



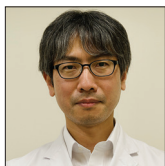
Case Report

Non-sinus type of transverse sinus dural arteriovenous fistulas on the arachnoid granulation of the dural sinus wall

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ABSTRACT

Background: The etiology of a non-sinus-type dural arteriovenous fistulas (DAVFs) with shunt points located on the sinus wall, previously described as on-the-wall-type DAVFs, is unknown.

Case Description: Two cases of non-sinus-type transverse sinus DAVF with a shunt point limited to the dural sinus wall, causing cortical venous reflux, were successfully treated with endovascular transarterial Onyx embolization. The Onyx cast showed multiple feeders from the occipital and middle meningeal arteries aggregated in the arachnoid granulation (AG), which dilated the draining vein.

Conclusion: Non-sinus-type DAVFs with shunt points located on the AG may be one of the presentations of an on-the-wall-type DAVF.

Keywords: Arachnoid granulation, Dural arteriovenous fistula, On-the-wall-type, Onyx transarterial embolization, Transverse sinus

INTRODUCTION

A dural arteriovenous fistula (DAVF) is a rare intracranial vascular malformation, accounting for 10–15% of all cases. During the development of DAVFs, meningeal arteries develop fistulous connections with the dural sinus or cortical veins through the enlargement of pre-existing physiological shunts or the development of *de novo* fistulas through neoangiogenesis.^[6] In particular, the non-sinus type requires careful attention due to the high bleeding risks associated with dangerous direct cortical venous reflux. In such types of DAVFs, shunt points limited to the dural sinus wall have been reported as “in-” or “on-the-wall-type” DAVFs in the transverse sinus (TS) and superior sagittal sinus; however, their etiology remains unknown.^[1,2,4,8] We present two rare cases of on-the-wall-type TS-DAVFs treated successfully with transarterial Onyx embolization. In both cases, postoperative images revealed that the Onyx cast traced the embolized multiple feeders aggregating into the arachnoid granulation (AG), from which a dilated draining vein was launched. The present cases indicate that an AG with a DAVF may be one of the presentations of an on-the-wall-type DAVF.

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CASE DESCRIPTION

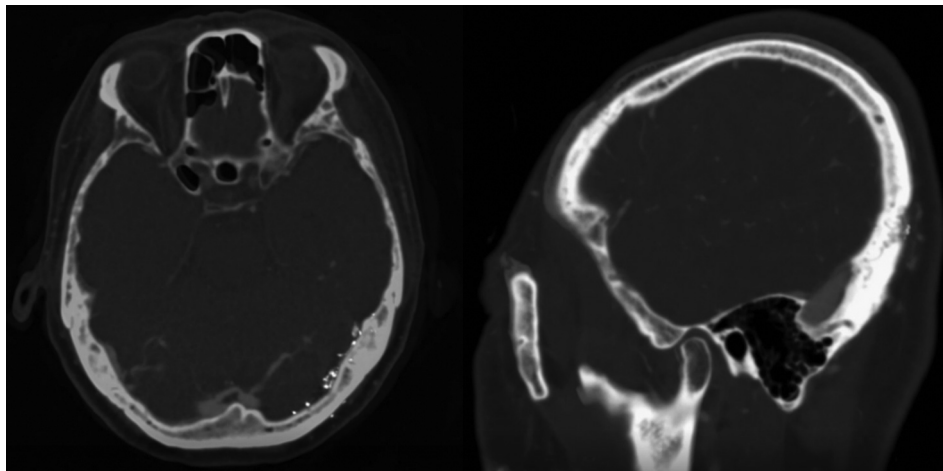
Case 1

A 64-year-old man with motor weakness in the right hand was admitted to our hospital. Magnetic resonance imaging revealed no lesions responsible for his symptoms; however, time-of-flight magnetic resonance angiography demonstrated venous reflux into the vein of Labbe (VOL), suggesting a TS-DAVF [Figure 1a]. Digital subtraction angiography (DSA) showed that the TS-DAVF was supplied by the occipital artery (OA) and the middle meningeal artery (MMA) [Figure 1b]. Cortical venous reflux was detected into the VOL without venous drainage into the dural sinus, which is a high bleeding risk (Borden type III, Cognard type III). The shunting point was suspected to be limited to the TS wall. Transarterial Onyx embolization through OA was performed endovascularly under general anesthesia. A 6-Fr Roadmaster catheter (Goodman, Aichi, Japan) was placed in the external carotid artery as a guiding catheter, and a DeFrictor microcatheter (Medico's Hirata, Osaka, Japan) with Tactics (Technorat, Aichi, Japan) was used as an intermediate catheter. The catheter tip was placed in the mastoid branch of the OA. A SHOURYU HR (Kaneka Medics, Kanagawa, Japan) 7 × 7-mm balloon catheter was placed on standby in the TS to prevent unexpected Onyx penetration into the sinus. A total of 1.82 mL of Onyx18 (ev3 Neurovascular, Irvine, CA) was injected to achieve successful penetration into the VOL, including the shunt point, without neurological complications [Figure 1c-e]. No Onyx penetration into the TS was observed. Postoperative three-dimensional-DSA and computed tomography (CT) fusion imaging revealed that

the Onyx cast successfully showed the embolized multiple feeders from the occipital and middle meningeal arteries aggregated into the AG and a dilated draining vein launched from the shunt point [Figure 1f-h] [Video 1].

Case 2

A 54-year-old man was incidentally suspected of having a TS-DAVF with cerebral cortical venous reflux on contrast-enhanced CT for examination of thyroid disease [Figure 2a]. Subsequent DSA revealed a TS-DAVF supplied by the MMA and OA [Figure 2b]. The shunt point was suspected to be limited to the TS wall, with no involvement of the dural sinus (Borden type III, Cognard type IV). Due to the high bleeding risk, transarterial Onyx embolization through the MMA was performed endovascularly under general anesthesia. A 6-Fr Roadmaster catheter (Goodman, Aichi, Japan) was placed in the external carotid artery as a guiding catheter, and a DeFrictor microcatheter (Medico's Hirata, Osaka, Japan) with Tactics (Technorat, Aichi, Japan) was used as an intermediate catheter. The tip of the catheter was placed in the petrosquamous branch of the MMA. A Scepter C (Terumo, Tokyo, Japan) 4 × 10-mm balloon catheter was placed and inflated on the proximal side of the OA to reduce blood flow during Onyx injection. A total of 1.47 mL of Onyx18 was injected to achieve successful penetration into the cortical vein, including the shunt point on the TS wall, without neurological complications [Figure 2c-e]. No Onyx penetration into the TS was observed. In postoperative fusion images, the Onyx cast showed multiple feeders aggregated into the AG and a dilated draining vein similarly [Figure 2f-h] [Video 2].



Video 1 and 2: Left external carotid artery angiography (lateral view) shows a non-sinus-type transverse sinus dural arteriovenous fistula with the shunt point limited to the dural sinus wall, causing cortical venous reflux. Postoperative three-dimensional digital subtraction angiography and computed tomography fusion imaging revealed that the Onyx cast successfully showed the embolized multiple feeders from the occipital and middle meningeal arteries aggregated into the arachnoid granulation and a dilated draining vein launched from the shunt point.

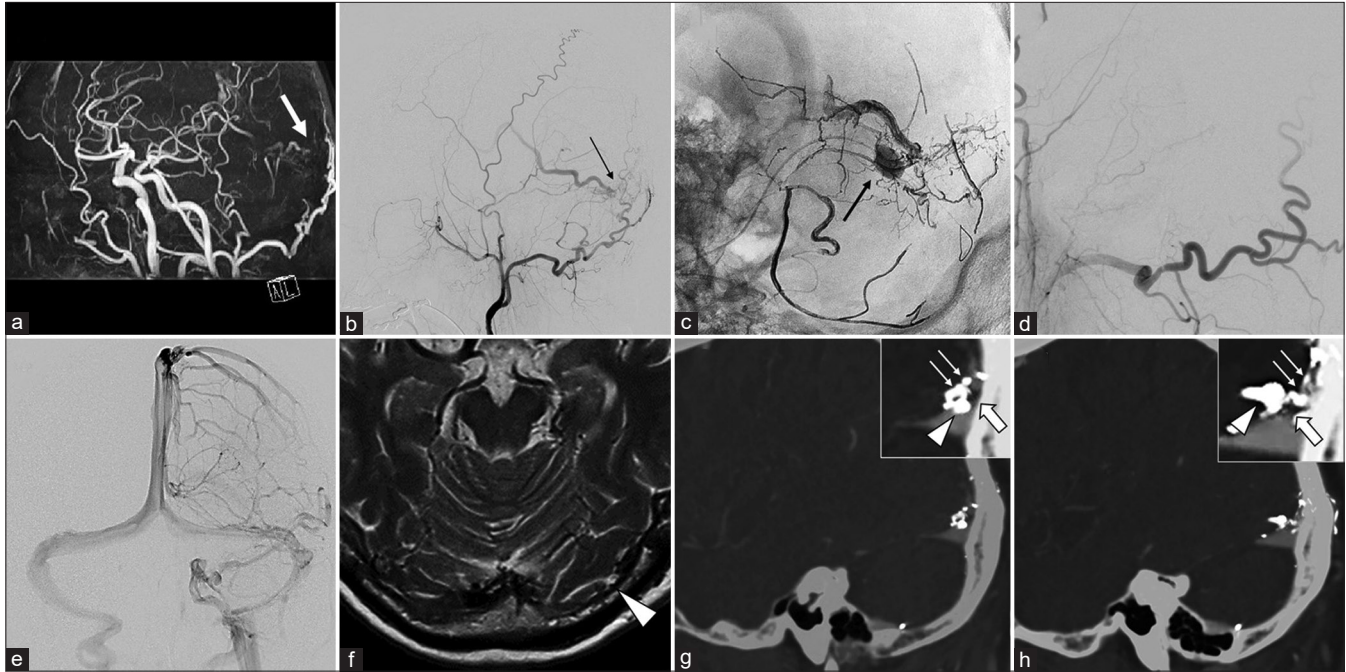


Figure 1: (a) A time-of-flight magnetic resonance angiography image demonstrates a left transverse-sigmoid dural arteriovenous fistula (DAVF) with cortical venous reflux (white arrow). (b) Left external carotid artery angiography (lateral view) demonstrates multiple feeding arteries of a DAVF from the mastoid branches of the occipital artery (OA) and petrosquamous branches of the middle meningeal artery directly draining into the vein of Labbe (VOL) (black arrow). The shunting point was suspected to be limited to the transverse sinus (TS) wall with no venous drainage into the dural sinus. (c) Transarterial Onyx embolization was performed through the mastoid branch of the OA with a DeFrictor microcatheter (Medico's Hirata, Osaka, Japan) and achieved successful penetration into the VOL. A SHOURYU HR (Kaneka Medics, Kanagawa, Japan) 7 × 7-mm balloon catheter was placed on standby in the TS for Onyx penetration into the sinus; however, the shunting point was completely isolated from the TS (black arrow). (d) Final view after Onyx embolization; complete occlusion of the arteriovenous shunt. (e) The venous phase of internal carotid artery angiography demonstrates that the left TS was intact. (f) Heavy T2-weighted magnetic resonance imaging before Onyx embolization demonstrates the existence of arachnoid granulation (AG) in the shunting point of the left TS (white arrowhead). (g and h) The sagittal view of postoperative digital subtraction angiography and computed tomography fusion image shows that the Onyx cast demonstrated that multiple feeders (white arrows) aggregated into the AG (white arrow) and a dilated draining vein launched from the shunt point (white arrowhead).

DISCUSSION

Two cases of non-sinus-type TS-DAVF with the shunt point limited to the dural sinus wall causing cortical venous reflux were successfully treated with endovascular transarterial Onyx embolization. Interestingly, post-Onyx-embolization images showed that the Onyx cast could clearly trace the feeding arteries to the draining veins, including the shunt point on the AG outside the TS [Figures 1g and h; 2g and h]. A rare non-sinus-type DAVF with a shunt point limited to the dural sinus wall has been reported as a variant of AVFs within the wall of dural sinuses^[1] or as an on-the-wall-type DAVF.^[4,8] Such DAVFs may result from the recanalization of an obstructed venous sinus due to venous thrombosis, and some reported that a giant AG causing venous hypertension secondarily resulted in a thrombosed vault DAVF;^[2,5] however, the dural sinuses were not involved, and there was no thrombosis in the present cases. The AG is a small extension of the arachnoid membrane into the venous sinus and plays an important role in

the drainage of the cerebrospinal fluid into the venous sinuses. It is occasionally observed at the TS and frequently exists at the termination of the VOL.^[3] The AG is generally avascular, as a fibrotic degenerative form of arachnoid villi, which is classified as interdural or intradural, depending on their location and site of drainage.^[9] The interdural AGs adhere to the arachnoid membrane and cross the infradural folds of the dura's inner layer, whereas intradural AGs are located within the leaflets of the dura and open directly into the sinus. Involvement of the venous system and attachment of the dura mater could provide an opportunity for the origination of a DAVF on the AG. The present cases indicate that the dural feeders aggregated into the interdural AG base, which is the fold of the dura mater, and cortical venous reflux occurred from the shunt point without draining into the dural sinuses. These AGs would be interdural without a direct opening into the sinus.

Transarterial Onyx embolization has recently become widely recognized in the treatment of DAVFs.^[7] It

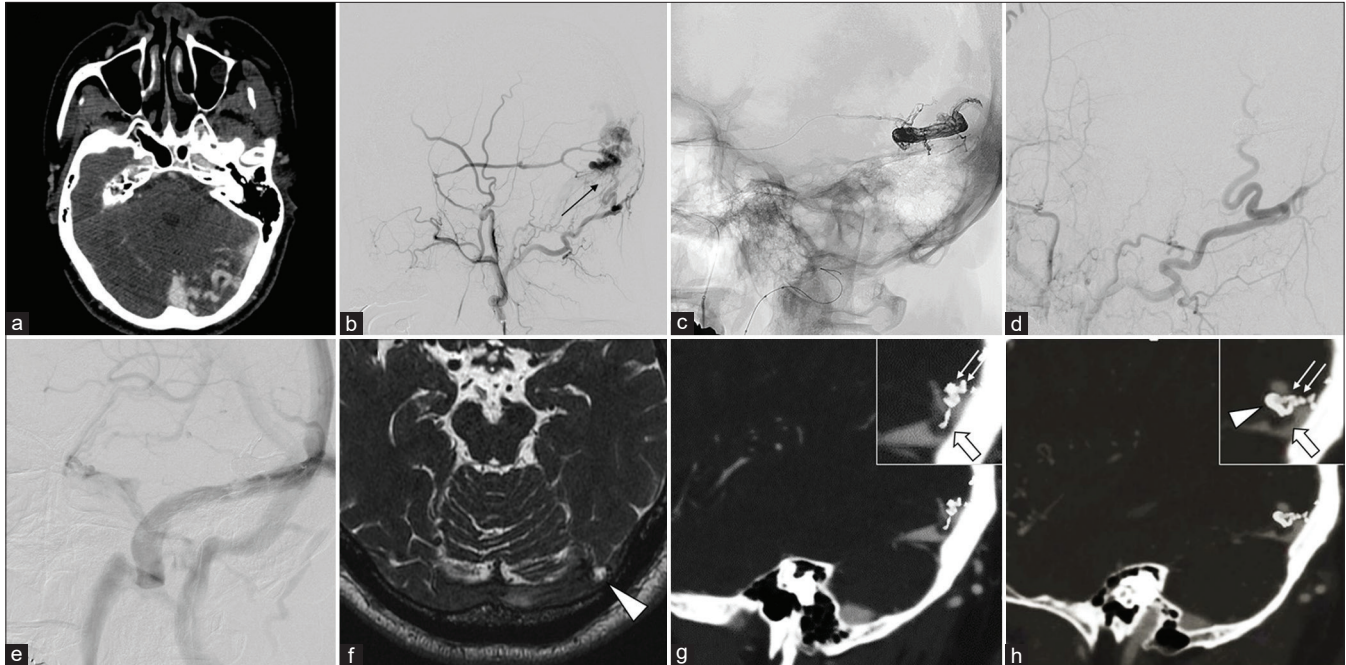


Figure 2: (a) Contrast-enhanced computed tomography (CT) demonstrates cortical venous reflux, indicating a left transverse-sigmoid dural arteriovenous fistula (DAVF). (b) Left external carotid artery angiography (lateral view) demonstrates multiple feeding arteries of a DAVF from the petrosquamous branches of the middle meningeal artery (MMA) and transosseous branches of the occipital artery (OA) directly draining into the cortical vein. The shunting point was suspected to be limited to the transverse sinus (TS) wall with no venous drainage into the dural sinus (black arrow). (c) Transarterial Onyx embolization was performed through the petrosquamous branch of the MMA with a DeFrictor microcatheter (Medico's Hirata, Osaka, Japan) and achieved successful penetration into the cortical vein. A Scepter C (Terumo, Tokyo, Japan) 4×10-mm balloon catheter was placed and inflated on the proximal side of the OA, with flow reduction during Onyx injection. (d) Final view after Onyx embolization; complete occlusion of the arteriovenous shunt. (e) The venous phase of internal carotid artery angiography demonstrates that left the TS was intact with no Onyx penetration. (f) Heavy T2-weighted magnetic resonance imaging before Onyx embolization demonstrates the existence of arachnoid granulation (AG) in the shunting point of the left TS (white arrowhead). (g and h) The sagittal view of postoperative digital subtraction angiography and CT fusion image shows that the Onyx cast demonstrated that multiple feeders (white arrows) aggregated into the AG (white arrow) and a dilated draining vein launched from the shunt point (white arrowhead).

is effective for these types of DAVFs because Onyx penetration into the draining vein can close the shunt point with multiple feeders. Although the shunt point was not investigated with open surgery in our cases, the Onyx cast was helpful in tracing the feeding arteries and draining veins, including the shunt point at the AGs, on postoperative images.

CONCLUSION

A non-sinus-type DAVF with shunt points located on the AG may be one of the presentations of an on-the-wall-type DAVF.

Ethical approval

The Institutional Review Board approval is not required.

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.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the

writing or editing of the manuscript and no images were manipulated using AI.

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