Treatment of carotid-cavernous sinus fistulas using a superior ophthalmic vein approach

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The authors describe the method and results of treatment of 12 consecutive patients with carotid-cavernous sinus fistulas (CCFs). Treatment was by embolization via a transvenous approach through the superior ophthalmic vein (SOV). The CCFs (two direct and 10 dural) had previously been treated unsuccessfully or, for mechanical reasons, could not be treated by the standard techniques of endoarterial balloon occlusion, particle or glue embolization of feeding vessels from one or both external carotid arteries, or transvenous occlusion of the fistula via the ipsilateral inferior petrosal sinus. All 12 patients were successfully treated either by advancement of a detachable balloon catheter through the ipsilateral SOV into the cavernous sinus with subsequent inflation and detachment of the balloon (11 patients) or by introduction of multiple thrombogenic coils into the fistula via the ipsilateral SOV (one patient).

All patients had complete resolution of symptoms and signs after successful occlusion of the CCF. There were no intraoperative complications; however, one patient required postoperative embolization of a residual posteriorly draining fistula via the ipsilateral external carotid artery, and another developed a persistent abducens nerve paresis that eventually required surgical correction. Ten (83.3%) of the 12 patients underwent cerebral angiography 3 to 6 months after surgery, and none showed evidence of a recurrent fistula. Similarly, none of the 12 patients developed recurrent symptoms and signs suggesting recurrence of the fistula during a follow-up period that ranged from 6 months to 10 years (mean 64 months). It is concluded that the transvenous approach to the cavernous sinus through the SOV is a safe and effective treatment of both direct and dural CCFs that are not amenable to transarterial or other transvenous approaches.

Key Words • carotid-cavernous sinus fistula • embolization • transvenous approach • superior ophthalmic vein • arteriovenous fistula • detachable balloon

Arteriovenous fistulas that involve the cavernous sinus (carotid-cavernous sinus fistulas, CCFs) often produce ophthalmological symptoms and signs. Chemosis, conjunctival injection, eyelid swelling, proptosis, diplopia, and loss of vision may all result from the effects of these fistulas.14 Patients with CCFs may also experience acute subarachnoid or intracranial hemorrhage from rupture of arterialized cortical veins.3,10

There are two main types of CCF.14 Direct CCFs consist of a communication between the main trunk of the internal carotid artery (ICA) and the venous channels within the cavernous sinus. These fistulas are almost always caused by trauma or rupture of an intracavernous carotid aneurysm and are usually characterized hemodynamically by high flow. Dural carotid-cavernous sinus fistulas are communications between the cavernous sinus and extradural branches of ICA, external carotid artery (ECA), or both. These fistulas usually become symptom-
sinus, and we report our results using this approach in 12 consecutive patients with CCFs.

**Clinical Material and Methods**

**Patient Population**

The 12 patients in this series ranged in age from 26 to 71 years (Table 1). Five patients were men and seven were women. The fistula was unilateral and of the dural type in nine patients (75%). One patient (Case 11) had bilateral dural fistulas. Two patients had a unilateral direct fistula. One, a 27-year-old woman (Case 2), had a small channel connecting the ipsilateral ICA to the cavernous sinus, which prevented the introduction of a balloon-tipped catheter through an endoarterial route. The second patient with a direct CCF, a 31-year-old man (Case 4), had previously undergone attempted trapping of a traumatic fistula without success, resulting in occlusion of the ipsilateral ICA in the neck. Five patients in this series (Cases 1, 4, 5, 6, and 11) have been described previously in the literature by Debrun, et al.,5 (Cases 1 and 5), by Hanneken, et al.,9 (Cases 1, 4, 5, and 6), by Monsein, et al.,15 (Cases 1, 5, 6, and 11), and by Miller14 (Cases 5 and 11).

Among the 10 patients with dural fistulas, five (Cases 1, 3, 5, 8, and 10) had unilateral fistulas fed by dural branches of the ipsilateral ICA and ECA, and one (Case 6) had a unilateral fistula fed only by branches from the ipsilateral ECA. Two patients (Cases 7 and 9) had a unilateral fistula fed by branches from both the ipsilateral and contralateral ICA and ECA. One patient (Case 12) had a unilateral fistula fed by branches from the ipsilateral ICA and ECA and branches from the contralateral ICA. In the patient with bilateral dural CCFs (Case 11), the fistulas were both fed primarily by branches from the ipsilateral ICA and ECA. The venous drainage in all 12 cases was anterior, resulting in variable enlargement of the ipsilateral and occasionally the contralateral SOV. In no case was there opacification of the ipsilateral inferior petrosal sinus during angiography.

All 12 patients presented with signs and symptoms of typical CCF (Table 1). These included proptosis (12 patients), diplopia with limitation of eye movements (generalized in 10 patients and caused by an abducens nerve paresis in two), and redness of the affected eye with typical arterialization of the conjunctival vessels (12 patients). Only four patients (Cases 2, 4, 7, and 9) had a subjective bruit, all of whom also had an objective bruit. These included the two patients (Cases 2 and 4) with a direct fistula. Thus, only two (20%) of 10 patients with a dural fistula (Cases 7 and 9) had an objective or subjective bruit, and these were the only patients in the series with a unilateral fistula fed by branches from the ICA and ECA on

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**TABLE 1**

*Data on patients with carotid-cavernous sinus fistulas treated with the superior ophthalmic vein approach*

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age at Treatment (yrs), Sex</th>
<th>Side</th>
<th>Type of Fistula</th>
<th>Source</th>
<th>Manifestations</th>
<th>Result</th>
<th>Complications</th>
<th>Postop Angio</th>
<th>Follow-Up Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>26, M</td>
<td>Lt</td>
<td>dural</td>
<td>Lt ICA</td>
<td>proptosis, EOM, redness</td>
<td>cured</td>
<td>none</td>
<td>yes</td>
<td>9 yrs</td>
</tr>
<tr>
<td>2</td>
<td>27, F</td>
<td>Lt</td>
<td>direct</td>
<td>Lt ICA</td>
<td>proptosis, EOM, redness, bruit</td>
<td>cured</td>
<td>none</td>
<td>yes</td>
<td>7 yrs</td>
</tr>
<tr>
<td>3</td>
<td>28, F</td>
<td>Rt</td>
<td>dural</td>
<td>Rt ICA</td>
<td>proptosis, redness, VI palsy</td>
<td>cured</td>
<td>none</td>
<td>no</td>
<td>18 mos</td>
</tr>
<tr>
<td>4</td>
<td>31, M</td>
<td>Rt</td>
<td>direct</td>
<td>Rt ICA</td>
<td>proptosis, EOM, redness, bruit, loss of vision</td>
<td>cured</td>
<td>none</td>
<td>yes</td>
<td>8 yrs</td>
</tr>
<tr>
<td>5</td>
<td>43, F</td>
<td>Lt</td>
<td>dural</td>
<td>Lt ICA</td>
<td>proptosis, EOM, redness, loss of vision</td>
<td>cured</td>
<td>none</td>
<td>yes</td>
<td>10 yrs</td>
</tr>
<tr>
<td>6</td>
<td>48, M</td>
<td>Rt</td>
<td>dural</td>
<td>Rt ECA</td>
<td>proptosis, redness, VI palsy</td>
<td>cured</td>
<td>none</td>
<td>no</td>
<td>1 yr</td>
</tr>
<tr>
<td>7</td>
<td>52, M</td>
<td>Rt</td>
<td>dural</td>
<td>Rt ECA</td>
<td>proptosis, EOM, redness, bruit, loss of vision</td>
<td>cured</td>
<td>none</td>
<td>yes</td>
<td>9 yrs</td>
</tr>
<tr>
<td>8</td>
<td>59, F</td>
<td>Lt</td>
<td>dural</td>
<td>Lt ICA</td>
<td>proptosis, EOM, redness</td>
<td>cured</td>
<td>VI palsy</td>
<td>yes</td>
<td>3 yrs</td>
</tr>
<tr>
<td>9</td>
<td>62, F</td>
<td>Lt</td>
<td>dural</td>
<td>Lt ICA</td>
<td>proptosis, EOM, redness, bruit</td>
<td>cured</td>
<td>none</td>
<td>yes</td>
<td>6 mos</td>
</tr>
<tr>
<td>10</td>
<td>63, M</td>
<td>Lt</td>
<td>dural</td>
<td>Lt ICA</td>
<td>proptosis, EOM, redness</td>
<td>cured†</td>
<td>none</td>
<td>yes</td>
<td>6 yrs</td>
</tr>
<tr>
<td>11</td>
<td>67, F</td>
<td>Bilat</td>
<td>dural</td>
<td>Lt ECA</td>
<td>bilat proptosis, EOM, redness, ptosis</td>
<td>cured</td>
<td>none</td>
<td>yes</td>
<td>6 yrs</td>
</tr>
<tr>
<td>12</td>
<td>71, F</td>
<td>Rt</td>
<td>dural</td>
<td>Rt ICA</td>
<td>proptosis, EOM, redness</td>
<td>cured</td>
<td>none</td>
<td>yes</td>
<td>3 yrs</td>
</tr>
</tbody>
</table>

*Abbreviations: angio = angiography; ECA = external carotid artery; ICA = internal carotid artery; EOM = diplopia with limitation of extraocular movements; VI = sixth (abducens) nerve.
†This patient required postoperative particle embolization to complete closure of the fistula.
both sides. Two of the 12 patients (Cases 4 and 5) had loss of vision caused by stasis retinopathy. A third patient (Case 7) had decreased vision in the affected eye, but this was caused primarily by diabetic retinopathy. The duration of symptoms until treatment among the 12 patients ranged from 3 weeks to 1 year.

Operative Technique

Although there was some minor variation in the technique as our experience increased, the basic procedure remained the same for all 12 patients. All procedures were performed under fluoroscopic guidance in a neurosurgical operating room. Verbal and written consent were obtained using a protocol approved by the Institutional Review Board of the hospital. Latex balloons (No. 9 or 16; Nycomed/Ingenor, Paris, France) were used under a physician-sponsored Investigational Drug Exemption. After induction of general anesthesia, a sheath was usually placed in a common femoral artery to permit intraoperative angiography. In 11 patients (92%), an incision was made in the skin of the superior sulcus of the upper eyelid nasally, under magnification provided by an operating microscope (Fig. 1). The incision was carried down through the orbicularis oculi muscle, with hemostasis being rigorously controlled. The orbital septum was identified and opened, exposing the retroseptal orbital fat. Blunt dissection was used to identify the SOV, which varied in size from 3 to 8 mm in diameter. The vein was carefully cleaned of its attachments to surrounding orbital fat until a segment measuring 5 to 20 mm was exposed. Two ligatures consisting of 2-0 black silk suture for small veins and a 1-mm diameter silicone vessel loop for large veins were passed underneath the vessel using a right-angle clamp, and the two ends of each ligature were passed through a piece of tubing that also varied in size from a No. 5 pediatric feeding tube to a No. 5 French catheter. The two ligatures were then placed approximately 10 mm apart to isolate a small segment of the vein (Fig. 2).

Once the ligatures were in place around the vein, a small incision was made in the wall of the vein between the ligatures, using spring-action scissors. Brisk arterial bleeding indicated that a full-thickness opening had been achieved, and the ligatures were then tightened by means the tubing. With two jeweler’s forceps, the balloon-tipped catheter was placed into the opening in the vein (Fig. 3). Placement requires two people, with one threading the catheter and the other manipulating the ligatures to allow passage of the catheter while limiting bleeding. The catheter was threaded posteriorly under fluoroscopic control until the balloon tip was observed to be within the cavernous sinus (Fig. 4 upper). The balloon was then inflated with iodinated contrast material, and intraoperative angiography was usually performed through an angiographic catheter introduced via the common femoral arterial sheath into the ipsilateral common carotid artery. Once angiography demonstrated that the balloon was in an ap-
propriate position and that flow through the fistula was reduced or absent, the balloon was detached (Fig. 4 lower). Nine patients required only a single balloon, whereas three patients required two; no patient required more than two balloons. One patient (Case 10) had such a small SOV that the balloon-tipped catheter could not be inserted despite multiple attempts. Accordingly, a No. 18 Tracker microcatheter was introduced, and multiple thrombogenic platinum coils were released into the cavernous sinus.

After detachment of the balloon, the catheter was withdrawn, and the SOV was permanently occluded by bipolar cautery and ligatures or, when the vein was quite large and its wall thick, the incision was closed using 10-0 black silk suture. The orbit was then irrigated with antibiotic solution, and the skin incision was closed with a running 8-0 nylon suture. No attempt was made to close the orbital septum in most cases. A Xeroform gauze pad was then placed over the incision site, and a light eye patch was placed over the pad.

One patient (Case 1) had angiographic evidence of occlusion of the proximal portion of the SOV in the anterior orbit at the time his fistula was diagnosed. He therefore underwent craniotomy and partial unroofing of the orbit on the affected side. The superior periorbita was then opened, and the enlarged SOV was identified. A segment of the patent distal portion of the vein in the midorbit was then isolated and cannulated in the manner described above.

Results

Eleven (92%) of the 12 patients experienced immediate closure of their fistulas by the technique described above, verified by either intraoperative or immediate postoperative cerebral angiography (Table 1). In one patient (Case 10) intraoperative cerebral angiography following detachment of the balloon showed that only the anterior portion of the fistula had been closed and that the fistula was now draining posteriorly into the ipsilateral external carotid artery cortical veins. The patient underwent immediate occlusion of the posterior portion of the fistula using particle embolization introduced through the inferior petrosal vein.

There were no intraoperative complications in any of the 12 patients. Several patients experienced transient worsening of ocular misalignment, but only one patient (Case 8) had a persistent ocular motor deficit. This patient, a 59-year-old woman, developed a complete ipsilateral abducens nerve palsy that did not improve over the subsequent 12 months. She was treated initially with botulinum toxin serotype A (Botox) injected into the left medial rectus muscle and eventually underwent strabismus surgery.

It was recommended to all 12 patients that they undergo postoperative cerebral angiography 3 to 6 months after surgery. Ten (83.3%) of the 12 patients agreed to do so. None of these patients showed evidence of a persistent or recurrent fistula. In addition, none of the 12 patients experienced signs or symptoms of a recurrent fistula during a follow-up period that ranged from 6 months to 10 years (mean 64 months) (Table 1).
Discussion

It has become clear that transarterial endovascular approaches can be used to cure both direct and dural CCFs.\textsuperscript{1,2,4,6,11,14} For instance, most direct fistulas can be occluded safely and permanently by introducing platinum coils or a detachable balloon into the cavernous sinus via a catheter that is introduced into the ipsilateral ICA and is passed through the fistula into the affected cavernous sinus. Unfortunately, if a catheter cannot be passed through the ICA because the patient has undergone a previous unsuccessful trapping procedure in which the artery has been ligated or if the artery has a congenital anomaly that precludes successful passage of the catheter into the cavernous sinus, this route cannot be used.\textsuperscript{5,9} Similarly, dural CCFs that have a substantial or total contribution from the dural branches originating from the ipsilateral or contralateral ICA, and selective embolization of feeding branches from the ECA is not uniformly successful in closing these fistulas.\textsuperscript{5}

Transvenous endovascular techniques can be used successfully to occlude some of these fistulas. A number of approaches to the venous effluent vessels have been described, including direct surgery of the cavernous sinus and approaches through the inferior petrosal sinus, angular vein, inferior ophthalmic vein, and SOV (S Oono, et al., unpublished data).\textsuperscript{3,9,12,13,15,17} An approach through the inferior petrosal sinus is particularly likely to provide a safe and successful route for endovascular treatment when the sinus opacifies during angiography.\textsuperscript{13,15} When it does not, however, cannulation of this vessel is usually extremely difficult, if not impossible.

For cases in which standard transarterial or transvenous approaches either cannot be performed for mechanical reasons or have been unsuccessful, our experience suggests that an approach through the SOV is safe and reliable when performed using appropriate techniques by a team consisting of an orbital surgeon, a neurosurgeon, and an interventional neuroradiologist. In addition, we believe that in some cases the SOV approach is not only less time-consuming but easier for the patient than attempts to perform embolization of multiple ECA feeding vessels. The precise technique recommended for closure of a direct or dural fistula, therefore, should be individualized. Whenever the SOV approach is used, we recommend that a cerebral angiogram be performed 3 to 6 months after surgery to make certain that the fistula has been permanently occluded. Finally, because the main potential complications of this procedure are failure to identify the SOV, misidentification of the superior oblique tendon as the SOV, bleeding, and infection, we believe that the procedure should be performed using an operating microscope in a sterile operating room with fluoroscopic capabilities that permit intraoperative angiography.

Investment Disclosure

The authors have no financial interest in any of the instruments or methodology described in this report.

References


Manuscript received February 27, 1995.
Accepted in final form April 27, 1995.
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