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

F. Bing\textsuperscript{a,∗}, M. Albrieux\textsuperscript{b}, V. Vinh Moreau-Gaudry\textsuperscript{b}, A. Vasdev\textsuperscript{a}

\textsuperscript{a} Service de neuroradiologie, CHU de Grenoble, 38043 Grenoble cedex 09, France

\textsuperscript{b} Service d'ophtalmologie, CHU de Grenoble, 38043 Grenoble cedex 09, France

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.

© 2009 Elsevier Masson SAS. All rights reserved.

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...
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>
<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).
Cavernous sinus fistula treated through the transvenous approach

267

be the consequence of sinus thrombosis [5,6]. They can
sigmoid sinus. These are acquired lesions and thought to
most common site of involvement following the transverse-
arteriovenous fistulas comprise 10—15% of all intracra-
Discussion
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 devel-
oped 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 occlu-

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 devel-
oped 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 occlu-

Discussion
Dural arteriovenous fistulas comprise 10—15% of all intracra-
inal 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
vascular 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

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
cells in C).
Figure 4  Initial orbital and neuro-ophthalmological presentations of a right carotid cavernous fistula (patient number 1, aged 84 years) with conjunctival injection, chemosis and ptosis of the right eye (A). B shows the same patient 2 days after transvenous embolization. The transient VIth nerve palsy disappeared completely a month later.

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

Cavernous sinus fistula treated through the transvenous approach