Anatomical safety and precaution of transarterial embolization of a falcotentorial dural arteriovenous fistula fed by the artery of Davidoff and Schechter: Case report and review of the literature

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INTRODUCTION

Tentorial dural arteriovenous fistula (TDAVF) is a rare disease. However, it should be actively treated because of its higher rate of intracranial hemorrhage than other dural arteriovenous fistulas (DAVFs) due to its direct cortical venous drainage. The treatment of TDAVF is predominantly performed through an endovascular approach to the AVF feeder or draining veins and embolization using coils or liquid embolic materials. A commonly reported feeder of TDAVF is the artery of Davidoff and Schechter (ADS), a pure meningeal branch originating from the posterior cerebral artery (PCA) that supplies the medial tentorium and falcotentorial junction.

To our knowledge, there are no reported cases of the ADS associated with the fetal type posterior communicating artery (PCoA). We present the case of a patient with...
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TDAVF supplied by the ADS mimicking the ipsilateral PCA due to the similar pathways around the brain stem that was safely treated by transarterial embolization. Additionally, related published literature was reviewed for evaluating the safety of embolization via the ADS.

CASE DESCRIPTION

A 63-year-old male visited the neurosurgery department with a complaint of headache. He was subsequently diagnosed with a suspicious DAVF at the falcotentorial junction on magnetic resonance angiography. Digital subtraction angiography (DSA) demonstrated a Galenic type of TDAVF fed by a branch mimicking the left PCA, which appeared to arise from the top of the basilar artery (Fig. 1). The TDAVF drained directly into the vein of Galen, with reflux to the basal vein of Rosenthal (BVR), lateral mesencephalic vein, and cavernous sinus. Ectatic changes were observed in the draining veins, suggesting venous hypertension. The left PCA was not indicated on vertebral artery (VA) angiography due to the fetal type PCoA flow from the left internal cerebral artery (ICA). The main feeding artery ran beneath the fetal type PCoA around the midbrain and made an upward turn towards the falcotentorial junction, indicating that it was the ADS. \(^1\) \(^2\) \(^3\) \(^4\) \(^5\) \(^6\) \(^7\) \(^8\) \(^9\) \(^10\) \(^11\) Additionally, left external carotid artery (ECA) angiography showed another feeder from the branch of the occipital artery (Fig. 1D).

Under general anesthesia and systemic heparinization, transarterial embolization was performed via the right femoral artery. A 6 French Envoy guiding catheter (Cordis Corporation, Miami Lakes, Florida, USA) was placed in the left VA. A microcatheter (detachable tip microcatheter, Apollo, ev3 Neurovascular, Micro Therapeutics, Inc., USA) was advanced through the catheter over the microwire (Synchro neuro guide wire, Stryker Neurovascular, Kalamazoo, MI, USA) and into the ADS. Access to the distal portion of the ADS was achieved, and the fistula was completely occluded using Onyx 18 (ev3 Neurovascular, Micro Therapeutics, Inc., USA), without any reflux (Fig. 2A-C). Postoperative VA angiography showed occlusion of the fistula and revealed that the entire left PCA with P1-PCoA junction, which was not visualized preoperatively due to the high flow of the ADS and fetal type PCoA. Thus, we could confirm the exact origin of the feeder ADS, which was the left P1-PCoA junction and not the top of the basilar artery (Fig. 2C). Postoperative ECA angiography also demonstrated occlusion of AV shunt (Fig. 2D). Postoperative magnetic resonance imaging revealed no acute ischemic or hemorrhagic complications, and the patient was discharged after two postoperative days without any neurological problems. Furthermore, a magnetic resonance angiography was performed 12 months later after the treatment for follow-up, no remnant and recurrence of DAVF were observed (Fig. 2E). Written informed consent was obtained to publish this report.

Literature review: TDAVFs supplied by the ADS

We searched the literature using the PubMed database (until June 2021) to identify studies of DAVFs supplied by the ADS and the type of treatment performed through the endovascular approach. “Artery of Davidoff and Schechter,” “Davidoff and Schechter,” and “tentorial dural arteriovenous fistula” were searched as either keywords or Medical Subject Heading terms. All searched articles and references were reviewed to identify all related studies.

Six journals of case reports and case series were found, out of which 25 patients were selected after applying the exclusion criteria. After including the patient in this study, a total of 26 patients were reviewed. The total number of endovascular treatment sessions was 32.
owing to the multiple embolization sessions performed in a few patients.\textsuperscript{\textcircled{14,68,12}} Patients’ age, sex, symptoms, DAVF location, feeding arteries, draining veins, Borden classification, number of embolization approach sessions, complications, and angiographic cure are presented in

\begin{table}[h]
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\begin{tabular}{|c|c|c|c|c|c|}
\hline
\textbf{Age} & \textbf{Sex} & \textbf{Symptoms} & \textbf{DAVF Location} & \textbf{Feeding Arteries} & \textbf{Draining Veins} \\
\hline
30-66 years & Male & Headache, Vomiting, Dizziness, Tinnitus, Hearing Loss, Exophthalmos, Vision Loss, Altered Mental Status & Tentorial & Occipital artery & Great Cerebral Vein of Galen \\
\hline
\end{tabular}
\caption{\textsuperscript{14-68,12}}
\end{table}

Patient age ranged from 30 to 66 years, and the varied symptoms included headache, vomiting, dizziness, tinnitus, hearing loss, exophthalmos, vision loss, and altered mental status. Four patients presented intracra-
Fig. 2. (A, B) Intraoperative angiography, access to distal portion of the feeder, ADS, was achieved with Detachable-tip microcatheter. (C) Postoperative VA angiography showing occlusion of the fistula by onyx (black arrow) and revealed entire left PCA (black arrow head) which was not visualized preoperatively due to the high flow of the ADS and fetal type PCoA (double arrow). Small residual proximal portion of ADS (white arrow) is also seen, arising at P1-PCoA junction. (D) Postoperative ECA angiography, demonstrating occlusion of AV shunt. (E) 1-year follow up MRA (rt picture) showed no recurrence of the AV shunt (white arrow). ADS, artery of Davidoff and Schechter; VA, vertebral artery; PCA, posterior cerebral artery; PCoA, posterior communicating artery; ECA, external carotid artery; AV, arteriovenous; MRA, magnetic resonance angiography.
Table 1. Details of individual patients with DAVFs supplied by ADS

| Age/Sex | Symptoms, image findings | Location | Supply | Drainage | Borden classification | Approach site | Session | Complication | Outcome |
|---------|--------------------------|----------|--------|----------|------------------------|---------------|---------|--------------|---------|
| 1 N/A   | Dementia, hydrocephalus, tonsillar herniation | Falcotentorial | ADS, MHT, MMA, OA | ICV, PCV | N/A | ADS | 1 | None | Obliterated |
| 2 N/A   | N/A | Falcotentorial | ADS, All dural branches of both ECAs, PMA | SS, VoG, BVR, IOV, LAMV, APMV | N/A | MMA | 1 | None | Obliterated |
| 3 N/A   | N/A | Falcotentorial | ADS, WWA, all dural branches of both ECAs, PMA, AMMA | SS, VoG, BVR, LAMV | N/A | MMA | 1 | None | Obliterated |
| 4 N/A   | Paresthesia, thalamic ICH | Falcotentorial | ADS, MHT, MMA, OA, PMA | VoG, SS, BVR, LAMV, APMV | N/A | ADS | 1 | None | Obliterated |
| 5 N/A   | Dysphagia, dysphonia, ataxia | Falcotentorial | ADS, MHT, PMA, AMA, all dural branches of both ECAs | SS, VoG, BVR | N/A | PMA | 1 | None | Obliterated |
| 6 N/A   | N/A | Falcotentorial | ADS, MHT, all dural branches of both ECAs, PMA | VoG, SS, BVR, IOV | N/A | MMA | 1 | None | Obliterated |
| 7 N/A   | N/A | Falcotentorial | ADS, MHT | SVV, SS | III | MHT, ADS | 1 | None | Obliterated |
| 8 N/A   | N/A | Falcotentorial | ADS, MHT, MMA, PMA | VoG, IOV, BVR, LAMV, APMV | N/A | OA | 1 | None | Obliterated |
| 9 N/A   | Seizure | Falcotentorial | ADSs, MHT, AMA, all dural branches of both ECAs | VoG, SS, BVR, IOVs, numerous infratentorial veins | N/A | MMA, PMA | 2 | None | Partially obliterated |
| 10 N/A  | Headache, exophthalmos, hearing loss, hydrocephalus | Falcotentorial | ADS, all dural branches of both ECAs, MHT, PMA, PMCA | VoG, SS, BVR, IOVs | III | PMCA, ADS | 1 | Parinaud syndrome, tectal compression Bithalamic infarction | Obliterated |
| 11 N/A  | Headache | Falcotentorial | ADS | Superior cerebellar cortical vein | II | ADS | 1 | Left upper extremity tremor, brain stem infarction | Obliterated |
| 12 N/A  | N/A | SSS posterior portion | ADS, PCA | SVV, VoG | I | TA (not ADS) | 1 | None | Partially obliterated |

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Most patients had falcotentorial DAVF (22/26). Numerous feeding arteries were reported, where dural arterial feeders, including the occipital artery, middle meningeal artery, recurrent meningeal artery, and posterior meningeal artery, and pial arterial feeders, including the PCA, VA, superior cerebellar artery, posterior inferior cerebellar artery, meningohipphysis, trunk, and ICA, were described. Most of the DAVFs were type III, according to the Borden classification.

Eight of the twenty-six patients underwent transarte-
rial embolization via the ADS. Angiographic cure rate was 88.4% (23/26) in all patients and 100% (8/8) in the ADS group. One patient had a complication of a brain stem infarction when embolization was performed at the junction of the ADS and PCA. No complication was reported after embolization via the ADS when distal access was achieved. One patient in the ADS group had a complication of a thalamic infarction and Parinaud syndrome as a result of additional embolization of posterior medial choroidal artery and tactile compression of large thrombosed venous varix. Byrne and Garcia and Griessenauer et al. reported six cases of endovascular treatment of DAVF fed by the ADS; however, the exact approach route was not described. Moreover, no complications were reported after the embolization sessions in these cases. Summary of reported cases are presented in Table 2.

DISCUSSION

Patients with TDAVF may present with a variety of pathologic conditions, such as tinnitus, headache, seizure and intracerebral hemorrhage. Some of the asymptomatic TDAVFs are found incidentally through brain imaging during the evaluation of other unrelated problems or health screenings. Although asymptomatic, it should be treated promptly because of its higher rate of intracranial hemorrhage than other DAVFs due to its direct cortical venous drainage.

Our case represents the Galenic type of TDAVF fed by the ADS and occipital artery branch with direct cortical drainage and retrograde reflux to the BVR, indicating Type III DAVF according to the Borden classification. Since most of the Galenic type of TDAVFs were Type III, the transvenous approach was limited due to the direct cortical drainage and deep location, forcing the operator to adopt the transarterial approach. The surgical approach is a traditional option, which should be considered when there is an anatomical complexity in the endovascular access to the lesion.

Feature of the ADS when associated with fetal type PCoA

Although rarely, the engorgement of the ADS can be confused with the ipsilateral PCA in patients with the fetal type PCoA on VA angiography, as in this case. This is because the ADS and PCA have similar pathways that run around the brain stem (Fig. 3). It is very important to distinguish the ADS from the PCA for planning transarterial embolization because embolization of the PCA itself is a forbidden option.

Fetal type PCoA is divided into full and partial categories depending on the presence of the ipsilateral P1 segment. In our patient, preoperative DSA showed "full" fetal type PCoA, with absent PCA territory flow through the basilar artery and P1 segment. Due to the non-visualization of the ipsilateral PCA, the enlarged ADS mimicked the PCA and seemed to arise from the top of the basilar artery. However, postoperative VA angiography demonstrated

Table 2. Summary of reported cases of endovascular treatments for DAVFs supplied by ADS

| Article                      | No. of cases | Mean age | No. of treatment sessions | ADS approach | Complete obliteration | Complication |
|------------------------------|--------------|----------|---------------------------|---------------|-----------------------|--------------|
| Islak et al. (2021)          | 10           | N/A      | 11                        | 5             | 9/10 (ADS-5)          | 1            |
| Roman et al. (2021)          | 2            | N/A      | 2                         | 1             | 1/2 (ADS-1)           | 1            |
| Bhatia et al. (2019)         | 6            | 46.5 (30-65) | 9                      | 1             | 6/6 (ADS-1)           | 0            |
| Gioppo et al. (2017)         | 1            | 60       | 1                         | 0             | 1/1                   | 0            |
| Byrne and Garcia (2013)      | 4            | 59.7 (45-66) | 6                      | N/A           | 3/4                   | 0            |
| Griessenauer et al. (2013)   | 2            | 56 (50-62) | 2                         | N/A           | 2/2                   | 0            |
| Our case                     | 1            | 63       | 1                         | 1             | 1/1 (ADS-1)           | 0            |
| Total                        | 26           | 47.0 (30-66) | 32                        | 8             | 23/26 (ADS-8)         | 2            |

DAVFs, dural arteriovenous fistulas; ADS, artery of Davidoff and Schechter; N/A, indicates not applicable
that the embolization of the ADS revealed the flow to the PCA territory from the basilar artery and P1 segment, indicating that the patient actually had “partial” fetal type PCoA, but the high flow of the ADS was stealing the flow.

Safety of embolization via ADS

To perform transarterial embolization, understanding the exact angioarchitecture and hemodynamics of the feeders from the pial artery as well as the dural arteries is necessary and important because TDAVs supplied by the pial arteries have a more aggressive nature.\(^{3,13,15}\) Fatal hemorrhagic complications after embolization via the dural arteries instead of the pial arteries have been reported.\(^ {3,13,15}\) They result from the obliteration of the venous outlet of a high-flow pial artery feeder, resembling a known mechanism of hemorrhagic complication after treatment of arteriovenous malformation. Initial superselection and embolization of the individual feeders of the pial arteries have been suggested for avoiding these complications.\(^{3,13,15}\)

A dural branch of the pial artery of PCA is the ADS, which is the only meningeal branch originating from the peduncular or ambient segment of the PCA and runs around the midbrain beneath the PCA followed by a sharp superior turn towards the falcotentorial junction to supply the medial portion of the posterior tentorium and falcotentorial junction. It is a pure meningeal branch that does not supply the brain stem or adjacent parenchymal tissues despite its long length and course.\(^ {10}\) The ADS is small and usually not visualized on the DSA of patients with normal anatomy due to its superimposition with other posterior circulation networks. However, it is occasionally detected in patients with pathologic conditions that contribute to arterial engorgement, such as DAVFs, arteriovenous malformation, or tumors.\(^ {1,6,7,11}\) The ADS is a common feeder of the Galenic type of TDAVF, which is supplied from many directions because of its deeper and central location than any other TDAVF. Selecting the pial arterial branch and ADS, rather than the dural arterial supply as the initial embolization target, may lower the risk of hemorrhagic complications while providing easier selection and higher obliteration rate through the VA and
dilated ADS than the tortuous and narrow ECA branches. Some researchers suggest that there is an anatomical risk of reflux through the PCA or basilar artery during transarterial embolization of the ADS, which can lead to fatal ischemic complications in the posterior circulation. Considering this, Bhatia et al. employed a few risk reduction methods for the endovascular treatment of falcomental DAVFs.\(^1\) They recommend not to attempt embolization if distal access is not achieved. Additionally, close monitoring for reflux should be performed during the injection of embolic materials. Recently, Roman et al. presented a complication of a brain stem infarction after embolization through the ADS, which was performed at the anastomosis between the ADS and PCA and not at the distal portion of the ADS, consequently increasing the risk of reflux of embolic materials to the basilar artery and PCA.\(^2\) These studies highlight the importance of performing embolization at the distal portion of the feeder to lower the risk of reflux to the arteries of the posterior circulation, far from the pial artery. When distal access is achieved, embolization through the ADS is a safe option because of its long pathway that does not supply the adjacent brain parenchyma.\(^3\) However, the operator should be aware of the risk of reflux during injection because artery-to-artery anastomosis can sometimes develop between the arteries of the cerebellar tentorium due to the various tentorial arterial networks.\(^4\)

**CONCLUSIONS**

The recognition and understanding of the ADS and its relationship with the PCA and PCoA are important for the endovascular treatment of TDAVF. Due to its long course that does not supply the brain parenchyma, we could safely perform a transarterial Onyx embolization. Importantly, embolization should be performed in the distal portion of the feeder to reduce the risk of reflux of embolic materials.

**Disclosure**

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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