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Case Report

Utility of targeted balloon protection of the venous sinus for endovascular treatment of dural arteriovenous fistula by transarterial embolization with Onyx: A case report and literature review

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ABSTRACT

Background: Onyx has already been reported as an effective and safe agent in transarterial embolization of cranial dural arteriovenous fistula (d-AVF). However, successful treatment is related to not only complete shunt obliteration but also preservation of a normal route of venous drainage. Here, we present a case of transverse sigmoid d-AVF in which successful treatment was achieved by transarterial Onyx embolization with targeted balloon protection of the venous drainage.

Case Description: A 70-year-old man presented with a 3-month history of tinnitus in the left ear and mild headache. Magnetic resonance imaging (MRI) showed a cluster of abnormal blood vessels in the area of the left transverse sinus (TS)-sigmoid sinus (SS) junction. Cerebral angiography demonstrated a Cognard type IIa d-AVF at the left TS-SS junction, supplied mainly by vessels such as the left middle meningeal artery, left occipital artery, and left meningohypophyseal trunk. In the venous phase, the ipsilateral TS-SS was recognized as a functional sinus and the left vein of Labbe drained into the TS near the drainage channel. Based on these findings, we decided to perform endovascular treatment under a transarterial approach with Onyx using targeted balloon protection of the venous sinus to protect against Onyx migration and preserve antegrade sinus flow. The patient recovered well without sequelae, and follow-up MRI 12 months later showed complete disappearance of the d-AVF.

Conclusion: This treatment strategy using targeted balloon protection may be very useful to preserve antegrade sinus flow in patients with Cognard type IIa d-AVF.

Keywords: Dural arteriovenous fistula, Onyx, Targeted balloon protection of the venous sinus, Transarterial embolization

INTRODUCTION

Intracranial dural arteriovenous fistula (d-AVF) represents 10–15% of all intracranial vascular malformations.[5,6,10,14] In general, fistulas occur in the areas of the transverse and sigmoid sinuses and can remain asymptomatic until the patient reaches middle age or older.[2,14] However, patients may report symptoms of serious neurological disorders often resulting from bleeding, so this condition requires appropriate therapeutic intervention. Treatment options typically include arterial and/or venous embolization followed by surgery or radiosurgery, as needed. Recent rapid advances in endovascular technology have allowed neuro-interventionalists to treat d-AVF much more safely and effectively. In particular, Onyx (ethylene vinyl alcohol copolymer) has already been reported as an effective and safe agent in transarterial embolization (TAE) of cranial d-AVF.[4,11,13] However, when performing this procedure, care must be taken to preserve the normal venous drainage, such as the superior sagittal sinus, transverse sinus (TS), and sigmoid sinus (SS). In particular, successful treatment of a Borden type 2 or Cognard type II d-AVF is related to not only complete shunt obliteration but also preservation of the normal venous drainage.[8] We present herein a case of d-AVF that occurred at the TS-SS junction, in which successful treatment was achieved by TAE with Onyx combined with targeted balloon protection of the venous sinus to preserve the normal route of venous drainage.

CASE DESCRIPTION

A 70-year-old man with a history of slight hypertension presented with a 3-month history of tinnitus in the left ear and mild headache. Consciousness was clear and no neurological deficits were evident. Magnetic resonance angiography (MRA) on admission showed a cluster of abnormal blood vessels in the area of the left TS-SS junction [Figure 1a]. Fluid-attenuated inversion recovery imaging on magnetic resonance imaging revealed no abnormal changes [Figure 1b]. Cerebral angiography demonstrated a d-AVF at the left TS-SS junction, supplied mainly by the left middle meningeal artery (MMA), left occipital artery, left meningohypophyseal trunk, left posterior meningeal artery, and meningeal branch of the left superior cerebellar artery [Figures 2 and 3]. In the venous phase, venous flow drained mainly into the right TS, but the left vein of Labbe drained into the left TS near the drainage channel. On the other hand, no retrograde flow was recognized in the ectatic cortical vein [Figures 2 and 3]. Based on these findings, Borden type 1, Cognard type IIa d-AVF was diagnosed based on the location in the left TS-SS. The shunt point was confined to the short segment, but the affected venous sinuses (left TS and SS) were required for normal perfusion of brain parenchyma. A transvenous endovascular approach using embolic coils for lesions involving the TS and SS, as so-called sinus packing, was considered overly challenging. We, therefore, planned to perform endovascular treatment using the transarterial approach with Onyx and short-term placement of a sinus protection balloon to protect against Onyx migration and preserve normal venous sinus flow. After inducing general anesthesia, a 6-Fr Launcher guiding catheter (Medtronic Vascular, Danvers, MA) was inserted into the femoral artery and advanced to the left external carotid artery. A 4.2-Fr FUBUKI catheter (Asahi Intec, Aichi, Japan) was introduced as the distal access catheter into the left MMA. A Headway DUO microcatheter (MicroVention Inc., Aliso Viejo, CA, USA) was then navigated over a CHIKAI 0.35-mm (0.014-inch) microwire (Asahi Intec, Aichi, Japan) near the shunt point at the junction of the TS and SS [Figure 4a and b]. Second, a 6-Fr Launcher guiding catheter was introduced into the femoral vein and advanced to the right internal carotid vein (ICV), then a SHOURYU (Kaneka Medics, Kanagawa, Japan) was placed in the left TS-SS junction near the shunt point through the right TS over the confluence of bilateral transverse sinuses. To avoid migration of Onyx into the TS-SS junction and preserve antegrade sinus flow, we inflated the SHOURYU at the same site [Figure 4c], and consequently performed embolization using Onyx 18 to prevent embolic material from straying into the TS-SS [Figure 4d]. No Onyx migrated into the drainage channel and to the SS throughout the procedure. The procedure was completed after confirming complete disappearance of shunt flow. No procedural complications were encountered (total

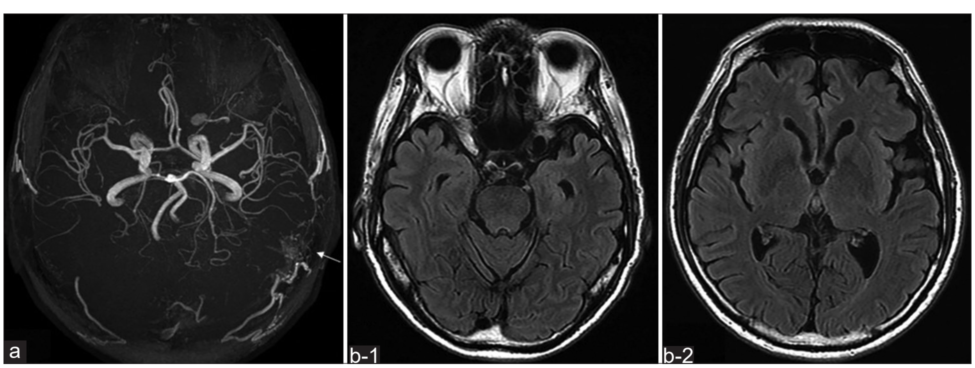

Figure 1: Magnetic resonance imaging on admission. (a) Magnetic resonance angiography shows abnormal clusters of numerous blood vessels in the area of the left transverse sinus-sigmoid sinus junction (white arrow). (b) Fluid-attenuated inversion recovery imaging reveals no abnormal changes.

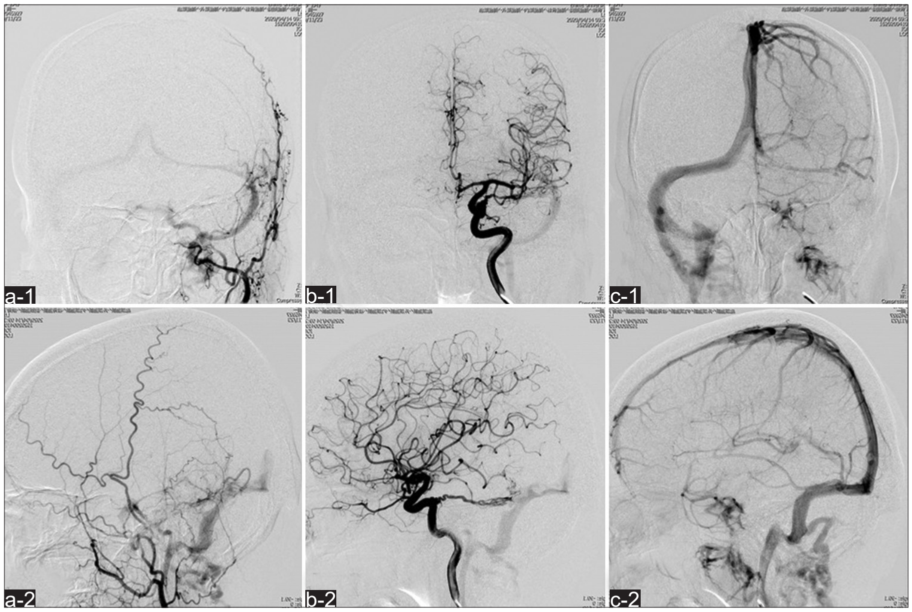

Figure 2: Preoperative cerebral angiography. (a) Left external carotid angiography (a-1: anterior posterior view, a-2: lateral view) showing shunt flow to the junction of TS-SS via the left middle meningeal artery and left occipital artery. (b) Left internal carotid angiography (b-1: anterior posterior view; b-2: lateral view) revealing fistula to the same area through the left meningohypophyseal trunk in the early phase. In the late venous phase (c-1: anterior posterior view; c-2: lateral view), the draining venous flows mainly into the right TS, but the left SS is partially used for normal venous perfusion. Retrograde flow in the ectatic cortical vein is not recognized. TS: Transverse sinus, SS: Sigmoid sinus.

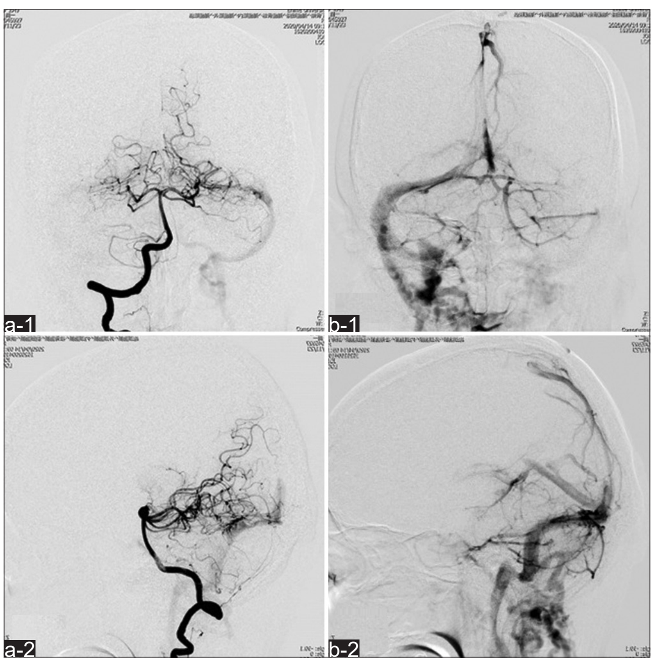

Figure 3: Preoperative cerebral angiography. (a) Left vertebral artery angiography (a-1: anterior posterior view; a-2: lateral view) showing the shunt flow to the same portion through left posterior meningeal artery and the meningeal branch of the left superior cerebellar artery in the early arterial phase. In the late venous phase (b-1: anterior posterior view; b-2: lateral view), venous flow drains mainly into the right TS, but the left SS is partially used for normal venous perfusion. Retrograde flow is not apparent in the ectatic cortical vein. TS: Transverse sinus, SS: Sigmoid sinus.

SHOURYU inflation time, 25 min). Final post embolization cerebral angiography showed complete occlusion of the shunt point and good antegrade venous perfusion of the left TS and SS to the left ICV [Figure 5a-c]. The patient was discharged home on postoperative day 7. He recovered well and without sequelae, and follow-up MRA 12 months later showed good reconstruction of the left TS-SS, and complete disappearance of the d-AVF [Figure 5d]. The clinical study of this report was approved by the ethics committee of the authors' institution, and informed consent was obtained from the patient prior to initiating the study.

DISCUSSION

Cranial d-AVFs are a general term for lesions that occur in the meninges.[13] In general, arterial blood supply to these lesions is through numerous arteries associated with the dura mater arising from the anterior or posterior circulation, with less common contributions from parenchymal arteries. On the other hand, venous shunting occurs into the dural venous sinuses or directly into the cortical or spinal veins.[4-6,10,11,13,14] The treatment strategy for d-AVF thus depends on breaking off this abnormal shunt area in the dura-arteriovenous system.

The main object of d-AVF treatment is to prevent retrograde high flow shunt of the dural arteriovenous system into the cortical veins of the brain parenchyma.[13] In recent years, the clinical management of d-AVF has included

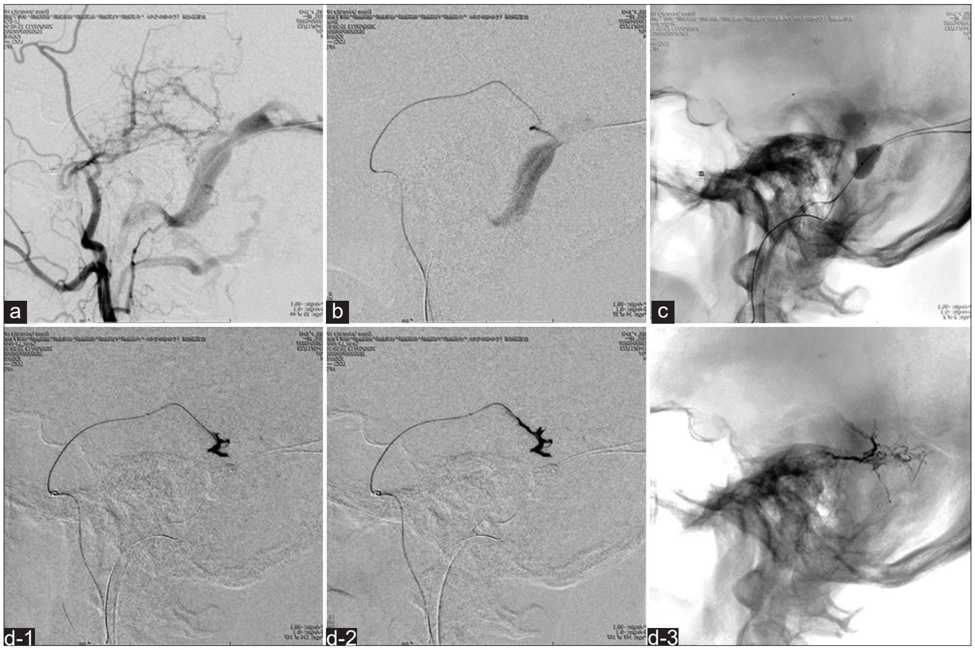

Figure 4: Endovascular surgery by transarterial embolization. (a and b) Cerebral angiography shows a Headway DUO microcatheter navigated to the near shunt point at the junction of the TS and SS (white arrow: Headway DUO; black dashed arrow: 4.2-Fr FUBUKI). (c) SHOURYU is placed and inflated in the left TSSS junction near the shunt point. (d) Embolization using Onyx 18 is performed while preventing embolic material from straying into the TS-SS (d-1, d-2: Digital subtraction angiography; d-3: Conventional angiography). TS: Transverse sinus, SS: Sigmoid sinus.

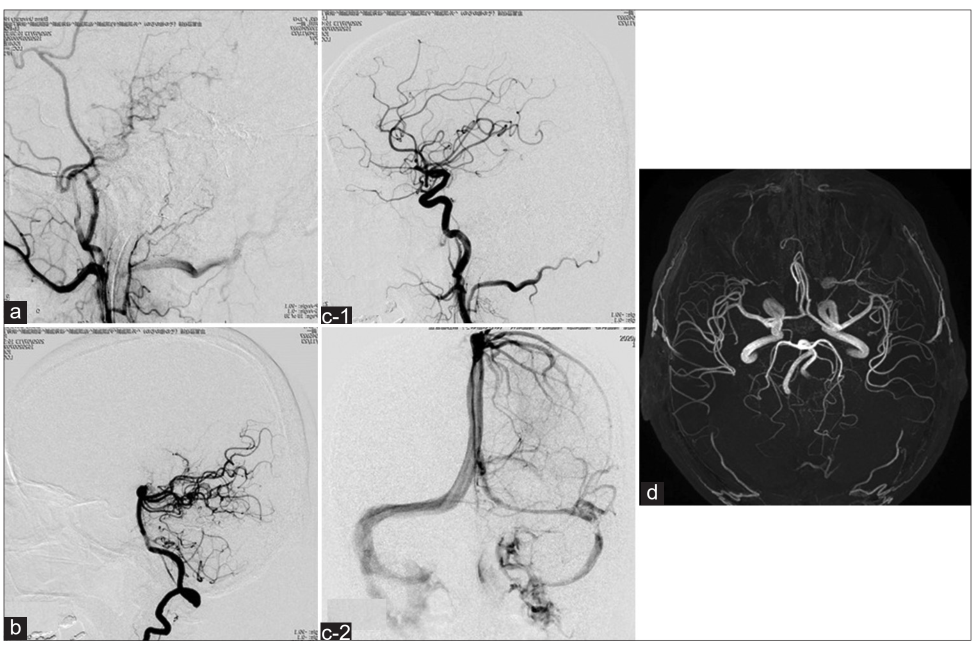

Figure 5: Postoperative cerebral angiography and MRA findings. (a-c) Digital subtraction angiography (a: left ECAG; b: left VAG; c-1: left ICAG) (lateral view) in the early arterial phase confirms complete disappearance of shunt flow. In the late venous phase, good antegrade venous perfusion of the left TS and SS to the left internal carotid vein is identified (c-2) left ICAG) (anterior-posterior view). (d) Follow-up MRA 12 months later shows left TS-SS venous flow has been well reconstructed and that the d-AVF has completely disappeared. MRA: Magnetic resonance angiography, ECAG: External carotid angiography, VAG: Vertebral artery angiography, ICAG: Internal carotid angiography, TS: Transverse sinus, SS: Sigmoid sinus, d-AVF: Dural arteriovenous fistula.

isolated endovascular surgery, such as TAE or transvenous embolization (TVE), surgical craniotomy, or radiosurgical repair, or a combination of these procedures. The ideal treatment is to break off the fistula from the artery and completely occlude the proximal vein in a safe, reliable, and controlled manner.[13] With the development of endovascular techniques and associated new devices, endovascular therapy has become the first-line treatment for d-AVF. Previously, some lesions have been difficult to completely close from the transarterial approach (TAE).[13] Transvenous endovascular methods were, therefore, developed using embolic coils for lesions involving the transverse and sigmoid sinuses. However, this approach can be challenging if the segment contains normal venous drainage of brain parenchyma or is isolated from previous craniotomy and radiation, stenosis, or thrombosis.[13] In the present case, performing sinus packing with an embolic coil by TVE seemed very dangerous, because the left SS was included in the route of normal venous perfusion. We, therefore, chose to treat with TAE instead of TVE.

Compared to other embolic materials including n-butyl-2-cyanoacrylate, Onyx can be delivered more slowly, so embolization from the artery to the dural vein of d-AVF can be controlled more effectively with Onyx.[1,9] In addition, Onyx is cohesive and non-thrombogenic, allowing better packing of lesions and making parenchymal venous occlusion less likely.[1,9] However, one potential risk is incomplete closure or fragmentation and migration of Onyx across the fistula to embolize cortical veins or venous sinuses, including the TS and SS. In particular, if the affected venous sinus is being used for normal perfusion, venous sinus occlusion due to inappropriate migration of Onyx can lead to fatal outcomes, such as cerebral infarction and bleeding. To avoid such complications, we performed the embolization procedure using Onyx with flow control by balloon protection of the venous sinus using the short, super-compliant SHOURYU balloon near the fistula through a transvenous approach.

Sinus protection by a transvenous balloon has been reported as another useful adjunct to endovascular treatment of d-AVF.[3,7,8,12,15] They showed that short sinus-protection balloon-assisted TAE was effective for the treatment of a Borden type 2 and Cognard Type II d-AVF.[3,7,8,12,15] These issues should be kept in mind when considering treatment for TS-SS d-AVF, as in our present case, concerning d-AVF at the TS-SS junction, most shunts are present on the proximal side of the inflow area at the vein of Labbe. Preserving the inflow area at the vein of Labbe and dilating a balloon at a site at which the shunt point can be accurately obliterated is therefore necessary. At this point, balloon migration to the periphery may lead to occlusion of the vein of Labbe. While such occlusion for a few minutes is not problematic, the flow pattern must always be examined using internal carotid angiography. During positioning of the balloon, careful attention is required to avoid interference with the normal cortical venous drainage by ensuring that the balloon only covers the small drainage channel. Matsuo *et al*. advocated appropriate patient selection as the key to the success of this technique. Important criteria for use of short-duration balloon protection were as follows: presence of a Cognard type I or II fistula, localization of the fistula at major functional sinuses, and presence of a single fistula on the sinus wall or close to the sinus into which a single channel is draining.[8] In addition, they excluded patients with multiple or diffuse fistulous points on the sinus wall because a short balloon could not protect the sinus completely.[8] In our case, the diagnosis was confirmed in a d-AVF located at the left TS-SS junction (Borden type 1, Cognard Type IIa). The shunt point was confined to a short segment at the functional venous sinus (left TS and SS) on the proximal side of the inflow area at the vein of Labbe. As a result, using targeted sinus protection with the balloon technique achieved clinically beneficial effects from this procedure in terms of both radiological findings and improvement of clinical features. We believe that this unique technique of occluding diseased connections between the shunt and normal sinus by targeted sinus protection is effective and facilitates Onyx penetration into the fistula. Further experience with more cases is needed to clarify the safety and effectiveness of this technique, and longer patient follow-up is required.

CONCLUSION

We have described a case of d-AVF at the junction of the TS-SS, in which successful treatment was achieved by TAE combining application of Onyx with targeted balloon protection of the venous sinus to preserve a normal route of venous drainage. This unique technique using a sinus protection balloon not only provided complete occlusion of the d-AVF but also avoided venous compromise and reduced the risk of Onyx migration into the patent sinus. This novel assistive technique may represent an effective, innovative, and less-invasive treatment for d-AVF by TAE with Onyx.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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