Dural Arteriovenous Fistula on the Wall of the Superior Sagittal Sinus Treated with Transarterial Embolization with Onyx: A Case Report

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Objective: Dural arteriovenous fistula (DAVF) is classified as sinus type if it occurs in a venous sinus and as non-sinus type if it directly flows into a cortical vein. The latter is considered to have a high risk of hemorrhage because blood flow directly returns to the cerebral vein.

Case Presentation: A 63-year-old man presenting with right hemiparesis and dysarthria was diagnosed with DAVF. We diagnosed transient ischemic attack (TIA) due to left internal carotid artery stenosis or cortical reflux of the DAVF. Treatment of DAVF was undertaken first, followed by carotid artery stenting (CAS) of the internal carotid artery stenosis.

Conclusion: Transarterial embolization (TAE) can be used for the treatment of DAVF located on the wall of the superior sagittal sinus (SSS). Further studies with greater accumulation of case are required.

Keywords ▶ on-the-wall type, superior sagittal sinus, dural arteriovenous fistula, Onyx transarterial embolization

Introduction

Dural arteriovenous fistula (DAVF) is classified as sinus type if it occurs in a venous sinus and as non-sinus type if it flows into a cortical vein. The former may retrogradely return to the cortical vein after flowing into a venous sinus. The latter is considered to have a high risk of hemorrhage because blood flow directly returns to the cerebral vein.

The present case is a superior sagittal sinus (SSS)-DAVF with a shunt point on the sinus wall. However, the blood did not flow back into the sinus, but flowed out to the cortical vein. Its hemodynamics are considered to carry a high hemorrhagic risk. According to the classification of DAVF, the present case is classified as Borden type III, Cognard type IV. This flow pattern has been reported to be a variant of SSS-DAVF with shunt point termed “on-the-wall type,” that is, blood flow just touches the sinus wall and flows toward the cortical vein.

SSS-DAVF has recently been treated with multimodality. SSS DAVF has been treated by various methods such as transarterial embolization (TAE) and, transvenous embolization (TVE). However, it is difficult to decide upon the appropriate treatment because the flow pattern varies with each cases. We report the present case about investigation of the pathology, and treatment of SSS-DAVF along with a literature review.

Case Presentation

The patient was a 63-year-old man who was transferred to our hospital for transient right paresis and dysarthria; however, the symptoms had resolved at the time of his arrival. He had a past medical history of untreated hypertension and he smoked cigarettes.

MRI

No acute cerebral infarction was detected on diffusion-weighted imaging, but left internal carotid artery stenosis
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of the bilateral internal carotid arteries, SSS functioned as a venous return in the cerebral hemisphere, and we confirmed no stenosis or obstruction of SSS (Fig. 2d). On evaluation of the shunt by 3D-DSA multi-planar reconstruction imaging (MPR), we noted accumulation of blood flow from the bilateral MMA on the SSS wall and shunt point formation (Fig. 2a and 2b).

Diagnosis
In the present case, we diagnosed transient ischemic attack (TIA) due to left internal carotid artery stenosis or cortical reflux of the DAVF. Both pathological conditions were indicated for treatment. However, we considered that TAE via the external carotid artery would be difficult after carotid artery stenting (CAS) because of interference from a guiding catheter stent. Thus, treatment of DAVF was undertaken first, followed by CAS of the internal carotid artery stenosis.

Treatment
Based on the evaluation on 3D-DSA, the shunt point was considered to be at the same site of the SSS wall. Thus, we decided to perform TAE via the left MMA through which a

was diagnosed. Moreover, bilateral white matter degeneration was observed on fluid-attenuated inversion recovery (FLAIR) at the same time (Fig. 1a) and cortical vein dilation was noted in the left hemisphere on T2-weighted imaging (Fig. 1b).

DSA
On selective angiography of the right external carotid artery, blood flow from the anterior branch of the right middle meningeal artery (MMA) formed a shunt on the left wall of the SSS posterior to the coronal suture. However, blood did not flow back into the sinus and directly refluxed to the dilated left cortical vein (Fig. 1c and 1d). In addition, the flow returned to the left transverse-sigmoid (T-S) junction (Fig. 1e). In addition, the flow to the cortex partially flowed into the SSS anterior to the shunt point (Fig. 1f) and then returned to the right T-S sinus (Fig. 1e). The blood in the right superior temporal artery also flowed into the same shunt point (Fig. 1f). On angiography of the left external carotid artery, blood flow from the left MMA formed a shunt at the same site and refluxed to the ipsilateral cortical vein without going through the sinus (Fig. 2c). On angiography of the bilateral internal carotid arteries, SSS functioned as a venous return in the cerebral hemisphere, and we confirmed no stenosis or obstruction of SSS (Fig. 2d). On evaluation of the shunt by 3D-DSA multi-planar reconstruction imaging (MPR), we noted accumulation of blood flow from the bilateral MMA on the SSS wall and shunt point formation (Fig. 2a and 2b).
sinus wall. By plug and push method, we repeatedly injected Onyx 18 into the dilated cortical venous lumen that was not functioning with normal return (Fig. 3a and 3b). This time Onyx gathered around the venous sinus, subsequently entered the dilated bridging vein and venous lacunae, and refluxed to the cortical vein (Fig. 3c). After embolization was complete, disappearance of the shunt was confirmed by imaging of the bilateral external carotid arteries (Fig. 3d). There was no problem with drainage to the SSS, which was confirmed by imaging the ipsilateral common carotid artery (Fig. 3e and 3f), and treatment was completed.

**Discussion**

**Characteristics of SSS DAVF**

Reportedly, SSS-DAVF accounts for about 8% of DAVF cases, and there are various treatment options. An absence of uniform treatment options makes conservation of the venous sinus a necessity because the hemodynamics of SSS-DAVF varies and SSS is the major element of venous return from the cerebral hemisphere via several bridging veins.
TAE becomes difficult because the SSS-DAVF has the presence of several feeding arteries bilateral. TVE may also be difficult because of obstruction to access routes and sinus stenosis. Moreover, it is difficult to approach the shunt point, as seen in the present case when blood flows into the sinus wall and refluxes into the cortical vein. Furthermore, both TAE and TVE pose a high risk and may not achieve cure when the draining vein of the shunt and normal venous return are shared in hemodynamics. Such cases cannot be cured by TAE or TVE alone and complex treatment is necessary in many cases.

**On-the-wall-type DAVF**

In the present case, the shunt point was formed on the venous sinus wall mainly using the bilateral MMA as the feeder. Blood flow did not directly return to the venous sinus thereafter, and it flowed out into the cortical vein and dilated venous lacunae. It is unclear how on-the-wall-type DAVF is caused. However, the following possibility has been investigated: Venous sinus obstruction occurred, and a vein developed as an outflow path and formed DAVF, followed by recanalization of the venous sinus. This pathology leads to on-the-wall-type DAVF. Partial stenosis remained as a residual finding when an obstructed venous sinus was recanalized. However, there was no problem with patency of the venous sinus; therefore, we suggest that this possibility is low.

It has been reported that the formation on-the-wall-type DAVF is due to venous thrombosis near the venous sinus, but the absence of such findings has been reported by others.

It is difficult to evaluate closely by imaging alone whether the shunt point is present on the venous sinus wall or if there is inflow into the surrounding bridging vein. It may be necessary to evaluate accurately and examine the shunt point by direct surgery. In our patient, we evaluated the shunt point based on caliber change. There was a change in the concentration of the contrast medium because the change in diameter with transition from artery to vein caused differences on selective 3D-DSA MPR. Regarding this finding, it was confirmed that there was blood flow in the venous sinus wall by selective 3D-DSA MPR of the right external carotid artery (Fig. 2a) and the left external carotid artery (Fig. 2b) in the present case. In addition, outflow into the cortical vein and venous lacunae after inflow...
into the venous sinus wall were confirmed in the behavior of Onyx TAE (Fig. 3c), based on which it was judged as on-the-wall-type DAVF.

Regarding shunt point localization, it has been reported in a pathological study that the DAVF shunt point is in the dura.1,8) The DAVF shunt point may be originally present in the dura on any of the sinus, bridging vein, or venous lacunae, as indicated by the asterisk in Fig. 4. However, in the on-the-wall type, the shunt point is present on the dura of the sinus wall and the pathology of DAVF is considered different, as indicated by the arrow in Fig. 4. Further accumulation of knowledge on shunt point localization is also necessary. SSS-DAVF is originally classified as the sinus type, but the on-the-wall type in the present patient represents hemodynamics without drainage through the sinus, similar to that of the non-sinus-type DAVF formed in the anterior cranial base and tent. A sinus is present in a structure surrounded by the dura propria and periosteal dura and dural veins are also present in similar regions. It is considered that a physiological shunt is present between dural arteries and dural veins in this interdural space.11) The shunt point of the sinus type is originally formed in this region, and various inflow and outflow pathways are formed thereafter. In contrast, the anterior cranial base and tent are comprised of only dura propria. An arteriovenous shunt is not physiologically formed in the dura. A bridging vein may be likely to function as an outflow path, and such a DAVF may be likely to progress to the aggressive type. In on-the-wall-type DAVF, the shunt point is present on the venous sinus wall and the sinus is not involved as an outflow path.

Blood directly flows out into the cortical vein in this manner and exhibits hemodynamic similarity to the non-sinus type.

**Onyx TAE**

It is difficult to treat DAVF with a shunt point present on the sinus wall via TVE, because in this type the blood reflexes to the cortex without going through the sinus. It is difficult to treat TAE via n-butyl-2-cyanoacrylate (NBCA) because it may cause feeder occlusion for multiple shunt points. In the current pathology, TAE with Onyx is capable of embolizing multiple shunt points by filling via a plug and push method even though many feeders are present. TVE is preferred to TAE for DAVF therapy and includes cases in which TAE may cause complications, such as cases involving a nerve-feeding blood vessel, cases with a feeder from the internal carotid artery, and cases using the external carotid artery with potential anastomosis with intracranial blood vessel as a feeder.9) In these cases, complications of TAE may be prevented by controlling blood flow using a balloon. Specifically, a guiding catheter is placed in the external carotid artery and then a balloon or balloon-attached catheter is placed in the inflow blood vessel or in its proximity to enable injection of Onyx through the guiding catheter. In addition, the use of a balloon-attached one for the guiding catheter makes blood flow control more effective. With blood flow control, Onyx can sufficiently enter the shunt over the outlet vein and prevent Onyx outflow into any other unexpected outlet vein.

Furthermore, when a balloon is used on the venous side, it is possible to prevent Onyx inflow into the functioning sinuses.

**Conclusion**

We encountered a patient with on-the-wall-type SSS-DAVF with a shunt not involving the sinus. It is difficult to decide upon a treatment strategy in many cases because the perfusion pattern of SSS-DAVF is complex and accounts for a major element of venous return. Pathologically, transvenous access to the shunt point is difficult either via the venous sinus, bridging vein, or cortical vein in the on-the-wall type and multiple shunts are present in many cases, for which treatment with TVE is frequently difficult. In contrast, a transarterial approach is possible in many cases and shunt point obstruction with Onyx by plug and push method is possible even in cases with multiple
shunt points. A favorable treatment outcome could be achieved via Onyx TAE in the present patient; however, further accumulation of cases is necessary.

Disclosure Statement

There is no company in which there is a conflict of interest to be disclosed for publication of this report.

References