CASE REPORT

A single burr hole approach for direct transverse sinus cannulation for the treatment of a dural arteriovenous fistula

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SUMMARY

A 55-year-old woman with a symptomatic Borden II/Cognard IIa+b transverse sinus dural arteriovenous fistula underwent an attempted percutaneous transvenous embolization which was ultimately not possible given the fistula anatomy. She then underwent a partial percutaneous transarterial embolization but the fistula recurred. Given the failed percutaneous interventions, the patient underwent a combined open surgical/transvenous embolization using neuronavigation and a single burr hole craniectomy. She has remained symptom free for 3 months. This case report illustrates the feasibility of combining minimally invasive open surgical access to allow for direct venous cannulation for endovascular embolization of a dural arteriovenous fistula when traditional percutaneous methods are not an option.

BACKGROUND

Dural arteriovenous fistulas (DAVFs) are intracranial vascular lesions with abnormal communications between dural arteries and dural and/or cortical venous systems. Management options include observation or obliteration through endovascular embolization, open surgery, or radiosurgery, and are guided by various factors, including lesion location and venous drainage.¹ DAVFs of the tentorial incisura and posterior fossa are associated with an increased risk of hemorrhage or progressive neurological deficit, while those located at the transverse-sigmoid and cavernous sinuses are considered more benign.²⁻³ Cortical venous drainage is associated with more aggressive DAVFs.²⁻³ The Borden and Cognard classifications are most commonly employed.⁴⁻⁵ While benign DAVF, such as Borden I/Cognard I and IIa DAVFs may be approached with observation, higher grade DAVFs (Borden II and III/Cognard IIb-V) should be treated.¹ Transarterial and/or transvenous embolization is often the preferred initial management option. Direct surgical access is an alternative when percutaneous access is not feasible. We report a case employing the use of a single burr hole approach for the direct cannulation of the transverse sinus for the treatment of a DAVF.

CASE PRESENTATION

A 55-year-old woman presented with left-sided pulsatile tinnitus, concentration problems, and short term memory difficulty. A left-sided transverse sinus DAVF was seen on CT angiography.

Conventional angiography confirmed the presence of a Borden II/Cognard IIa+b DAVF (figure 1). Given the presence of cortical venous drainage, treatment was recommended.

TREATMENT

The patient underwent attempted percutaneous embolization. A left common carotid artery injection revealed numerous arterial branches from the left occipital and middle meningeal arteries, as well as the ascending pharyngeal and cervical vertebral arteries. The left sigmoid sinus was occluded with multiple venous channels present and cortical venous reflux, including into the veins of Labbé and Trolard (figure 1). A transvenous approach for embolization was attempted first. Given the occluded left jugular and sigmoid sinuses, the planned strategy involved an approach to the left transverse sinus from the contralateral side through the torcula. However, this was ultimately not possible due to the isolated nature of the left transverse sinus. Therefore, transarterial embolization of branches of the occipital artery was performed using a combination of glue and coils. This resulted in an approximately 80% decrease in flow through

Figure 1 Initial diagnostic cerebral angiogram demonstrating a Borden II/Cognard IIa+b dural arteriovenous fistula (DAVF). During the arterial phase, filling of the transverse and sigmoid sinuses (black arrow) and superior petrosal sinus (white arrow) can be seen, as well as cortical venous reflux (black arrowhead). The DAVF is supplied by numerous branches (asterisk) from the occipital artery (white arrowhead).

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Figure 2 Post-embolization angiogram demonstrating 80% reduction in dural arteriovenous fistula (DAVF) flow and absence of cortical venous reflux (black arrowhead). The transverse and sigmoid sinuses can still be seen during the arterial phase (black arrow), indicating incomplete treatment of the DAVF. The occipital artery branches are no longer seen (asterisk).

the fistula and no further cortical venous reflux (figure 2). Her symptoms improved initially, but recurred 2 months later, and after 7 months repeat angiography demonstrated persistence of the DAVF. Given the incomplete treatment with percutaneous transvenous access and the persistence of the DAVF despite transarterial treatment, it was recommended that the patient undergo direct venous sinus cannulation of the transverse sinus via a transcranial route.

Preoperative CT angiography with skin fiducial markers was obtained for neuronavigation using the BrainLab system (BrainLab, Westchester, Illinois, USA). In the operating room, under general anesthesia, a 5 F sheath was placed in the left femoral artery. The patient was placed in a radiolucent skull clamp for rigid head fixation and intraoperative angiography and neuronavigation. Using the neuronavigation system, the transverse sinus was localized for incision and craniectomy planning. A single burr hole was made over the transverse sinus and epidural bleeding was controlled with bone wax, thrombin soaked Gelfoam (Pfizer, New York, New York, USA), and Floseal (Baxter, Deerfield, Illinois, USA). Using a combination of neuronavigation and roadmap guidance, the left transverse sinus was punctured directly using a micropuncture needle. The micropuncture wire was then advanced under fluoroscopic guidance through the needle into the isolated segment of the left transverse sinus. The needle was removed, and a micropuncture sheath was advanced over the wire, followed by removal of the inner dilator and wire (figures 3 and 4). A PX SLIM microcatheter (Penumbra Inc, Alameda, California, USA) was then advanced over a microwire through the micropuncture sheath into the left transverse sinus. Coil embolization proceeded with detachment of a total of 14 coils. Intraoperative angiography demonstrated occlusion of the fistula with normal capillary and venous phases (figure 5). The micropuncture sheath was removed from the transverse sinus and bleeding was controlled with Floseal, Gelfoam, and Surgicel (Ethicon, Inc, Somerville, New Jersey, USA). A single burr hole cover was placed over the bony defect and the wound was closed. The patient was monitored overnight in the neurointensive care unit and discharged home the following day (figure 6).

Figure 3 Intraoperative photograph demonstrating the small incision and burr hole approach with direct access of the transverse sinus with the micropuncture sheath.

OUTCOME AND FOLLOW-UP

At the 2 week follow-up, the patient reported improvement in cognitive and physical function with complete resolution of the pulsatile tinnitus. At the 3 month follow-up, she had returned to her baseline.

Figure 4 Intraoperative venogram of the left transverse sinus. The micropuncture sheath (white arrow) has been placed directly into the transverse sinus (black arrow). Cortical venous reflux is noted (black arrowhead).

Figure 5 Intraoperative angiogram demonstrating complete obliteration of the dural arteriovenous fistula. Note the presence of the coil pack within the transverse (black arrow), sigmoid (black arrowhead), and superior petrosal (white arrow) sinuses.

DISCUSSION

DAVFs represent an abnormal connection between dural arteries and the venous system of the brain. Drainage can be through leptomeningeal vessels or cortical veins. Treatment of DAVFs is aimed at reducing the risk of hemorrhage by obliterating the arteriovenous shunting that leads to venous hypertension. Treatment options include endovascular embolization (transarterial and/or transvenous), open surgery, radiosurgery, or conservative management. In this case report, we illustrate the effective and safe management of a DAVF through a combined strategy employing both endovascular and surgical procedures. Given the anatomy of the particular DAVF, it was not amenable to percutaneous endovascular embolization.

There have been several reports previously using the transcranial route for direct venous cannulation.^{6–10} The sizes of the bony openings have varied. In our patient, we were able to achieve a

cranial opening using only a burr hole placed precisely over the transverse sinus. This was accomplished by using neuronavigation to ensure the proper location of the craniectomy, as previously described.⁶ Others have reported on having to enlarge the bony opening due to suboptimal initial placement.⁸ This is potentially avoided through the use of neuronavigation. In our patient, bony reconstruction required only a single burr hole cover (figure 6).

We have reported the use of a single burr hole for direct transvenous access to the transverse sinus to embolization of a DAVF. In patients for whom transvenous embolization is the preferred treatment, but percutaneous access is not feasible, direct access to the sinus should be considered. Using neuronavigation for precise localization, this access may be safely achieved through a single burr hole in select cases, allowing for a minimally invasive approach that is well tolerated.

Learning points

- Understand some of the treatment options for dural arteriovenous fistulas (DAVFs).
- Understand the utility of combined open surgical and endovascular techniques for the treatment of DAVFs.
- Understand the importance of multidisciplinary teams in the treatment of DAVFs.

Contributors All authors have made substantial contributions to the conception or design of the work, or the acquisition, analysis, or interpretation of the data for the work; were involved in drafting the work or revising it critically for important intellectual content; and gave final approval of the version to be published. All have agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Competing interests Since the time of submission, PG reports giving a lecture for an honorarium on behalf of Penumbra.

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Figure 6 Head CT demonstrating the single burr hole and reconstruction with burr hole cover (white arrowhead). Coils are visible in the transverse sinus (white arrow).

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