Cavernous sinus fistula treated through the transvenous approach: Report of four cases

Traitement par voie veineuse des fistules carotido-caverneuses : à propos de quatre cas

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Superior ophthalmic vein;
Inferior petrosal sinus

Summary
Purpose. — To describe transvenous embolization in four patients with indirect dural carotid cavernous fistulas (CCFs) via the inferior petrosal sinus (IPS) or superior ophthalmic vein (SOV), and their clinical outcomes.

Methods. — The CCF approach was performed after retrograde venous catheterization from the femoral vein to the cavernous sinus via the IPS (n = 1) or SOV (n = 3). SOV catheterization was possible without surgical intervention. All patients presented initially with typical clinical signs of CCF. Patients treated via the SOV presented with thrombosis of the IPS.

Results. — Catheterization and embolization were successful in all patients, with complete angiographic occlusion of the fistula. No early or late complications occurred. All patients presented with favorable clinical outcomes and complete recovery of ocular symptoms.

Conclusion. — Retrograde transvenous embolization of CCF via the IPS, or SOV if the IPS is thrombosed, is a safe procedure with a good clinical outcome.

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Barrow et al. [1] classified dural carotid cavernous fistulas (CCFs) into four groups, according to their arterial feeders. Type A corresponds to a direct CCF, observed after trauma or rupture of a cavernous carotid aneurysm or dysplasia. Types B, C and D are indirect dural fistulas corresponding to arteriovenous shunts between the meningeal branches arising from the internal carotid artery (ICA) only, the external carotid artery (ECA) only, and both the ICA and ECA, respectively. Most indirect dural CCFs are well tolerated and resolve spontaneously or after carotid compression [2,3]. Endovascular treatment is proposed when the patient presents with ocular hypertension or disturbances of visual function. Treatment is considered an emergency when the patient presents with cortical venous drainage or, in particular, brain hemorrhage.

Endovascular treatment of CCF is via either the transarterial or transvenous approach. Transvenous embolization is preferred as there are usually numerous arterial feeders...
joining the nidus. Here, we report our results with transvenous treatment of dural CCF using a transfemoral approach and either the ophthalmic or petrosal route.

Methods

In 2007, four patients with dural CCF were treated with transvenous embolization via the superior ophthalmic vein (SOV) (in three patients) and the petrosal route (in one patient). These patients were all women, with an age range of 64—84 years (mean age, 73 years). Clinical and angiographic findings are summarized in Table 1. The CCFs were on the right side in three cases and on the left in the remainder. Three patients presented with ocular hypertension and were treated with intravenous acetazolamide (500 mg three times a day).

Diagnosis was made by computed tomography (CT; Fig. 1), and confirmed by angiography (Fig. 2). All lesions were type D, according to Barrow’s classification, and presented with a contralateral arterial supply to the dural CCF arising from the ICA. In all cases, we observed dilatation of the SOV without thrombosis, with the fistula in the posterior compartment of the cavernous sinus. The three patients treated via the SOV approach presented with inferior petrosal sinus (IPS) thrombosis, whereas the IPS was permeable for the patient treated via the petrosal route. No retrograde cortical venous drainage in the superficial middle cerebral vein was observed.

Endovascular procedures were performed using biplanar angiography equipment (Siemens, Erlangen, Germany). During the treatment, patients were under general anesthesia and fully heparinized: 3000 IU as a bolus and 1000 IU/h as a continuous infusion over less than 24 h to keep the activated clotting time to three or four times the normal rate. All patients were then treated with enoxaparin (6000 IU twice daily for 8 days). In all cases, 5-French catheters were placed in the right common femoral vein and left common femoral artery, allowing angiographic control and ‘roadmapping’.

Table 1 Clinical baseline characteristics of four cases of carotid cavernous fistulas.

<table>
<thead>
<tr>
<th>Age (years)/gender/side of lesion</th>
<th>Embolization</th>
<th>Orbital signs</th>
<th>Visual acuity</th>
<th>Elevated IOP (&gt; 21 mmHg)</th>
<th>Oculomotor nerve palsy</th>
</tr>
</thead>
<tbody>
<tr>
<td>84/F/R</td>
<td>Before</td>
<td>+</td>
<td>4/10</td>
<td>–</td>
<td>VI</td>
</tr>
<tr>
<td></td>
<td>After (1 M)</td>
<td>−</td>
<td>7/10</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>69/F/R</td>
<td>Before</td>
<td>+</td>
<td>5/10</td>
<td>+</td>
<td>VI</td>
</tr>
<tr>
<td></td>
<td>After (1 M)</td>
<td>−</td>
<td>5/10</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>64/F/R</td>
<td>Before</td>
<td>+</td>
<td>8/10</td>
<td>+</td>
<td>III and VI</td>
</tr>
<tr>
<td></td>
<td>After (1 M)</td>
<td>−</td>
<td>8/10</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>76/F/L</td>
<td>Before</td>
<td>+</td>
<td>4/10</td>
<td>+</td>
<td>III (partial)</td>
</tr>
<tr>
<td></td>
<td>After (1 M)</td>
<td>−</td>
<td>10/10</td>
<td>−</td>
<td>−</td>
</tr>
</tbody>
</table>

IOP: intraocular pressure; 1 M: 1 month.

Figure 1 Enhanced CT scan shows dilatation of the right superior ophthalmic vein.

Figure 2 Angiography of the right internal carotid artery (ICA) in lateral projection (A), the right external carotid artery in anteroposterior projection (APP) (B), the left ICA in APP (C) and the right primitive carotid artery in lateral projection at the late phase of injection (D). The fistula (black arrow) is being fed by the dural arteries of the carotid siphon (A, C) and the right (vidian) artery of the pterygoid canal (B).
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...using the 5-F Envoy (Cordis, Miami, FL, USA) as the guidance catheters. Hydrophilic microcatheters—namely, the Echelon 14 (ev3, Irvine, USA) and Tracker Excel 14 (Boston Scientific, Fremont, CA)—were used in two procedures each. The microguidewires used were either the Transend 0.014 (Boston Scientific) or Terumo 0.016 (Tokyo, Japan). Occlusion of the fistulas was performed with the use of Micrus coils (San Jose, CA, USA).

Results

In all four of our cases, it was possible to reach the CCF via a transfemoral approach. As the IPS was thrombosed in three cases, we preferred to pass through the internal jugular vein, angular vein and SOV. Transvenous navigation was relatively easy except in patient number 2, in whom we had difficulties reaching the facial vein despite the use of the roadmap technique. However, tortuous SOV roots were passed without difficulty. Inferior and superior roots of the SOV were visualized in all cases, with catheterization of the SOV through its superior root in two cases and through its inferior root in one case. Navigation through the IPS in patient number 4 was performed with no problems.

In all cases, immediate angiographic guidance showed complete thrombosis of the CCF and diminishing of SOV retrograde opacification (Fig. 3). Regression of chemosis and exophthalmia was immediately evident by the end of the procedure, and obvious the next day. Patients were symptom-free at the 1-month follow-up and improvement of orbital symptoms was already apparent the day after embolization (Fig. 4; Table 1). None of the patients developed symptoms or signs of recurrence during the follow-up period that ranged from 6 to 15 months. We also observed no vascular complications such as central retinal venous occlusion.

Discussion

Dural arteriovenous fistulas comprise 10—15% of all intracranial vascular malformations [4]. Dural CCFs are the second most common site of involvement following the transverse-sigmoid sinus. These are acquired lesions and thought to be the consequence of sinus thrombosis [5,6]. They can also appear after sinus infection, surgery or head trauma [7].

CCFs present anatomical and clinical peculiarities. As with our four patients, CCFs typically occur in postmenopausal women [2,8], suggesting a possible hormonal influence. Anatomically, the cavernous sinus is the only intracranial extradural venous sinus and is closely related to the laterocavernous sinus, one of the principal drainage pathways of the superficial middle cerebral vein [9,10]. Termination of the laterocavernous sinus frequently involves the posterior compartment of the cavernous sinus, although the superficial middle cerebral vein can also terminate at the anterosuperior aspect of the cavernous sinus [9], explaining why thrombosis of the cavernous sinus can lead to major cortical venous drainage. Moreover, the cavernous sinus presents numerous venous-drainage routes, including the SOV, inferior and superior petrosal sinuses, contralateral pterygoid plexus and superficial middle cerebral vein. Finally, the direction of the venous drainage can change the clinical presentation. Indeed, if drainage is via the SOV, then patients can present with orbital and neuro-ophthalmological symptoms, whereas retrograde pial venous drainage is associated with neurological symptoms or intracranial hemorrhage [11,12].

The pathophysiology of CCF remains unclear. It is difficult to determine if thrombosis of the IPS is the cause or the consequence of CCF. Some have hypothesized that IPS thrombosis can lead to increased pressure in the carotid cavernous sinus and secondary recanalization of embryonic arteriovenous communications [13]. Others have proposed that petrosal sinus thrombosis occurs after the development of dural shunts [14,15]. One of our patients presented with orbital signs of CCF 6 months after a head trauma. In her case, the dural shunt may have appeared first, and the orbital symptoms could have been the consequence of the subsequent petrosal sinus thrombosis.

Dural CCFs can be treated by transarterial [11,16—18] and/or transvenous [19—24] endovascular techniques. Transvenous embolization of CCF is known to be the most efficient way to manage fistulas [8,18,19,22,25]. The usual venous route is a posterior approach that goes through the internal jugular vein and IPS to join the pathological shunts of the cavernous sinus [19—21,23—26]. Regardless of IPS thrombosis, some authors prefer to go through the

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**Figure 3** Angiography showing transvenous embolization through the facial vein of the superior ophthalmic vein (SOV), and catheterization of the SOV with roadmapping (lateral projection in A and anteroposterior projection [APP] in B). A and B show the SOV (arrowhead), angular vein (arrow) and facial vein (double arrow). After positioning coils within the cavernous sinus, APP of the right external carotid artery (C) and lateral projection of the right ICA (D) show complete occlusion of the CCF (asterisk near the coils in C).
thrombosed sinus [25—28] whereas others prefer an anterior approach via the SOV, which used to be performed with surgical exposure [8,20,26,29—31]. Nowadays, improved techniques and materials allow catheterization of the SOV via a transfemoral transfacial venous route, without surgical exposure [19]. Other unusual transvenous approaches, including the superior petrosal sinus [32], contralateral pterygoid sinus [33] and cortical vein [34], have also been described. In cases of cortical venous drainage, where treatment is an emergency, it is important to try all of these different venous routes even when it is technically difficult and sometimes results in a very long procedure.

The transvenous transfemoral approach through the facial vein has been only poorly described [35]. Roadmap- ping allows visualization of the facial vein, angular vein and internal jugular vein, and is possible thanks to retrograde venous opacification during internal carotid angiography. However, in one of our patients, despite the absence of any anatomical variation, we had difficulties reaching the facial vein, which was barely identifiable. On the other hand, we had no problems whatsoever in navigating through tortuous SOV roots or passing the superior orbital fissure. We also observed no complications in any of our patients. Halbach et al. [36] have reported the risk of perforation of the SOV, which appears to be more likely when the CCF is recent, as the venous wall is not yet arterialized [37]. Another complication is acute thrombosis of the SOV [38,39], which can result in the redistribution of venous drainage to cortical pathways [33]. It is important to avoid complete occlusion of the cavernous sinus, as this can easily result in central retinal vein occlusion. In any case, heparin anticoagulation can prevent this serious complication. The transfemoral route through the facial vein is less traumatic than via a surgically exposed SOV. With the latter technique, Oishi et al. [26] have reported forehead dysesthesia, blepharoptosis and abducens nerve palsy. Damage to the trochlea, infections and granuloma have also been described [8,26,40].

The IPS route represents the most direct approach and appears to be relatively safe. The main complications include abducens nerve palsy, intracranial hemorrhage and cerebellar or extradural hematoma [25,26,39,41]. Whatever the transvenous route, overly tight packing of the CCF can result in transient VIth or IIIrd nerve palsy [8,20,26].

The patients’ follow-up included a monthly clinical examination for 3 months. After the clinical symptoms were completely resolved, one CT scan per month after treatment was sufficient.

In conclusion, the transfemoral transvenous approach through the SOV or IPS are effective and safe endovascular treatments for CCFs. The IPS route remains the most direct approach and should be attempted first. The facial—ophthalmic route is proposed if the IPS is thrombosed or inaccessible, if venous drainage towards the SOV is present or if the IPS does not communicate with the fistula.

Conflicts of interest

The authors declare no conflicts of interest.

References


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