Percutaneous transfemoral embolization of an indirect carotid–cavernous fistula with cortical venous access to the cavernous sinus

Case report

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The authors present the case of a 61-year-old man with an indirect carotid–cavernous fistula (CCF). Many now advocate a primary transvenous approach to deal with such lesions, with packing and thrombosis of the cavernous sinus leading to fistula obliteration. Transvenous access to the cavernous sinus via the inferior petrosal sinus is the usual route of access; both surgical and transfemoral superior ophthalmic vein approaches are also well described. In the case presented, the anatomy of the CCF was unfavorable for these approaches and its dominant venous egress was via a single enlarged arterialized cortical vein. The cavernous sinus was accessed with a transfemoral retrograde approach to the cortical draining vein. Successful CCF embolization was documented radiographically and clinically. To the authors’ knowledge, this procedure has not been previously described in the English literature.

KEY WORDS • carotid-cavernous fistula • endovascular therapy • transvenous embolization • Guglielmi detachable coil

INDIRECT carotid–cavernous fistulas (CCFs) or dural arteriovenous fistulas of the cavernous sinus are relatively uncommon lesions primarily treated via endovascular means. The arterial supply to these lesions is from numerous small pedicles often originating from both the internal carotid artery (ICA) and the external carotid artery (ECA). Transcatheter access to small branch vessels from the carotid siphon is difficult and there is often recruitment of additional supply following arterial embolization. Consequently, many now advocate a primary transvenous approach to these lesions, with packing and thrombosis of the cavernous sinus leading to fistula obliteration. Transvenous access to the cavernous sinus via the inferior petrosal sinus (IPS) is the usual route of access; both surgical and transfemoral superior ophthalmic vein approaches are also well described. We present a case of a patient harboring an indirect CCF with anatomy unfavorable for these approaches and dominant venous egress via a single enlarged arterialized cortical vein. In this patient, the cavernous sinus was accessed by using a transfemoral retrograde approach to the cortical draining vein. Successful radiographic and clinical fistula embolization was accomplished. To our knowledge, this procedure has not been previously described in the English literature.

Case Report

History. This 61-year-old right-handed man presented with approximately an 18-month history of right eye injection and chemosis, periorbital swelling, retroorbital headache, and transient episodes of diplopia. Magnetic resonance (MR) imaging demonstrated engorgement of the right cavernous sinus and congested extraocular muscles, leading to a presumptive diagnosis of a CCF (Fig. 1). The patient was referred to our institution for endovascular therapy.

Examination. Initial cerebral angiography demonstrated an indirect CCF fed primarily from the right carotid artery. Drainage from the cavernous sinus coursed primarily via the right sphenoparietal sinus into a single enlarged cortical vein and then to the superior sagittal sinus (SSS). Right ECA injection showed a blood supply to the fistula from distal branches of the internal maxillary artery including the pterygovaginal artery and the vidian artery. Selective
right ICA injections demonstrated blood supply to the fistula from multiple small branches of the carotid siphon. Supply from the left ICA and ECA was present, but to a lesser degree than on the right side. Of note, on angiography there was no visible drainage of the CCF via either the superior ophthalmic vein or the petrosal sinuses, obviating the conventional transvenous access to the cavernous sinus (Figs. 2 and 3).

**Initial Embolization Attempt.** Particulate embolization of distal internal maxillary branches of the right ECA was performed using 150- to 250-μm Tru-Fill polyvinyl alcohol particles, resulting in approximately a 20% decrease in the arteriovenous shunt. Transvenous attempts to catheterize the right IPS were unsuccessful, despite wire-directed probing of the jugular bulb and the sigmoid and lateral sinuses. In fact, we were unable to demonstrate angiographically either petrosal sinus. At this point, due to contrast load, the procedure was aborted with plans for the patient to return in 1 month for packing of the cavernous sinus via a transcortical venous approach.

**Embolization Procedure.** After general anesthesia had been induced in the patient, a No. 4 French hemostatic sheath was placed in the left common femoral artery. For purposes of roadmapping the venous drainage of the CCF, the right ECA was selectively catheterized using a No. 4 French vertebral catheter, which was set for a continuous heparinized saline drip. For venous access, a No. 7 French 80-cm-long vascular sheath was placed in the right common femoral vein and advanced to the level of the right jugular bulb. A Tracker-38 infusion microcatheter was inserted in a coaxial fashion through the No. 7 French sheath and navigated through the jugular bulb and the right transverse sinus into the proximal SSS. The patient was intravenously administered heparin: initially 5000 U followed by 1000 U/hour. A Prowler-14 microcatheter was inserted through the Tracker microcatheter and, using roadmapped injections from the arterial side, the microcatheter was negotiated over a 0.014-in guidewire through the SSS, down the draining cortical vein, and into the right cavernous sinus (Fig. 4). A total of 10 Guglielmi detachable coils (GDCs) were deployed in the right cavernous sinus (five 6 × 20-mm “10,” three 4 × 8-mm “10,” and two 10 × 30-mm “10” GDCs). Small adjustments in microcatheter positioning were made in the cavernous sinus to facilitate complete packing; embolization was deemed complete when subsequent attempts to deploy coils dislodged the microcatheter. Somatosensory evoked potentials were obtained before and after GDC deployment. No change from the baseline examination was noted.

**Postembolization Course.** On completion of coil deployment, repeated right ICA and ECA arteriography demonstrated no residual filling of the CCF (Fig. 5). The patient’s symptoms immediately improved and have remained that way as of the 2-month follow-up examination.

**Sources of Supplies and Equipment**

Particulate embolization was first attempted using Tru-Fill polyvinyl alcohol particles available from Cordis Endovascular (Miami Lakes, FL), which also supplied the No. 4 French vertebral catheter and the Prowler-14 microcatheter. The No. 7 French vascular sheath was obtained from Arrow (Reading, PA), the Tracker-38 infusion microcatheter from Target Therapeutics (Fremont, CA), and the 0.014-in Transcend EX guidewire from Medi-Tech (Watertown, MA). The GDCs were purchased from Target Therapeutics.

**Discussion**

A variety of treatment options are available for use in the management of dural arteriovenous fistulas. Manual compression of the carotid artery or its external branches may be efficacious in some patients. In patients with di-
minished visual acuity or cortical venous drainage (due to increased risk of hemorrhage), more urgent treatment is demanded. In an indirect CCF with a component of ICA supply, embolization from the arterial side may decrease the size of the arteriovenous shunt and improve symptoms, although ordinarily it is believed to be an incomplete treatment. Despite initial success, these lesions will usually recruit additional arterial feeding vessels, and many arterial pedicles originating from the ICA can be endovascularly inaccessible (or their catheterization unacceptably dangerous). Arterial embolization, however, can play a valuable role as an adjunct to venous embolization by decreasing the magnitude of the shunt and, thereby, promoting thrombosis in the dural sinus.

Dural venous sinus embolotherapy is gaining increasing acceptance as the preferred primary therapy for these lesions. In contradistinction to the transverse, sagittal, and sigmoid sinuses, the occlusion of which carries a small risk of infarction, the cavernous sinus can be occluded with little adverse effect. In a direct CCF, embolic material can be introduced into the cavernous sinus through the carotid siphon arterial rent. This route is unavailable in treating an indirect CCF. Embolization of the cavernous sinus via the IPS is a well-described technique often available to the neurosurgeon. Miller and Doppman, in a review of 346 consecutive IPS catheterizations for venous sampling procedures, were unsuccessful in only 2% of cases. They describe a small subset of patients in whom the IPS drains directly into the paravertebral venous plexus via a small condylar vein and is never in direct communication with the jugular bulb. Although the IPS was never angiographically demonstrated in our patient, he may have possessed this variant. Alternatively, our patient’s IPS may have been severely stenosed or occluded.

In many patients with an indirect CCF, the cavernous sinus is accessible via an enlarged superior ophthalmic vein, which may be accessed transfemorally (via upward passage through the facial and angular veins) or through an orbitotomy. The latter route demands an experienced

Fig. 3. Angiograms obtained after superselective injection of the right ECA inferolateral trunk branch (lateral [left] and frontal [right] projections). There are numerous small arterial feeders supplying the cavernous sinus (large black arrows) with retrograde opacification of a dilated cortical vein (small arrows) draining via the sphenoparietal sinus into the SSS (open arrows). The opaque structure extending posteriorly from the cavernous sinus to the lateral sinus is the vein of Labbé and not the superior petrosal sinus.

Fig. 4. Intraprocedural lateral radiograph demonstrating the circuitous course of the transcortical microcatheter as it passes from the SSS (open arrow) through the cortical vein (small arrows) to the central portion of the cavernous sinus (large black arrow).
orbital surgeon to expose the vein; its safe use has been described in small series using both embolic balloons and coils. In our patient, although the extraocular muscles were engorged on MR imaging, there was no angiographic demonstration of an accessible superior ophthalmic vein. Alternative routes of access to the cavernous sinus have been previously described: Jahan and colleagues reported an endovascular access to the cavernous sinus via the contralateral pterygoid plexus in a patient with thrombosis of the superior ophthalmic veins and nonvisualization of the IPS on angiography.

Surgical exposure and subsequent packing of the cavernous sinus has been reported in patients with failure of endovascular therapy. Tu, et al., described neurosurgical exposure and packing of the cavernous sinus in 19 patients harboring CCFs in whom endovascular therapy had been unsuccessful. Although the fistulas were obliterated in all 19 cases, the ICA (or a venous bypass graft) was found to be occluded in five patients on follow-up angiography. These authors also described a subset of patients with transient oculomotor and abducent cranial nerve palsies following surgery.

In this case, after careful consideration of available treatment options, we were able to perform retrograde microcatheter navigation down the draining cortical vein, through the sphenoparietal sinus, and into the cavernous sinus. Some have expressed concern about the risks of hemorrhage involved in the endovascular manipulation of a fragile, arterialized cortical vein. In addition to the risk of direct vessel perforation, hydrostatic pressure changes induced by catheterization or inadvertent thrombosis of cortical venous drainage could result in hemorrhage at the site of the CCF. These are certainly valid arguments and this procedure should not be undertaken lightly. However, using modern microcatheters and wires as well as careful biplane angiography with roadmapping, these risks can be reduced and considered vis-à-vis alternative open surgical exposure of the cavernous sinus. Safe catheterization of arterialized leptomeningeal veins has been previously reported: Kallmes and associates described successful navigation through the straight sinus and the vein of Galen into a dilated perimesencephalic vein for embolization of a tentorial dural arteriovenous fistula.

In some patients in whom this transfemoral transcortical venous route to the cavernous sinus is contemplated, access may not be possible because of the loss of catheter torque control and maneuverability that occurs when working over such a distance. In these patients a small craniotomy with direct exposure and puncture of the cortical vein would be an alternative to microneurosurgery of the cavernous sinus. This approach has been described by Kuwayama, et al., in a patient in whom the IPS approach to the cavernous sinus was possible, but tight septation of the sinus limited access to only its posterior compartment, which did not involve the fistula. Interestingly, these authors found the involved arterialized cortical vein to have a thickened wall, indicating that perhaps endovascular manipulation of these vessels is not as dangerous as has been previously thought.

References
dural fistulas involving the deep cerebral venous system. AJNR 10:393–399, 1989

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