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Case Report

Transvenous embolization of a Borden III middle cranial fossa dural arteriovenous fistula through the vein of Trolard and superficial middle cerebral vein: A technical case report[☆,☆☆]

Yoshinori Kadono, MD, PhD[a,b,*], *Kazushige Maeno, MD*[a]

[a] *Department of Neurosurgery, Takatsuki General Hospital, 1-3-13, Kosobe, Takatsuki, Osaka 569-1192, Japan*
[b] *Department of Neurosurgery, Osaka University Graduate School of Medicine, 2-2, Yamadaoka, Suita, Osaka 565-0871, Japan*

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A B S T R A C T

Endovascular treatment for isolated dural arteriovenous fistula (DAVF) in the middle cranial fossa (MCF) with pure cortical venous drainage poses challenges, including the absence of a safe access route for transvenous embolization (TVE) and the risk of ischemia to neuro feeding vessels and dangerous anastomosis at the sphenoid wing. Therefore, surgical treatment involving direct blockage of venous reflux via craniotomy is typically preferred. We describe the case of a 63-year-old woman presented with generalized seizures and was diagnosed with a Borden III left MCF-DAVF. Initial TVE was unsuccessful due to an occluded inferior petrosal sinus and a lack of connection between the cavernous sinus and the shunt point. After reducing the shunt flow with transarterial embolization, retrograde TVE through cortical drainage enabled successful treatment for the DAVF. We used a triple coaxial system (4-French guiding sheath, 3.2-French intermediate distal access catheter, and 1.5-French microcatheter) to retrogradely navigate a microcathter from the right jugular vein through the superior sagittal sinus, the vein of Trolard, and into the superficial middle cerebral vein, ultimately achieving shunt occlusion using several coils. This case demonstrates that TVE for MCF-DAVFs with pure cortical venous drainage is feasible when a safe anatomical route is established using appropriate strategies and instruments and provides a safe and effective treatment option for similar cases.

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* Corresponding author.
E-mail address: y-kadono@nsurg.med.osaka-u.ac.jp (Y. Kadono).
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Introduction

Dural arteriovenous fistula (DAVF) is a disease caused by abnormal vascular communication, an arteriovenous shunt, within the meninges. Dural arteries supply DAVFs, while dural sinuses and/or cortical veins drain them. DAVFs located in the middle cranial fossa (MCF), excluding the cavernous sinus (CS), are uncommon but aggressive lesions associated with cortical vein reflux. According to the classifications by Borden et al. [1] and Cognard et al. [2], intracranial DAVFs with a direct shunt to a cortical vein and retrograde drainage of a cortical vein pose a high risk of neurological symptoms or intracranial hemorrhage due to impaired cerebral perfusion caused by cortical venous reflux. These advanced DAVFs require immediate surgical and/or interventional treatment due to their malignant nature.

The traditional curative endovascular treatment for DAVFs involves transvenous occlusion of the affected sinuses [3,4]. In cases of DAVFs within the MCF, the preferred endovascular approach is transvenous embolization (TVE) through the inferior petrosal sinus (IPS) using coils rather than transarterial embolization using liquid materials. This preference arises due to the risk of cranial nerve complications around various dangerous foramina and the risk of migration to the connecting normal cerebral arteries. Because Borden III DAVFs without antegrade venous drainage have no simple connection to the affected sinus, these isolated DAVFs are usually treated by penetrating the obstructive outlet or by direct surgical disconnection of the pial venous drainage through craniotomy [5,6]. Usually, retrograde embolization through pial veins is generally avoided due to the perforation risk associated with their tortuous and fragile origin. Moreover, the retrograde approach is not preferred due to the need for long and complex catheterization pathways.

Recent advancements in neuroendovascular techniques and instruments have enabled the successful treatment of DAVFs using retrograde TVE through cortical veins. Several case reports have highlighted the feasibility and safety of this approach, particularly in challenging cases where traditional routes are inaccessible [7–10]. Herein, we report a challenging TVE procedure performed through the vein of Trolard and the superficial middle cerebral vein (SMCV) for an isolated type of MCF-DAVF and review relevant literature on retrograde endovascular embolization for DAVFs through cortical veins. This novel technique allows access to otherwise unreachable shunt points, offering a viable alternative to open surgical interventions.

Case description

A 63-year-old woman presented to our emergency room with a generalized seizure following a partial facial seizure. She was subsequently diagnosed with symptomatic epilepsy. A year earlier, she had developed facial paralysis and was initially diagnosed with multiple DAVFs. At that time, magnetic resonance imaging (MRI) revealed aggressive DAVF with intracranial venous reflux, prompting her to consider a close examination and treatment. However, we postponed the treatment at her request. After starting antiepileptic medications, she still had weakness on her right side and difficulty speaking. Magnetic resonance angiography (MRA) showed multiple DAVFs with aggressive intracranial venous reflux, and perfusion images revealed increased blood flow in the left side of her brain, leading to a diagnosis of symptomatic left MCF-DAVF (Borden type III) with other DAVFs (Figs. 1A–C).

One week after admission, an embolization following diagnostic angiography under general anesthesia was planned. An angiogram showed a left MCF-DAVF with broad intracranial venous reflux and cerebral venous congestion (Figs. 1D–F). The angiogram also revealed multiple feeders of MCF-DAVF, including many branches from the internal maxillary artery, but the middle meningeal artery was not involved (Fig. 1D). The main draining vein was the SMCV to the vein of Trolard, while deep drainage occurred through the uncal vein to the basal vein of Rosenthal. However, the CS and pterygoid plexus were occluded. Following diagnostic angiography, we determined the shunt point to be the laterocavernous sinus. Consequently, we planned TVE through the occluded IPS accessed from the femoral vein and could reach the lateral wall of the CS (Fig. 1G), however, we were unable to reach the shunt pouch. Finally, we abandoned TVE, and performed transarterial coil embolization of the anterior and middle deep temporal artery for flow reduction (Fig. 1H). Postoperative MRA indicated a partial reduction of shunt flow (Fig. 2A), but cerebral venous congestion remained.

Three weeks later, we attempted a different TVE by accessing the SMCV through the vein of Trolard from the jugular vein (Fig. 2B). First, we advanced a 4-French Cerulean (Medikit, Tokyo, Japan) into a 4-French long sheath placed in the right jugular vein to the transverse sinus but failed. Next, we applied a smaller 3.2-French distal access catheter, Guidepost (Tokai Medical Products, Aichi, Japan), which we successfully placed at the connection of the vein of Trolard and the superior sagittal sinus (SSS) (Figs. 2C and D). Despite attempts to advance a 1.5-French Marathon catheter (Medtronic, Irvine, CA, USA) through the distal access catheter toward the SMCV using multiple wires, we could not reach the shunt pouch. Finally, we successfully inserted a 1.5-French DeFrictor Bull (Medicos Hirata, Osaka, Japan) with a CHIKAI X10 microwire (Asahi Intecc, Aichi, Japan) into the distal access catheter, which we placed at the shunt point through the SMCV (Fig. 2C).

TVE commenced using an unshaped i-ED Infini coil (Kaneka Medix, Osaka, Japan) for the large pouch. However, due to its high flow, the coil was not placed directly around the shunt point. Second, some 3D-shaped coils (Barricade; Century Medical, Tokyo, Japan) (i-ED complex; Kaneka Medix, Osaka, Japan) were used to make anchor frames near the shunt point and the orifice of the uncal vein (Fig. 2D). After framing, i-ED Infini coils were utilized to fill large spaces; and, finally, 3D and helical coils were used for internal filling. Following the placement of the 29th coil, a final angiogram showed almost no shunt flow (Figs. 2E and F). Additionally, postprocedure CT scans revealed that the coils were appropriately placed at the MCF near the foramen ovale (Fig. 2G). An MRI the following day confirmed complete obliteration of the shunt with improved venous congestion (Fig. 2H). The patient had no complications such as cranial nerve palsy or cerebral infarction after the intervention. Other DAVFs were treated in subsequent sessions,

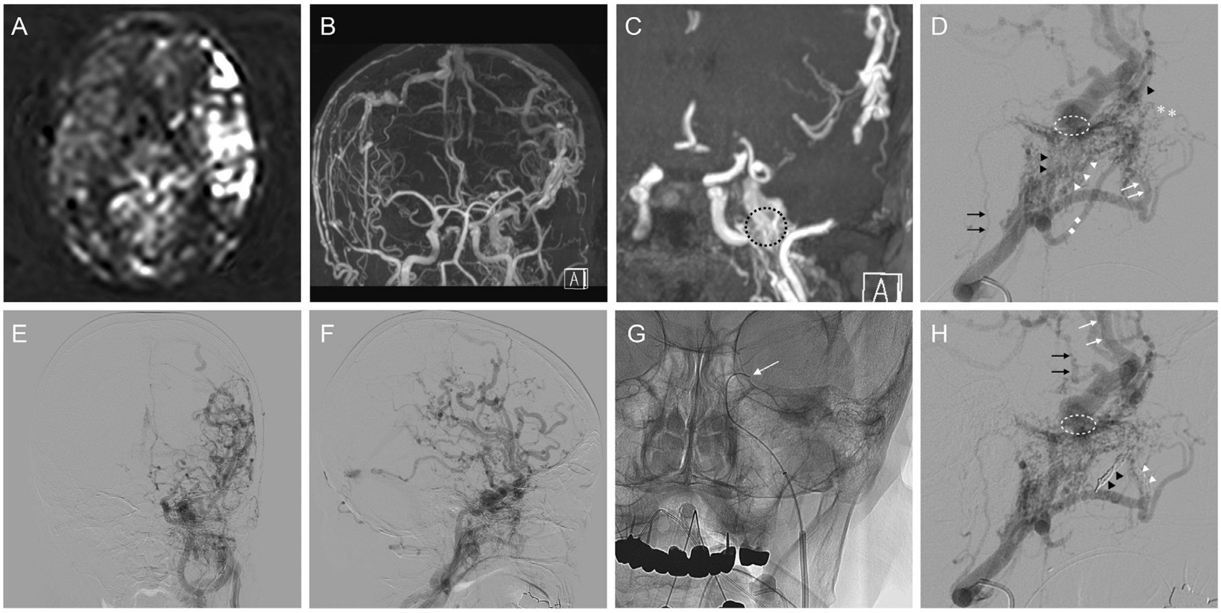

Fig. 1 – (A) Axial arterial spin labeling magnetic resonance images of the brain show posticteric left-hemispheric hyper-perfusion. (B) Magnetic resonance angiography and (C) its maximum intensity projection show a left middle cranial fossa (MCF)-dural arteriovenous fistula (DAVF) and other DAVFs. Many feeders from the left external carotid artery pour into the shunt pouch (black circle) at the left MCF. (D) Lateral view of the left external carotid artery angiography shows the left MCF-DAVF supplied from the left anterior (white arrow) and middle (rhombus) deep temporal arteries, the left accessory meningeal artery (white arrowhead), the left artery of the foramen rotundum (asterisk), and the left ascending pharyngeal artery (black arrow). However, the left middle meningeal artery (black arrowhead) is not involved by the MCF-DAVF. (E) Anteroposterior and (F) lateral views of the left common carotid artery angiography show the broad left hemispheric venous congestion and illustrate the occluded original outlets and many retrograde cortical refluxes. (G) The transfemoral approach from the occluded left inferior petrosal sinus reaches the lateral wall of the cavernous sinus (arrow) but is not inserted into the shunt pouch. (H) Post-transarterial embolization from the left anterior (white arrowhead) and middle (black arrowhead) deep temporal arteries; lateral view of the left external carotid artery angiography reveals the left MCF-DAVF shunt point (circle) and the retrograde drainage into the left superficial middle cerebral vein (white arrow) and the left uncal vein (black arrow) leading to the left basal vein of Rosenthal.

and a follow-up angiography a year later indicated no recurrence of the MCF-DAVF.

Discussion

The successful TVE of an isolated MCF-DAVF through the vein of Trolard and SMCV using an intermediate distal access catheter, a long, flexible microcatheter, and an ultra-flexible microwire represents a notable advancement in endovascular treatment techniques. Kuwayama first reported an effective approach of TVE through the SMCV. This approach involved a surgical craniotomy and a direct puncture of the SMCV [5]. Since then, several cases involving directly puncturing the SMCV have been documented [6,11]. However, our case is unique as it is the first reported instance of percutaneous TVE through the vein of Trolard and SMCV for a noncavernous sinus MCF-DAVF. Previous successful TVE cases involving cortical veins without craniotomy are summarized in Table 1. A notable instance involving percutaneous transvenous access through the cortical vein was the transjugular embolization of a sphenoid wing DAVF through the vein of Trolard [7] and the transfemoral embolization of CS-DAVF through the vein of Labbé [8]. Similarly, Iampreechakul reported successful percutaneous TVE through the vein of Trolard and the SMCV for a CS-DAVF [10]. These cases and ours reveal favorable outcomes without major complications, highlighting the feasibility and safety of this approach.

Compared to traditional methods like craniotomy and direct puncture, the described technique offers several advantages, including reduced invasiveness and potential complications. However, precise navigation through complex venous anatomy and the risk of vessel perforation remain challenges. Previous failed attempts in TVE, such as unsuccessful access from antegrade occluded veins or poor catheter traceability over long distances, informed our successful strategy. By selecting an intermediate distal access catheter with excellent traceability and employing a long, flexible microcatheter, we overcame these challenges. The vein of Trolard and the vein of Labbé are prominent cortical veins connecting the SSS or transverse sinus to the SMCV. In our case, the large and accessible connection between the vein of Trolard and the SMCV potentially dilated by high-flow vein reflux and anchored by brain edema, facilitated safe catheterization. While technical details are crucial, the most impactful aspects were the choice

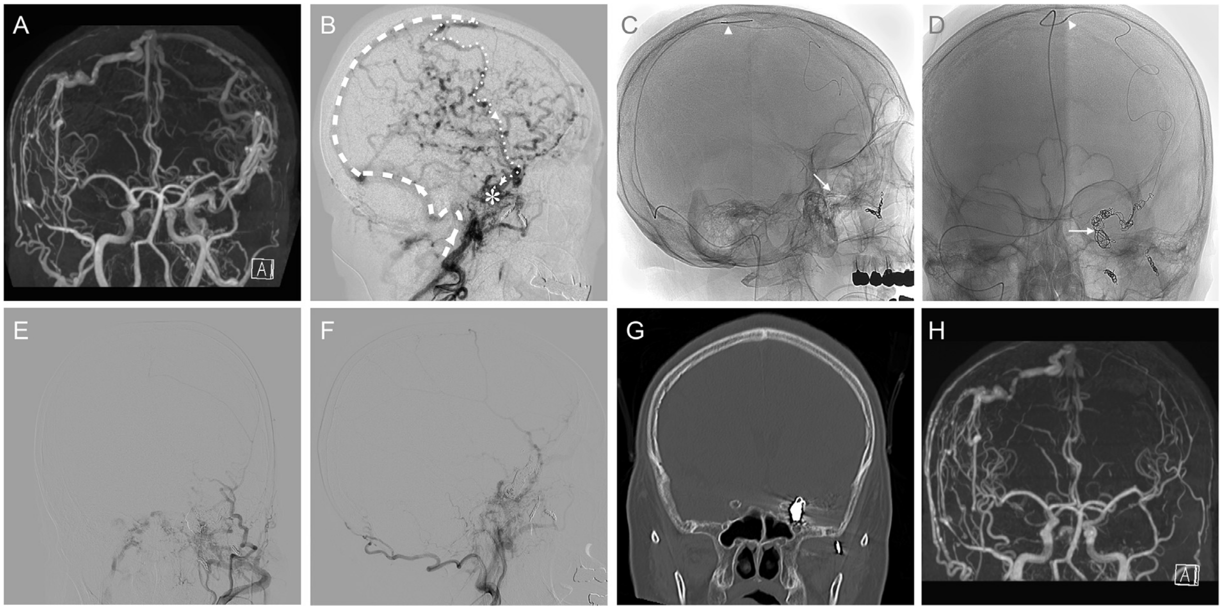

Fig. 2 – (A) Post-transarterial embolization, magnetic resonance angiography shows a partial reduction of the shunt flow. (B) The plan for the second session includes retrograde transjugular venous embolization through the superior sagittal sinus, the vein of Trolard, and the superficial middle cerebral vein. For the long distance to the shunt pouch (asterisk), an intermediate distal access catheter (dashed line) and a long flexible microcatheter (dotted line) were prepared. (C) Lateral and (D) anteroposterior intra-operative projections show the tip of the distal access catheter (arrowhead) and the tip of the microcatheter (arrow). (E) Anteroposterior and (F) lateral views of the postoperative left external carotid artery angiography show a semi-complete obstruction of the shunt flow of the middle cranial fossa arteriovenous fistula. (G) A coronal view of computed tomography shows the coil mass in the shunt pouch placed at the middle cranial fossa. (H) Magnetic resonance angiography the next day shows the complete obstruction of the shunt flow and the disappearance of venous refluxes.

Table 1 – Literature review of middle cranial fossa arteriovenous fistulas treated with transvenous embolization through cortical veins without craniotomy.

Authors	Age/Sex	Side	Location and fistula type	Venous drainage	Treatment	Approach	Outcome
Fukuda *et al.* [7]	58/Male	Rt	SW-DAVF	Rt uncal vein, the vein of Trolard and anterior temporobasal vein	TVE through the vein of Trolard	Juglar vein	GR
Kontas *et al.* [8]	61/Female	Lt	CS-DAVF	Lt SMCV	TVE through the vein of Labbé and SMCV	Femoral vein	GR
Ghosh *et al.* [9]	48/Female	Rt	CCF	Rt SMCV	TVE through SMCV	Burr hole on SMCV under image guide	GR
Iampreechakul *et al.* [10]	46/Female	Lt	CS-DAVF	Lt SpPS and SMCV	TVE through the vein of Trolard, SMCV, and SpPS	Femoral vein	GR
Present case (2024)	62/Female	Lt	MCF-DAVF	Lt uncal vein and SMCV	TVE through the vein of Trolard, SMCV	Juglar vein	GR

CCF, carotid cavernous fistula; CS, cavernous sinus; DAVF, dural arteriovenous fistula; GR, good recovery; Lt, left; MCF, middle cranial fossa; Rt, right; SMCV, superficial middle cerebral vein; SpPS, sphenoparietal sinus; SW, sphenoid wing; TVE, transvenous embolization.

of an intermediate distal access catheter with excellent traceability, the use of a long flexible microcatheter, and an ultraflexible microwire. The flex microcatheter, DeFrictor Bull, is characterized by its 100 cm hydrophilic coating, a 27 cm flexible tip, and an opaque marker positioned 5 mm before the tip. These components were vital for navigating the tortuous anatomy of the cortical veins and ensuring successful coil placement.

Another difficulty was ensuring precise coil placement to avoid overfilling or new cranial nerve palsies. MCF-DAVFs are known to be aggressive, often exhibiting deep vein drainage connecting to the basal vein of Rosenthal. Shi et al. [12] classified sphenoid wing DAVFs involving MCF-DAVFs into greater and lesser sphenoid wing types. Further, Su et al. reviewed 26 cases of non-CS MCF-DAVFs and reported that 19 were treated with TAE, 2 were treated with TVE, 5 were treated surgically, and 2 remained uncured by either endovascular or surgical methods [13]. Additionally, they mentioned that paracavernous sinuses may not be amenable to TVE via the CS due to a lack of connection in most patients. This observation aligns with a study by Tanoue and Ide et al. that explored the variation in connections between the paracavernous sinus, uncal vein, and SMCV within the MCF [14,15].

While our technique offers promising results, further research is needed to refine our approach and explore its applicability to other complex vascular malformations. This technique could be refined using improved catheter designs and other safe embolic materials, enhancing its application in similar cases. Additionally, advancements in fluoroscopic imaging equipment could further reduce procedural risks and improve outcomes based on precise, individual vascular anatomy. The ability to perform TVE without craniotomy opens new avenues for minimally invasive treatments, potentially expanding the options available to patients with aggressive DAVFs.

Conclusion

This case demonstrates that TVE can be a viable treatment option for MCF-DAVFs involving pure cortical venous drainage when a safe anatomical approach is available. The appropriate strategies for navigating long distances within a complex venous structure and use of flexible microcatheters and microwires may offer a less invasive alternative to traditional surgical methods. This alternative could impact future clinical practice by providing safe and effective treatment options for similar cases.

Declaration of generative AI and AI-assisted technologies in the writing process

The authors confirm the limited usage of artificial intelligence (AI)-assisted technology for assisting in English editing and that no images were manipulated using AI.

Patient consent

The authors obtained the patient's written consent for this study.

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