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Case Report

A Patient with a Cavernous Sinus Dural Arteriovenous Fistula in Whom an Approach through the Jugular Venous Arch Involving Facial Vein Return Was Adopted

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Objective: We report the case of a cavernous sinus dural arteriovenous fistula (CSdAVF) treated by transvenous embolization (TVE) via the jugular venous arch (JVA) connecting bilateral superficial cervical veins.
Case Presentation: A male patient in his 50s presenting with diplopia and headache was diagnosed with a CSdAVF. The first session of TVE resulted in incomplete obliteration of the fistula due to poor accessibility through the inferior petrosal sinus (IPS), and postoperative computed tomography angiography (CTA) disclosed a newly developed drainage route into the facial vein (FV) connecting to the anterior jugular vein (AJV) and the JVA. The patient underwent the second session of TVE through the JVA, FV, and the superior ophthalmic vein (SOV), and obliteration was achieved.
Conclusion: There is a considerable variation in the anatomy of facio-cervical veins in patients with CSdAVF. Meticulous preoperative evaluation of the venous drainage route using modern diagnostic tools is indispensable to achieve successful results in patients with CSdAVF.

Keywords ▶ dural arteriovenous fistula, coil embolization, jugular venous arch

Introduction

For the treatment of cavernous sinus dural arteriovenous fistulae (CSdAVFe), transvenous embolization (TVE) using a cavernous sinus (CS) approach via the inferior petrosal sinus (IPS) through the internal jugular vein (IJV) has been established as a safe and effective treatment method.[1] However, in some cases, the CS cannot be reached for anatomical reasons or obliteration is impossible using this trans-IPS route. In such cases, a route to reach the CS through the superior ophthalmic vein (SOV) via the facial vein (FV) is used as an alternative approach,[2] but there are many variations in the venous anatomy of the head and neck. In this study, we report a patient with a CSdAVF in whom the FV, as an outflow vein of the CSdAVF, had returned to the jugular venous arch (JVA) connecting the left and right superficial veins at the inferior anterior cervix, and TVE was performed using this route.

Case Presentation

The patient was a man in his 50s. He consulted our department for diplopia and headache. Brain magnetic resonance imaging (MRI) suggested a CSdAVF. Cerebral angiography revealed a CSdAVF with an arteriovenous shunt on an extensive area of the dura mater involving the left to medial posterior wall of the left CS, with the dural branches of the bilateral internal and left external carotid arteries as feeders. There was no venous pouch where arterial flows converge, and the outflow routes of drainers were from bilateral IPSs to the deep jugular vein of the posterior cervix via the anterior condylar confluence, lateral condylar vein, and suboccipital cavernous sinus, and from the inferior left CS to the pterygoid plexus (**Fig. 1A–1C**). Although the relationship between the IPS and IJV was unclear, TVE to occlude the shunt site around the posterior

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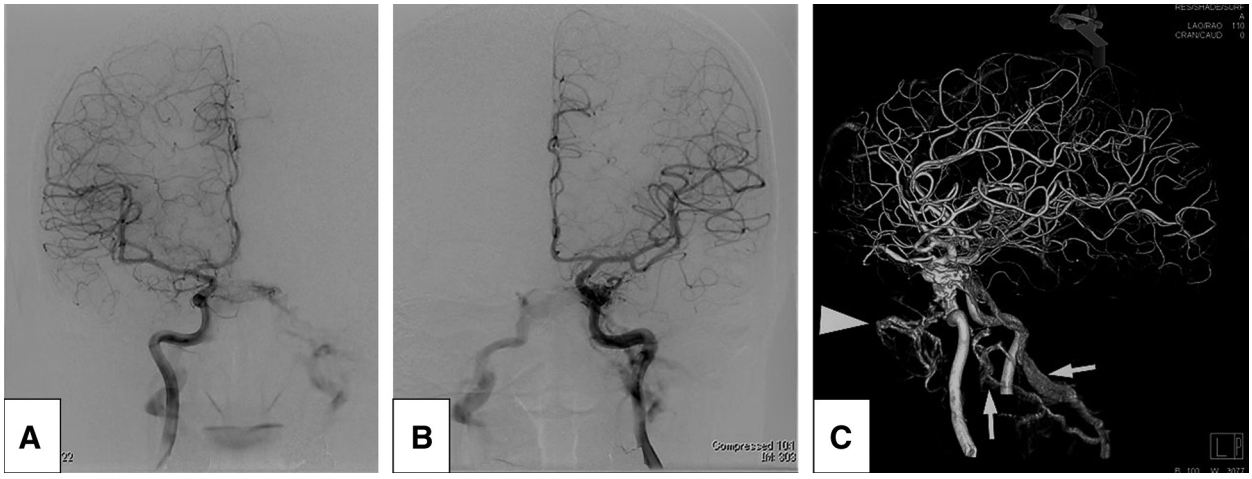

Fig. 1 Preoperative right (**A**) and left (**B**) internal carotid angiography (antero-posterior views), and a fusion image (**C**) of 3D-DSA of the bilateral internal carotid arteries (left-posterior oblique view) demonstrating a CSdAVF draining into the left pterygoid plexus (arrowhead) and bilateral deep cervical veins (arrows) in the posterior neck through the IPS. CSdAVF: cavernous sinus dural arteriovenous fistula; IPS: inferior petrosal sinus; 3D-DSA: three-dimensional digital subtraction angiography

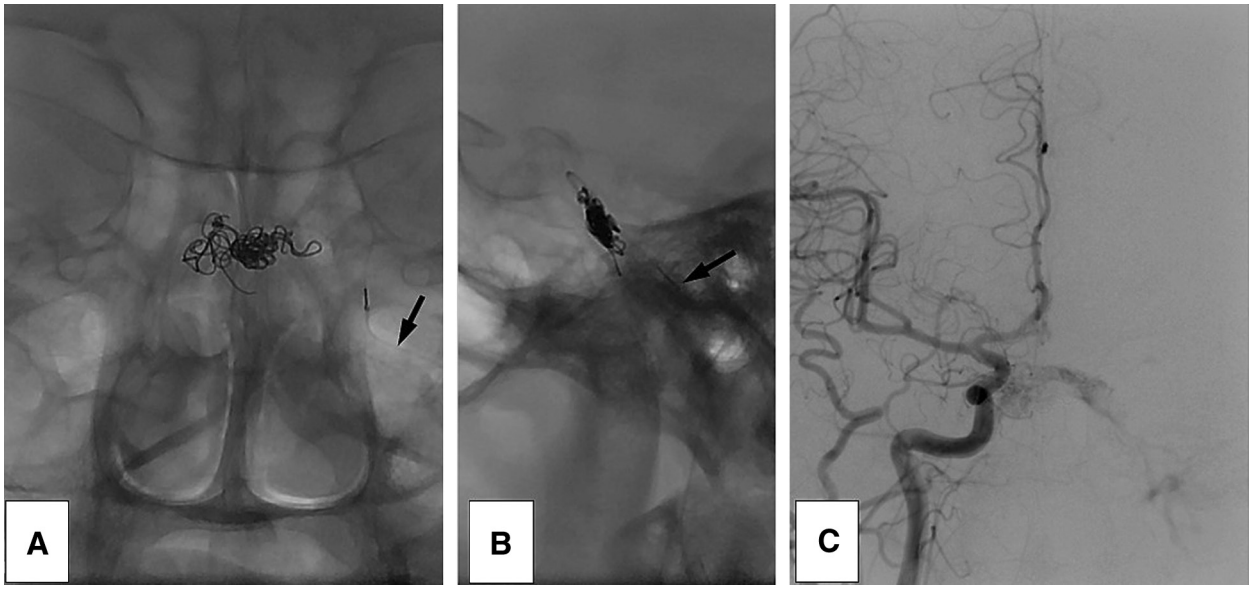

Fig. 2 Plain skull radiography (**A**: antero-posterior view, **B**: lateral view) after the first session of TVE showing coils delivered by a microcatheter navigated through the left IPS (arrow). Right internal carotid angiography (**C**: antero-posterior view) disclosing incomplete occlusion of the fistula. IPS: inferior petrosal sinus; TVS: transvenous embolization

wall of the left CS via the IPS following a standard procedure was initially selected.

Initial endovascular treatment

Under general anesthesia, a 6Fr Sheathless NV 90 cm (Asahi Intecc, Aichi, Japan) and Cerulean DD6 118 cm (Medikit, Tokyo, Japan) were coaxially inserted through the right femoral vein to reach the right IJV. However, a guidewire was unable to be advanced into the right IJV; thus, the Sheathless was guided into the left IJV. It was difficult to search for the orifice of the IPS, and the combination of a Headway-17 microcatheter 45° (Terumo, Tokyo, Japan) and CHIKAI black 0.014 soft tip (Asahi Intecc) was inserted into the left IPS. However, the route was narrow and the operability was poor. The Headway was transiently guided from the left CS to the right IPS, and the intercavernous sinus and most posterior part of the left CS were embolized with four detachable coils while pulling the Headway back (**Fig. 2A** and **2B**). At this point, the end of the Headway was kicked back to the left IPS, making additional insertion into the CS impossible. Angiography demonstrated incomplete obliteration of the arteriovenous

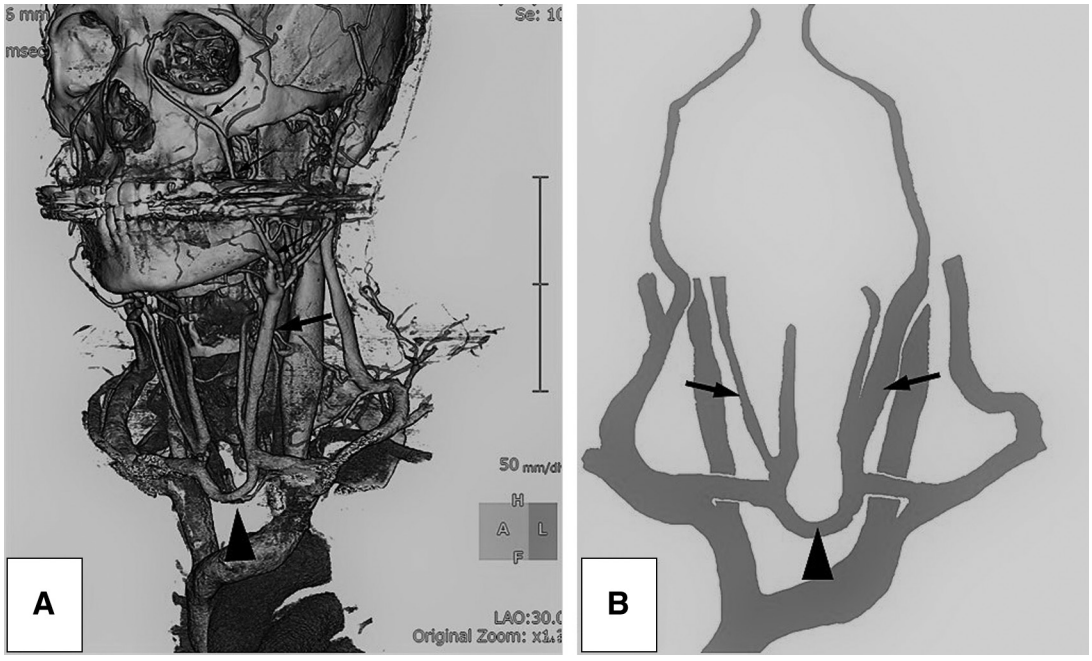

Fig. 3 (**A**) CTA 2 days after the first session of TVE demonstrating the enlarged left FV (small arrows) draining into the left AJV (arrow) and the JVA (arrowhead). (**B**) Schematic drawing of the anatomy of facio-cervical veins in the present patient indicating the location of the JVA (arrowhead) connecting bilateral AJVs (arrows). AJV: anterior jugular vein; CTA: computed tomography angiography; FV: facial vein; JVA: jugular venous arch; TVE: transvenous embolization

fistula (**Fig. 2C**). The left and right communications to the outflow tract were partially blocked, and slight regurgitation to the anterior bilateral SOVs was observed. An approach into the CS via the right deep jugular vein and IPS through the right vertebral venous plexus was adopted, but this was also impossible. In addition to an increase in the radiation exposure dose, there was no cortical vein reflux and there were no changes in the ocular findings or neurological symptoms; therefore, elective treatment was considered to be possible. The procedure was completed, planning additional treatment later.

Clinical course after initial treatment

Computed tomography angiography (CTA) 2 days after initial treatment demonstrated an outflow tract from the left CS to the JVA via the left SOV, left FV, and left anterior jugular vein (AJV) (**Fig. 3A** and **3B**). There were no marked changes in the symptoms, but a brain MRI after 1 month revealed the progression of left SOV dilation. Additional treatment was promptly scheduled. We decided to adopt the trans-JVA route observed on CTA.

Second session of endovascular treatment

Left/right carotid angiography under general anesthesia confirmed the disappearance of the outflow to the left/right IPSs and left pterygoid plexus, which were detected on the previous session. On the other hand, dilation of the left SOV was more remarkable than during the previous treatment session. Blood outflow to the JVA via the left FV and AJV was noted (**Fig. 4A**). A 6Fr Shuttle Sheath 80 cm and 6Fr Roadmaster 100 cm (Goodman, Aichi, Japan) were coaxially inserted to approach the left AJV through the left brachiocephalic vein, but a sharp bifurcation angle prevented the catheter from following the wire that was guided; therefore, this was abandoned. A Roadmaster was inserted into the right brachiocephalic vein, and a 4Fr Optiflash Benson Hanafee Wilson 120 cm (Terumo) and Radifocus M 0.035 wire (Terumo) were guided into the Roadmaster. By selecting the left AJV via the JVA through the right subclavian vein, the Roadmaster was able to be guided into the left AJV (**Fig. 4B**). The Optiflash was removed, and a Tactics intermediate catheter 3.2/3.4Fr 130 cm (Technocrat Corporation, Aichi, Japan) and NEWRODEO 10 microcatheter 157 cm (Medico's Hirata, Osaka, Japan) were coaxially inserted using a CHIKAI black 0.014 soft tip microguidewire (Asahi Intecc). Torsion of the left FV, which joined with the AJV, was slight, and the Tactics was guided into the left angular vein in order for the NEWRODEO to reach the left CS via the left SOV (**Fig. 4C**). A shunt was present at the posterior medial segment of the left CS. The NEWRODEO was guided to this site and 22 detachable coils were placed (**Fig. 5**). Bilateral

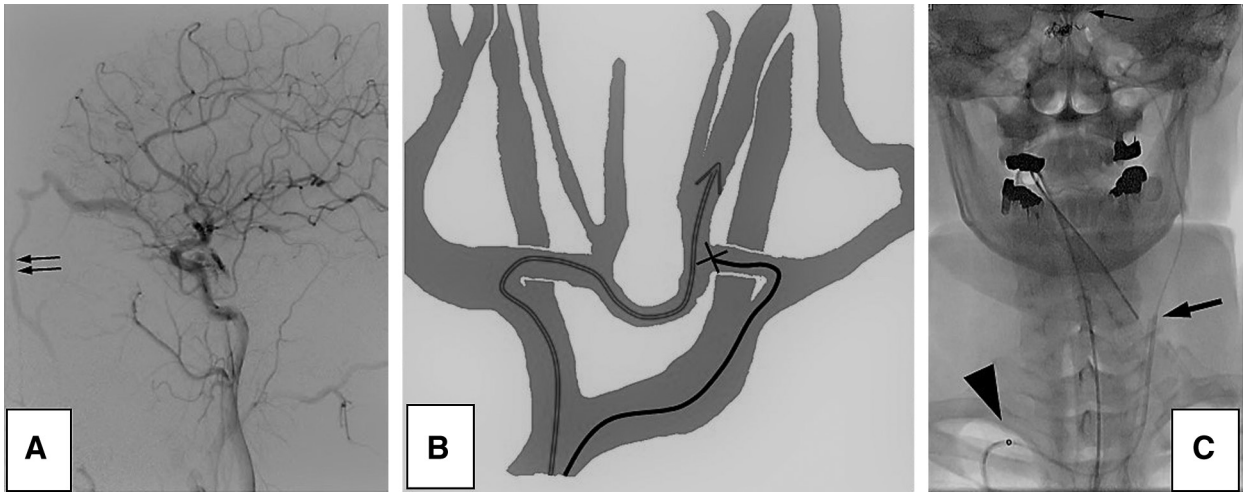

Fig. 4 (**A**) Right common carotid angiography (lateral view) before the second session of TVE showing the residual CSdAVF draining into the left SOV connecting to the left FV (small arrows). (**B**) Schematic drawing of the cervical veins demonstrating the failed approach through the left brachiocephalic vein and the successful route of catheter navigation through the JVA into the left AJV. (**C**) Plain radiography (antero-posterior view) after catheter navigation showing the locations of the tips of the Shuttle sheath (arrowhead), Roadmaster (arrow), and Tactics (small arrow) catheters. AJV: anterior jugular vein; CSdAVF: cavernous sinus dural arteriovenous fistula; FV: facial vein; JVA: jugular venous arch; SOV: superior ophthalmic vein; TVE: transvenous embolization

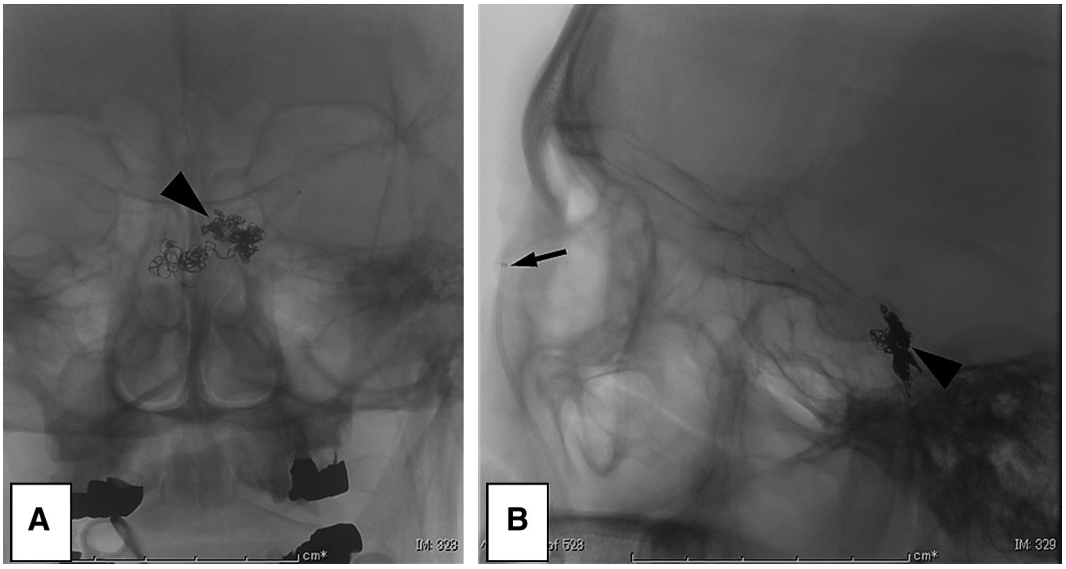

Fig. 5 Postoperative plain skull radiography (**A**: antero-posterior view, **B**: lateral view) showing additionally delivered coils (arrowheads) during the second session of TVE. The tip of the Tactics intermediate catheter (arrow) was placed in the angular vein. TVE: transvenous embolization

common carotid angiography confirmed the disappearance of the shunt (**Fig. 6**) and the procedure was completed.

Postprocedural course after the second treatment session

After the second procedure, left abducens nerve paralysis developed, but the patient was discharged 8 days after the treatment. Subsequently, diplopia gradually improved. Postprocedural MRI confirmed the normalization of the left SOV diameter. To date, there has been no recurrent CSdAVF.

Discussion

A previous study reported that TVE of CSdAVFe using an IPS-mediated approach led to a high success rate and radical cure regardless of the presence of IPS visualization.[1] However, when an IPS-mediated approach is impossible, an FV- or middle temporal vein-mediated approach or that through the SOV by direct puncture is necessary.[2] Miller et al.[3] reported that patients anatomically free from a communication between the IPS and IJV accounted for ≤1%. In

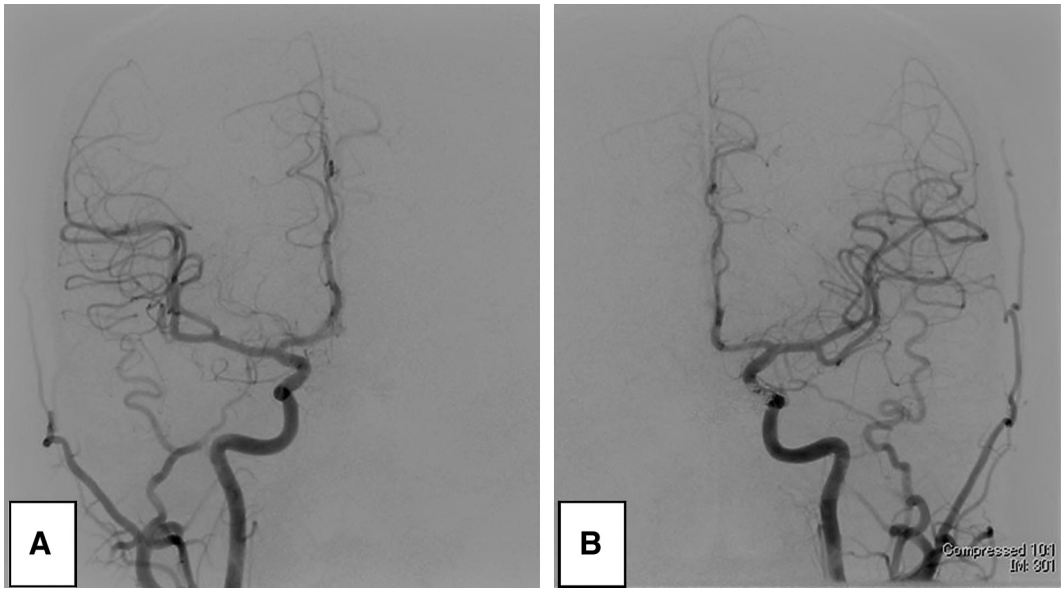

Fig. 6 Final right (**A**) and left (**B**) common carotid angiography (antero-posterior views) demonstrating obliteration of the CSdAVF. CSdAVF: cavernous sinus dural arteriovenous fistula

the present case, preoperative angiography revealed no communication, but catheterization to the IPS was possible; there was a communication. However, the route was narrow and operability was markedly poor. Initial treatment resulted in incomplete obliteration.

The FV connecting from the angular vein in the infraorbital region originates from the nasal root, and is located at an area posterior to the facial artery. It linearly descends from the superior medial area to the inferior lateral area, and anastomoses with the anterior branch of the mandibular vein, becoming the common FV and joining with the IJV at the level of the greater horn of the hyoid bone in many cases.[2,4] According to Choundhry et al.,[5] the FV joined with the external jugular vein (EJV), but not with the IJV, in 5% of autopsy cases. On the other hand, Luo et al.[2] examined venous anatomy in 26 patients on whom TVE of carotid cavernous sinus fistulae via the FV was performed, and reported that the FV was connected with the EJV in 16 (62%). Furthermore, as other rare exceptional FVs, an FV joining with the mandibular vein at the level of the parotid gland and that joining with the superficial temporal vein were reported.[6,7]

This is the first report of a JVA-mediated approach for TVE of a CSdAVF. The JVA connects the left and right AJVs at an area anterior to the trachea above the sternum. It is a U-shaped vein that exists in the inferior middle neck region.[8,9] On the lateral side, it communicates with the EJV or subclavian vein. As the clinical importance of the JVA, the following points were reported: the JVA functions as an alternative route for lead induction of a pacemaker[8] and a central venous catheter inserted through the EJV may migrate.[9] Naito et al. reported a patient with a carotid cavernous sinus fistula characterized by a return current from the FV to the subclavian vein via the JVA. They incised the mandibular region and directly punctured the FV to approach the CS. As the vascular bifurcation angle between the subclavian vein and JVA is sharp, an approach from the femoral vein to the JVA may be difficult, and there is a method to reach the JVA by EJV or brachial vein puncture. In the present case, an 80-cm-long sheath was inserted through the femoral vein, and a 100-cm guiding catheter was guided into the AJV via the JVA using a 4Fr catheter with a markedly flexible end. In addition, stable microcatheter support was achieved by advancing a Tactics, which was used as an intermediate catheter, to the level of the medial ocular angle. Furthermore, physicians should understand that there are some CSdAVF patients in whom confirmation of JVA presence using CTA facilitates percutaneous TVE, as demonstrated in the present case.

Conclusion

We report a patient with a CSdAVF in whom TVE was performed through the JVA to which the FV had returned. In many CSdAVF patients, the standard approach route, the IPS, is occluded. Furthermore, there are many variations in the venous anatomy of the facial cervix. Before surgery, it may be important to evaluate the anatomy of the cervical vein as a return route in detail. For such an assessment, CTA may be useful.

Disclosure Statement

The authors declare no conflict of interest.

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