Dural arteriovenous fistulas (DAVFs) of the cavernous sinus are acquired arteriovenous shunts between the dural branches of the internal and external carotid arteries and the cavernous sinus. These fistulas may present with cortical venous reflux, but more commonly drain antegrade toward the superior ophthalmic vein (SOV). Transvenous embolization is the most common endovascular treatment, but in some cases transvenous access to the compartment of the shunt may not be possible. In cases with no cortical venous reflux, manual compression of the SOV is an excellent alternative treatment, which is well known but rarely reported in the literature. The authors describe a series of 3 cavernous DAVFs with anterior drainage treated successfully by intermittent manual compression of the SOV. (http://thejns.org/doi/abs/10.3171/2013.2.JNS121976)

**Key Words**
- dural arteriovenous fistula
- carotid-cavernous fistula
- conservative treatment
- manual compression
- vascular disorders

Case Reports

**Case 1**

This 54-year-old woman presented with a 3-week history of left proptosis, painful ophthalmoplegia, conjunctival injection, and decreased visual acuity in the preceding few days. Her IOP was elevated to 26 mm Hg.

Time-resolved MRA showed dilation and early filling of the left SOV, suspicious for a cavernous DAVF (Fig. 1A). Digital subtraction angiography confirmed the lesion, which was supplied mainly by branches of the left ECA. There was exclusive anterior venous drainage through the SOV and no evidence of CVR (Fig. 1B). During the diagnostic angiogram the ECA was injected while applying compression to the SOV. This maneuver did not trigger CVR and showed significant slowing of the shunt (Fig. 1C). An attempt to embolize this fistula via a transvenous approach failed. We were not able to reach the draining vein either through the petrosal sinus or the facial vein. The patient was instructed to perform repeated manual compression of the SOV at home 4–6 times every day for 5–10 minutes per session, or until the pain became too intense to continue compression. With this maneuver, the patient’s symptoms gradually improved. Her IOP normalized at 3 weeks, and time-resolved MRA at 4 weeks showed a normal-appearing SOV with no early filling (Fig. 1D).

**Case 2**

This 71-year-old woman presented with a 4-month history of right painless proptosis and conjunctival injection. Intraocular pressure was increased with normal visual acuity. This patient had an aneurysm clip in her brain that was not compatible with MRI, and therefore 4D-CTA was performed. This demonstrated early filling and dilation of the right SOV. Digital subtraction an-
giography confirmed a right cavernous sinus DAVF with supply from dural branches of both cavernous internal carotid arteries and the right ECA. The venous drainage pattern was benign toward the SOV and there was no CVR. Angiography performed with SOV compression showed significant slowing of the shunt and no rerouting. Given the benign clinical and angiographic characteristics and the patient’s preference, a conservative approach using manual SOV compression was chosen. The patient had abrupt symptom worsening 4 weeks later, characterized by increased proptosis, conjunctival injection, and blurred vision, and CTA demonstrated a complete SOV thrombosis. Clinical worsening was attributed to shunt closure. She was treated with a course of steroid therapy and IOP was closely monitored. Symptoms gradually resolved over a period of 3 weeks. Follow-up CTA at 4 months showed no residual arteriovenous shunting.

Case 3

This 68-year-old man presented with a 3-month history of left-sided chemosis, proptosis, and red eye. Evaluation with 4D-CTA showed a left cavernous DAVF with anterior drainage through the SOV and no evidence of CVR (Fig. 2A). The patient also suffered from a chronic aortic dissection involving the arch and extending into the left common carotid artery (Fig. 2B). Since we could not perform arterial injections, endovascular treatment was impossible. The patient was managed conservatively with manual compression of the SOV. Five weeks later the patient had an abrupt worsening of the proptosis and conjunctival injection, but no changes in visual acuity. This was attributed to shunt closure because CTA at that time showed no opacification of the SOV (Fig. 2C). The patient was managed conservatively with close monitoring of the IOP. Symptoms resolved gradually over a period of 2.5 weeks. At the 3-month follow-up, time-resolved MRA showed no signs of residual arteriovenous shunt and a normal-caliber SOV (Fig. 2D).

Discussion

The clinical presentation and natural history of DAVFs depend on the pattern of venous drainage from the cavernous sinus. Most importantly, patients with CVR are at risk for associated intracranial hemorrhage and nonhemorrhagic neurological deficits. Up to one-third of patients will have evidence of CVR on angiography.

Spontaneous fistula closure has been reported to occur in 20%–60% of patients, although the time to closure has not been well described. Nukui et al. reported a 20% spontaneous cure rate within the first 6 months and rates of 45% during the 1st year and 60% after 2 years of follow-up.

Treatment is recommended in patients with CVR or
Ophthalmic vein compression for low-flow cavernous sinus DAVF

with ocular symptoms refractory to medication. Transarterial embolization often results in an incomplete radiographic occlusion of the fistula. Transvenous embolization has a high success rate in achieving closure of the fistula and is therefore the treatment of choice. The most frequently used transvenous approaches are via the inferior petrosal sinus, using a transfemoral venous approach, or via a cutdown to the SOV. Transfemoral facial vein approaches to the SOV have also been described. Despite the multiple options, in some cases access to the venous compartment where the fistula is located is impossible. Reasons include hypoplastic or thrombosed petrosal sinuses, presence of venous stenosis, compartmentalization of the cavernous sinus, and lack of proximal support in patients with a large right atrium. Tortuosity of the facial, angular, or ophthalmic veins may also preclude access. Alternative noninvasive treatment options have been reported for cavernous DAVFs. There are a few reports of manual compression of the ipsilateral carotid artery and internal jugular vein, which may induce thrombosis of the slow-flow shunt. This maneuver is performed using the contralateral hand to detect early ipsilateral brain ischemia. Higashida et al. reported a 30% cure rate with this technique with a mean time to closure of 41 days, while Kai et al. reported the same cure rate, but with a longer median time to closure (4.1 months). Predictors of success include a lower IOP, a shorter interval between symptom onset and initiation of compression, and venous drainage via the SOV. Manual carotid compression is contraindicated in patients with progressive vision loss, CVR, known carotid disease, or a history of stroke. Complications are rare and include stroke, bradycardia, and hypotension.

We present a short series of 3 patients with benign cavernous DAVFs who responded to manual compression of the SOV. Technically, compression of the SOV is performed by applying gentle pressure with the thumb over the superomedial orbital rim 4–6 times a day, for approximately 10 minutes each time. Unlike carotid compression, this maneuver will not induce a carotid body reaction and is not contraindicated in patients with carotid bifurcation atheromatous disease. Two of our patients underwent DSA, which demonstrated 1) a slow-flow cavernous DAVF, with 2) exclusive anterior venous drainage, 3) significant reduction in the shunt volume when SOV compression was applied, and 4) no rerouting of the venous drainage to cortical veins. Performing compression during the diagnostic angiogram verifies that the SOV compression does not produce CVR and may also predict success of SOV compression. One of our patients did not undergo DSA due to a chronic aortic dissection, and we accepted the results of noninvasive imaging as indicating that the patient was fit for manual SOV compression. Clinical and imaging cure occurred in all 3 patients within 4–6 weeks of SOV compression. This time to cure is much shorter than the time for spontaneous cure of these fistulas, which is usually not less than 6 months. Two of our patients suffered from transient worsening of symptoms at the time of SOV thrombosis and closure of the shunt. This paradoxical worsening is a well-known phenomenon in cavernous DAVFs and can also occur after endovascular occlusion. Typically, it is well managed with steroids and acetazolamide, and, in rare instances, with anticoagulation.

The maneuver of SOV compression for benign cavernous DAVFs that we describe is well known to many senior neurointerventionalists but is nearly unreported in the literature. We chose to report our recent experience to raise awareness of this method in younger interventionalists who may not have been exposed to this treatment option. Patients with benign cavernous DAVFs do not usually experience permanent morbidity or mortality but do suffer from proptosis, diplopia, and intermittent pain, which may have a negative impact on their lifestyle. These patients may benefit from faster symptom resolution.

Conclusions

Compression of the SOV is a well-known but rarely reported maneuver for conservative management of benign cavernous DAVFs. These shunts have a high spontaneous cure rate, but this maneuver likely accelerates their closure. Corticovenous reflux during compression should be ruled out prior to treatment.

Disclosure

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

Author contributions to the study and manuscript preparation include the following. Conception and design: Agid, Cruz. Acquisition of data: van Dijk. Analysis and interpretation of data: Cruz. Drafting the article: Cruz, van Dijk. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Agid.

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