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Case Report

Treatment of tentorial dural arteriovenous fistula with preservation of the vein of Galen using a combination of transarterial and transvenous embolization

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ABSTRACT

Background: Dural arteriovenous fistulas (DAVFs) are abnormal connections between the dural arteries and dural venous sinuses or subarachnoid veins. A rare subtype of DAVF is tentorial DAVF (TDAVF), which is highly aggressive and often exhibits direct retrograde leptomeningeal drainage, increasing the risks of hemorrhage and venous ischemia. Transarterial embolization (TAE) using Onyx has become the preferred treatment method. In Onyx-based TAE, a long embolic material segment should be established within the draining vein past the shunt point. Here, we report a case of a patient with TDAVF who was successfully managed with preservation of the normal deep venous system through a combination of transarterial and transvenous embolization (TVE).

Case Description: A 56-year-old man was referred to our hospital following an abnormal brain imaging finding during a routine checkup. Angiography identified a TDAVF draining into the vein of Galen, categorized as Cognard type III. During Onyx injections, excessive penetration of the draining vein may lead to deep venous system occlusion, potentially causing severe complications. To mitigate this risk, we performed transarterial Onyx injection with TVE using coils, achieving complete occlusion without inducing deep venous infarction.

Conclusion: The combination of TVE using coils and Onyx TAE is an effective approach for managing TDAVF, particularly in cases where the distance from the shunt point to the normal venous return is brief, the shunt flow is high, or crucial veins, such as deep cerebral veins, are involved.

Keywords: Endovascular treatment, Tentorial dural arteriovenous fistula, Transarterial embolization, Transvenous embolization, Vein of Galen preservation

INTRODUCTION

Dural arteriovenous fistulas (DAVFs) are defined as abnormal connections between the dural arteries and dural venous sinuses or subarachnoid veins. They represent 10–15% of intracranial vascular malformations.[3,12-14,18] Tentorial DAVF (TDAVF) is a rare subtype, accounting for only 4–8% of all intracranial DAVFs. Despite its low prevalence, TDAVF is highly aggressive and often exhibits direct retrograde leptomeningeal drainage, which significantly increases the risks of hemorrhage and venous ischemia. Therefore, prompt intervention is necessary, not only in the presence of symptoms but also in the incidental discovery of the lesion.[3,9-11,14,17,22]

Treatment options for DAVFs include surgical, vascular occlusion, radiation therapy, and endovascular treatment. However, with the introduction of Onyx, transarterial embolization (TAE) using Onyx has become the preferred choice in many institutions.[6,7] Inadequate occlusion can lead to more complex and challenging feeders, requiring complete occlusion through the embolic agent permeating from the shunt point into the draining vein. In Onyx-based TAE, establishing a relatively long embolic material segment within the draining vein past the shunt point is often necessary.[2]

Here, we present a case of a patient with TDAVF who was successfully treated with a combination of Onyx TAE and transvenous embolization (TVE) using coils. In this case, the lesion revealed high flow with multiple feeders, and a relatively short draining vein immediately drained into the vein of Galen with a normal venous return. Our unique method for combining TAE and TVE is as follows: before the Onyx injection, we placed coils in the proximal portion of the draining vein to prevent the Onyx cast from migrating into the vein of Galen.

In this report, we discuss the safety, efficacy, and technical considerations of this combined approach.

CASE DESCRIPTION

A 56-year-old man was incidentally diagnosed with a TDAVF during a brain checkup, with magnetic resonance angiography revealing its presence, later confirmed through cerebral angiography. The DAVF's blood supply was provided by the right tentorial, right middle meningeal, and superior cerebellar arteries. The shunt pouch formed on the tentorium cerebelli, draining into the vein of Galen [Figure 1]. No varices were visible, and the venous drainage was classified as Cognard type III or Borden type III. Although embolization using Onyx was initially planned, further angiographic evaluation revealed a high-flow shunt with the drainage vein merging into the vein of Galen and maintaining normal

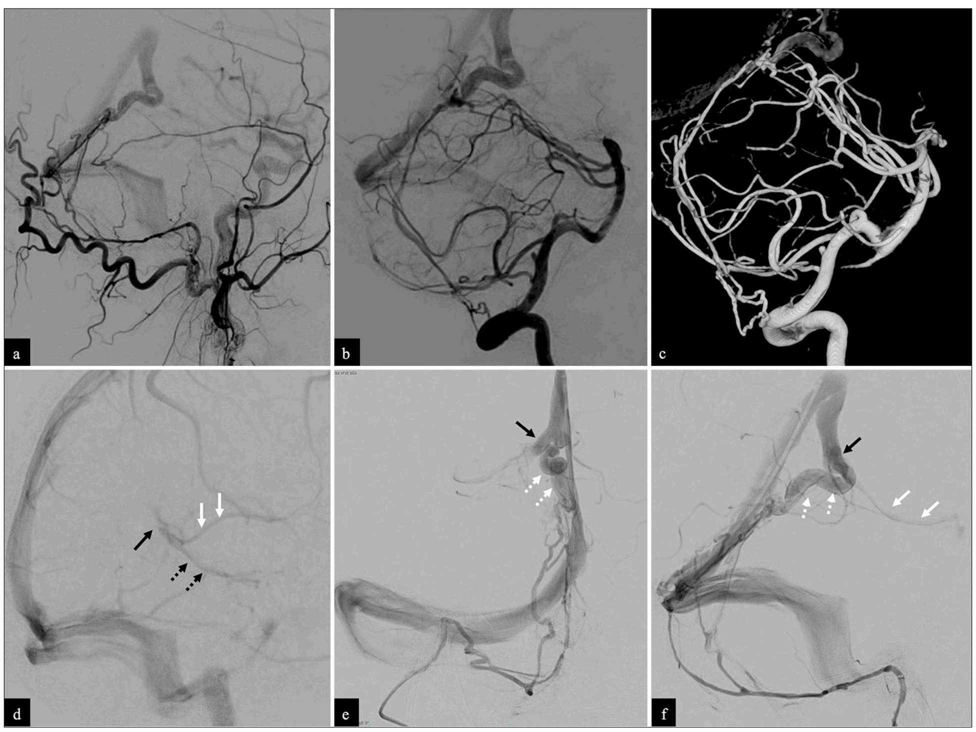

Figure 1: Preoperative cerebral angiography. (a) Lateral view of the right external carotid artery angiogram? Displaying a tentorial dural arteriovenous fistula (TDAVF) supplied by the occipital artery. (b and c) Lateral view and three-dimensional images of the left vertebral artery angiogram reveal the TDAVF supplied by the posterior meningeal artery. (d) Venous phase of the right internal carotid artery angiogram showing the delayed opacification of the basal vein of Rosenthal (dashed black arrows) and the internal cerebral vein (solid white arrows), which converge to form the vein of Galen. Note the subtle opacification of the vein of Galen (solid black arrow) indicating the junction with the TDAVF's drainage vein. (e and f) Frontal and lateral views from selective angiography of the right posterior meningeal artery. Solid black arrows indicate the junction of the drainage vein (dashed white arrows) and normal Galenic venous system, along with the associated venous reflux into the basal vein of Rosenthal (solid white arrows).

outflow. Concerns about potential obstruction of deep venous outflow led to the decision against using Onyx in the peripheral vein of Galen. To prevent complications, we selected a dual approach involving TVE at the origin of the drainage vein and TAE.

Under general anesthesia, a 7 Fr Roadmaster catheter (Goodman, Aichi, Japan) was positioned in the right external carotid artery. Using a CHIKAI Guidewire (ASAHI INTECC, Aichi, Japan) for navigation, a DeFrictor Nano microcatheter (MEDICO'S HIRATA INC, Osaka, Japan) was advanced to the tentorial artery near the fistula, and a TACTICS PLUS catheter (Technocrat, Aichi, Japan) was inserted into the right occipital artery. Another 7 Fr Roadmaster catheter (Goodman) was placed in the left internal jugular vein. Guided by a CHIKAI Guidewire (ASAHI INTECC), an SL-10 microcatheter (Stryker, Fremont, California, USA) was advanced to the drainage vein near the fistula, and a Guidepost microcatheter (TOKAI MEDICAL, Aichi, Japan) was positioned in the right occipital artery [Figures 2a-c]. The transvenous outlet was occluded using five Target Coils (Stryker), with a total length of 61 cm. On placement of the third coil, movement toward the drainage vein near the vein of Galen was observed, prompting the rapid deployment of the fourth and fifth coils to reduce shunt blood flow. The Guidepost microcatheter was pressed against the coil mass to prevent migration and was retracted [Figures 2d and e]. Arterial closure was achieved by precise injection of Onyx 18 to seal the shunt without disrupting normal flow. Coils on the venous side facilitated controlled delivery of the injected Onyx cast, preventing fragmentation or reaching the vein of Galen [Figure 2f]. Subsequent imaging confirmed complete closure of the DAVF while maintaining normal venous outflow [Figure 3]. The patient had an uneventful postoperative recovery, with no recurrence noted at the 6-month follow-up digital subtraction angiography.

DISCUSSION

TDAVF primarily receives blood supply from the middle meningeal, occipital, and posterior meningeal arteries, with most cases exhibiting retrograde leptomeningeal drainage, corresponding to Borden type II or III and Cognard IIb–IV classifications.[5,15] The shunt point is located in the tentorial dura rather than the venous sinus wall; however, lesions draining into the straight or superior petrosal sinus are also considered.[17] TDAVFs are rarely asymptomatic or incidentally detected; typically, they are progressive lesions linked to hemorrhage or worsening neurological deficits. Previous reports indicate that 79–92% of TDAVFs present with progressive neurological deficits and 38–74% with hemorrhage.[3,5,9,10,19,22]

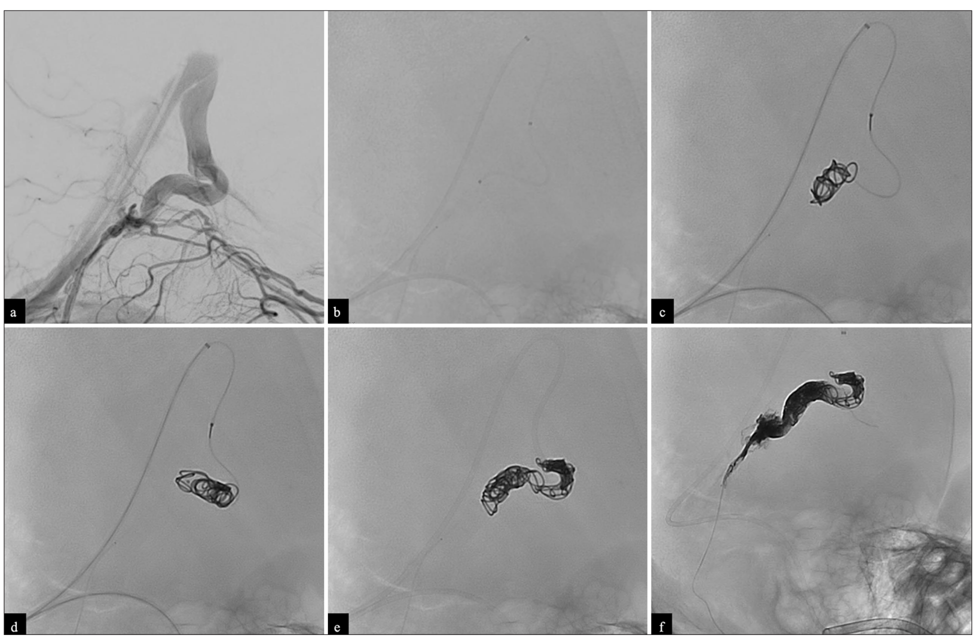

Figure 2: Operative cerebral angiography. (a) Working image (lateral view) of the left Vertebral angiography (VAG). A distal access catheter is already guided into the straight sinus. (b) Non-subtracted lateral view displaying microcatheters guided into both the draining vein and the posterior meningeal artery. (c) Coil filling within the draining vein near the shunt point and (d) movement of the coil mass are depicted. (e) Following coil embolization of the draining vein, the distal access catheter was guided near the coil mass, and the microcatheter was withdrawn. (f) An Onyx cast fills beyond the shunt point from the posterior meningeal artery into the draining vein.

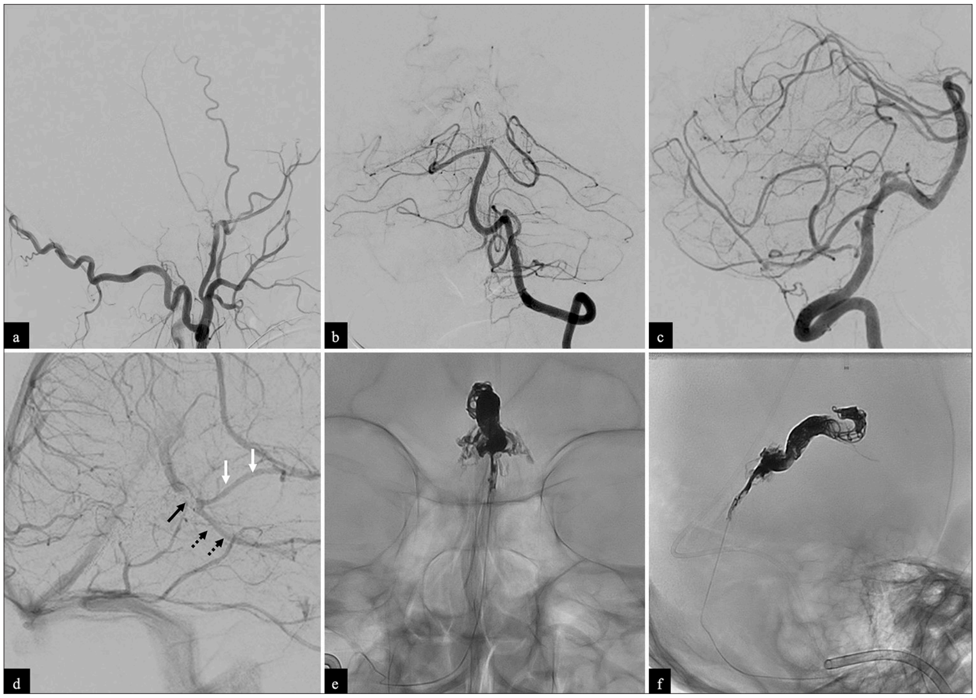

Figure 3: Postoperative cerebral angiography. (a) Lateral view of the right external carotid angiogram, (b) frontal view, and (c) lateral view of the left vertebral angiogram showing complete occlusion of the fistula. (d) Venous phase of the right internal carotid artery angiogram showing the merging point (solid black arrow), where the basal vein of Rosenthal (dashed black arrows) and the internal cerebral vein (solid white arrows) converge into the vein of Galen, indicating the persistence of normal venous drainage. (e and f) Non-subtracted frontal and lateral views displaying the Onyx cast and the coil mass.

TDAVFs are categorized into three subtypes: marginal, lateral, and medial. Lawton *et al*. identified the medial subtype to encompass Galenic, straight sinus, and torcular DAVFs.[14,15] The Galenic subtype typically receives its blood supply from the posterior cerebral and superior cerebellar arteries, which are found only in medial TDAVFs.[15] Accordingly, the current case was classified as the Galenic subtype.

TAE with Onyx is the primary treatment for TDAVF,[6,7] achieving complete obliteration rates of 62–92%, a significant improvement compared to the 26% rate before the introduction of Onyx.[1] However, TDAVFs often exhibit a complex arterial supply, posing challenges for shunt closure, and the TAE occlusion rate for TDAVFs ranges from 56% to 83%. Complications may include intracranial hemorrhage, cerebral infarction, and cranial nerve palsy, with an incidence of 9–33%, significantly higher than the complication rate of 0–7.5% observed in other DAVFs treated with TAE.[1,11,20]

One limitation of Onyx in TAE is its gradual solidification, leading to a higher likelihood of adhesive fragmentation and unforeseen venous infarction in high-flow DAVFs.[2,16,19,21] In addition, due to its reduced thrombogenic properties, achieving full closure of the DAVF and avoiding postoperative reoccurrence necessitate adequate glue administration extending past the shunt point into the draining vein.[4]

In our case, preoperative cerebral angiography revealed a relatively high shunt flow, with the draining vein converging into the vein of Galen and normal venous return. Thus, during Onyx TAE, preventing migration into the vein of Galen and subsequent impairment of venous outflow is crucial. To accomplish this, we initially conducted TVE with coils to decrease outflow from the shunt, prevent Onyx migration, and facilitate adequate injection of Onyx past the shunt point into the venous side.

The disadvantages of TVE include the potential for venous perforation due to the intricate venous anatomy and the necessity to navigate through potentially fragile and dilated meningeal veins. Inadequate occlusion can also increase the risks of venous hypertension and hemorrhage.[10,19] In addition, inadequate anchoring of the coil during TVE can lead to the risk of coil migration due to the high-flow shunt outflow. In this case, the draining vein had a relatively short and straightforward path, facilitating safe catheter navigation. To prevent coil migration during TVE, regulating the flow on the arterial side is essential. Suppose the coil mass proves unstable during the removal of the microcatheter. In that case, it is crucial to guide a distal access catheter close to the coil mass to stabilize it while withdrawing the microcatheter, thereby preventing coil migration. Recent reports have detailed the implementation of the Pressure Cooker Technique from the venous side, utilizing a combination of coils and Onyx. This approach allows for precise control of both shunt outflow and Onyx injection.[8] Originally developed for treating arteriovenous malformations, this technique has also been adapted for patients with DAVFs. However, as detachable-tip microcatheters are not yet available in Japan, it will be necessary to consider their introduction in the future.

CONCLUSION

The combination of TVE using coils and Onyx TAE proved to be an effective approach for managing TDAVF, particularly in cases where the distance from the shunt point to the normal venous return is brief, the shunt flow is high, or crucial veins, such as deep cerebral veins, are involved.

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