Vertebro-Vertebral Fistula Occlusion Using a Woven EndoBridge™-Device

Rasmus Holmboe Dahl, MD1, Mohammad Ghasemi-Rad, MD2, Vagn Eskesen, MD3, Susanne Christiansen Frevert, MD1, Christine Sølling, MD, PhD4, Goetz Benndorf, MD, PhD1,2

1Department of Radiology, Copenhagen University Hospital - Rigshospitalet, Copenhagen, Denmark
2Department of Radiology, Baylor College of Medicine, Houston, TX, USA
3Department of Neurosurgery, Copenhagen University Hospital - Rigshospitalet, Copenhagen, Denmark
4Department of Neuroanaesthesiology, Copenhagen University Hospital - Rigshospitalet, Copenhagen, Denmark

INTRODUCTION

Vertebro-vertebral fistulas (VVFs) are rare vascular lesions caused by direct arteriovenous shunting between the extracranial vertebral artery (VA) and the neighboring vertebral veins. They usually develop at the craniocervical junction, although any level of the cervical VA may be involved.1,3 Lesions can arise spontaneously or be secondary to trauma or iatrogenic injury.2,3 Spontaneous VVF s are often associated with connective tissue disorders such as neurofibromatosis type 1, fibromuscular dysplasia, Ehlers-Danlos syndrome, and Marfan syndrome.1,4 Endovascular therapy (EVT) is the preferred management strategy,2,3 while surgery may be considered if EVT is unsuccessful or not feasible.1,5 We present a case of a late post-traumatic VVF in a young patient without known underlying conditions treated by embolization using a Woven EndoBridge™ (WEB)-device (MicroVention).
CASE REPORT

Clinical Presentation and Diagnostic Work-up
An 18-year-old female presented with a 16-month history of fatigue, nausea, headache, dizziness, concentration deficits, and tension in the shoulder region that began around the time she started her secondary education. Her symptoms were thought to be related to stress and anxiety, and were initially managed by a psychologist. Four months prior to admission to our department, the patient underwent examination by an osteopath revealing a painless swelling and a bruit in her left upper neck. She subsequently underwent an extended clinical work-up at various institutions. A diagnosis was finally established when a magnetic resonance imaging (MRI) study revealed an arteriovenous shunting lesion at the left C1-level of the spine. MR angiography showed enlargement of the left VA and vertebral venous plexus. Initially considered a spontaneous fistula, the patient later recounted that 2.5 years earlier, she had fallen multiple times from her bicycle. A digital subtraction angiography (DSA) revealed a high-flow left-sided VVF involving the distal V3-segment of the VA with significant steal phenomenon (Fig. 1A–D).

Endovascular Management
Endovascular treatment was planned with the aim to preserve patency of the left VA. The procedure was performed under general anesthesia using propofol and remifentanil for induction and maintenance. A muscle relaxant, rocuronium, was administered before intubation. Blood pressure was monitored with an intra-arterial line, and it was kept stable during the procedure with an infusion of norepinephrine. Heparinized saline flushing was used throughout the EVT aiming for an activated clotting time (ACT) of 2 times the baseline value.

Bilateral femoral access was obtained with a 5F diagnostic catheter positioned into the right VA for control runs. On the

Fig. 1. (A) Left vertebral artery (VA) injection reveals a high-flow vertebro-vertebral fistula (VVF) with significant steal phenomenon and no antegrade flow in the left V4-segment. The fistulous point is marked with an asterisk. The extracranial left VA (arrow) and downstream venous system are dilated. (B) Right VA injection shows flow reversal in the left V4-segment of the VA. The fistulous point is marked with an asterisk. (C) Volume-rendered three-dimensional reconstruction from a left VA (short arrow) injection in left lateral view with a clip-plane close to the fistulous point (asterisk and long arrows). The fistulous point measured approximately 5.5 mm x 6.3 mm in diameter. There is extensive filling of the vertebral venous plexus and paraspinal veins. (D) Multiplanar reconstruction of a cone-beam computed tomography with a left VA (arrow) injection shows the fistulous point (asterisk) between the V3-segment of the VA and the vertebral venous plexus. (E) Early phase left VA (arrow) injection shows the fistulous connection (asterisk) between the VA and proximal venous drainage. (F) Detachable coils (arrowheads) provided a scaffold for deployment of the Woven EndoBridge™device (MicroVention) (asterisk). Catheter in the left VA (arrow). (G) Control runs with left VA (arrow) injection shows complete occlusion of the VVF. The left VA is preserved. (H) Follow-up digital subtraction angiography after 5.5 months shows persistent occlusion of the fistula. The left VA (arrow) is patent and has a normal caliber.
left side, a 6F Infinity sheath (Stryker) was introduced into the left subclavian artery, which allowed navigation of a 6F Sofia™ (MicroVention) into the distal left VA close to the fistula site. From here, a Scepter™ 4.0×15 mm balloon catheter (MicroVention) was advanced into the proximal portion of the draining left vertebral vein. Some detachable coils were deployed first under flow control to create a scaffold. Then, a Headway™ 21 (MicroVention) was advanced into the initial portion of the vein where a 7×5 mm WEB-device was deployed (Fig. 1E, F). Similar to recommendations for treatment of intracranial aneurysms,6 we slightly oversized the diameter of the WEB-device by adding 1 mm to the width of the initial draining vein that measured 6 mm on DSA runs. Control injections showed complete occlusion of the arteriovenous shunting while the distal left VA was fully preserved and flow in the posterior circulation was reversed (Fig. 1G). The patient woke-up without neurologic deficits and was discharged the next day.

Follow-up
Follow-up MR angiography at 4 months and DSA at 5.5 months showed stable occlusion of the fistula and no significant deformation of the WEB-device (Fig. 1H). The patient fully recovered, and her anxiety completely resolved. She successfully completed her education. Genetic testing for connective tissue disorders was negative.

DISCUSSION

Indications for treatment of VVFs are based on clinical symptoms and imaging features. Symptomatic patients often suffer from headaches, neck pain or bruit, but may also develop neurologic deficits due to nerve root or spinal cord compression from enlarged and pulsating veins.1,2,4 Furthermore, steal phenomena may cause vertebrobasilar insufficiency, and venous hypertension may compromise drainage of perimedullary veins leading to congestive myelopathy.2,3,7 Even in asymptomatic patients, treatment is often indicated especially if spinal or intracranial venous drainage or a reversal of flow in the basilar artery are observed.1,2,7 Psychological symptoms may also develop in some patients undergoing a prolonged clinical work-up, as seen in our case.

EVT is the preferred management strategy in patients with VVFs,2,3 while surgery is reserved for cases with difficult access anatomy or when EVT is unsuccessful.1,5 Methods for treatment of VVFs include either constructive or deconstructive techniques depending on the feasibility of preserving the VA.1,3 Deconstructive techniques are an option in cases with adequate flow from the contralateral VA. Under these circumstances, both the fistula and parent artery can often be safely occluded.2,3,8 In a recent review, traumatic VVF were more often treated by deconstructive (73%) rather than constructive (11%) techniques.1 However, we believe preservation of the parent artery is an important treatment goal even if adequate cross-flow exists, especially in young patients.

Constructive techniques aim to preserve the parent artery by selectively occluding the fistulous connection using various techniques.1,8 Traditionally, this goal has been achieved by using detachable balloons, which are no longer readily available.2,3 The use of coils, either alone or in combination with stents or FDs, or even liquid agents are feasible alternatives.8,9 Coils alone may not be sufficiently occlusive,8 especially in high-flow shunts with large wall defects making adjunct techniques such as stents and FDs necessary. These implants require long-term antiplatelet regimens and may not be ideal in young patients.

The WEB-device is an intrasaccular flow diverter that leads to rapid disruption of flow and thrombosis; it is an established treatment option in patients with ruptured and unruptured aneurysms.10 Tropine et al.11 described the successful occlusion of a Barrow Type A carotid-cavernous fistula (CCF) with a WEB-device, but its use in other types of high-flow arteriovenous shunting lesions has never been reported. One distinct advantage of detachable balloons in the treatment of CCFs is to create a relatively regular and smooth interface with the parent artery, which is more difficult to achieve when using coils without adjunctive techniques. In order to combine a strong thrombogenic effect with a smooth healing of the parent artery at the level of the wall defect, the use of an intrasaccular device with a “balloon-like” spherical shape seemed preferable. While balloons occlude mainly by mechanical blockage and are relatively rigid, the WEB-device is more pliable, accommodates better to an irregular geometry, and could potentially generate better endothelialization of the neck. To our knowledge, this is the first case of a VVF treated with a WEB-device, which demonstrates its potential as an additional treatment option in patients with arteriovenous fistulas.

In conclusion, high-flow arteriovenous shunts such as VVFs can be effectively treated using the WEB-device. Similar to

https://doi.org/10.5469/neuroint.2023.00430
detachable balloons, they can be deployed directly into fistulous connections, causing rapid thrombosis and occlusions while allowing for preservation of the parent artery. Stable positioning of the WEB-device can be supported by adjunctive use of coils.

Fund
None.

Ethics Statement
Institutional Review Board approval was waived for this study. Written informed consent for publication of this report was obtained from the patient.

Conflicts of Interest
The authors have no conflicts to disclose.

Author Contributions
Concept and design: RHD and GB. Analysis and interpretation: RHD and GB. Data collection: RHD and GB. Writing the article: RHD and GB. Critical revision of the article: RHD, MGR, VE, SCF, CS, and GB. Final approval of the article: RHD and GB. Overall responsibility: GB.

ORCID
Rasmus Holmboe Dahl: https://orcid.org/0000-0002-2014-7400
Mohammad Ghasemi-Rad:
https://orcid.org/0000-0001-6763-900X
Vagn Eskesen: https://orcid.org/0009-0004-3538-0899
Susanne Christiansen Frevert:
https://orcid.org/0000-0003-3187-4125
Christine Sølling: https://orcid.org/0000-0002-0724-4695
Goetz Benndorf: https://orcid.org/0000-0002-9824-6900

REFERENCES