. AJNR Am J Neuroradiol. 2011 Jan;32(1):152-8.
2. Andreou A, Ioannidis I, Nasis N. Transarterial balloon-assisted glue embolization of high-flow arteriovenous fistulas. Neuroradiology. 2008 Mar;50(3):267-72.
3. Brassel F, Solymosi L. An unusual congenital arteriovenous fistula of the vertebral artery and its embolization by a detachable balloon catheter. Neurosurg Rev. 1988;11(1):99-101.
4. Chiu AH, Aw G, Wenderoth JD. Double-lumen arterial balloon catheter technique for Onyx embolization of dural arteriovenous fistulas: initial experience. J Neurointerv Surg. 2014 Jun;6(5):400-3.
5. Dabus G, Linfante I, Martínez-Galdámez M. Endovascular treatment of dural arteriovenous fistulas using dual lumen balloon microcatheter: technical aspects and results. Clin Neurol Neurosurg. 2014 Feb;117:22-7.
6. Deng JP, Zhang T, Li J, Yu J, Zhao ZW, Gao GD. Treatment of dural arteriovenous fistula by balloon-assisted transarterial embolization with Onyx. Clin Neurol

Neurosurg. 2013 Oct;115(10):1992-7.

7. Fifi J, Niimi Y, Berenstein A. Onyx embolization of an extensive mandibular arteriovenous malformation via a dual lumen balloon catheter: a technical case report. J Neurointerv Surg. 2013 Mar;5(2):e5.
8. Jagadeesan BD, Grigoryan M, Hassan AE, Grande AW, Tummala RP. Endovascular balloon-assisted embolization of intracranial and cervical arteriovenous malformations using dual-lumen coaxial balloon microcatheters and Onyx: initial experience. Neurosurgery. 2013 Dec;73(2 Suppl Operative): ons238-43; discussion ons243.
9. Moret J, Lasjaunias P, Doyon D. Occipital approach for treatment of arteriovenous malformation of the vertebral artery by balloon occlusion. Neuroradiology. 1979 May;17(5): 269-73.
10. Mounayer C, Hammami N, Piotin M, Spelle L, Benndorf G, Kessler I, et al. Nidal embolization of brain arteriovenous malformations using Onyx in 94 patients. AJNR Am J Neuroradiol. 2007 Mar;28(3):518-23.
11. Newman CB, Hu YC, McDougall CG, Albuquerque FC. Balloon-assisted Onyx embolization of cerebral single-channel pial arteriovenous fistulas. J Neurosurg Pediatr. 2011 Jun;7(6):637-42.
12. Paramasivam S, Niimi Y, Fifi J, Berenstein A. Onyx embolization using dual-lumen balloon catheter: initial experience and technical note. J Neuroradiol. 2013 Oct;40(4):294-302.
13. Pierot L, Cognard C, Herbreteau D, Fransen H, van Rooij WJ, Boccardi E, et al. Endovascular treatment of brain arteriovenous malformations using a liquid embolic agent: results of a prospective, multicentre study (BRAVO). Eur Radiol. 2013 Oct;23(10):2838-45.
14. Serbinenko FA. Catheterization and occlusion of major cerebral vessels and prospects for the development of vascular neurosurgery. Vopr Neirokhir. 1971 Sep-Oct;35(5):17-27.
15. Shi ZS, Loh Y, Duckwiler GR, Jahan R, Vinuela F. Balloon-assisted transarterial embolization of intracranial dural arteriovenous fistulas. J Neurosurg. 2009 May;110(5):921-8.
16. Spiotta AM, Hughes G, Masaryk TJ, Hui FK. Balloon-augmented Onyx embolization of a dural arteriovenous fistula arising from the neuromeningeal trunk of the ascending pharyngeal artery: technical report. J Neurointerv Surg. 2011 Sep;3(3):300-3.
17. Takeda R, Usami T, Nakagawara J, Fujiwara H, Sato S, Hyogo T, et al. Clinical application of cerebral endovascular balloon catheter for arteriovenous malformation. Case report. Neurol Med Chir (Tokyo). 1984 Mar;24(3):194-201.
18. Taki W, Handa H, Yonekawa Y, Yamagata S, Miyake H, Matsuda I, et al. Detachable balloon catheter systems for embolization of cerebrovascular lesions. Neurol Med Chir (Tokyo). 1981 Jul;21(7):709-19.
19. Trattnig S, Samec P, Zeiler K. Balloon catheter technic and embolization--new therapeutic approaches in cerebral and spinal blood vessel malformations. Wien Klin Wochenschr. 1985 Aug;97(16):653-8.
20. van Rooij WJ, Sluzewski M, Beute GN. Brain AVM embolization with Onyx. AJNR Am J Neuroradiol. 2007 Jan;28(1):172-7; discussion 178.
21. Weber W, Kis B, Siekmann R, Kuehne D. Endovascular treatment of intracranial arteriovenous malformations with onyx: technical aspects. AJNR Am J Neuroradiol. 2007 Feb;28(2):371-7.