Indirect carotid-cavernous fistula — embolisation using the superior ophthalmic vein approach

P Szkup
MD, FCR (D) SA, MMed (UCT)

Department of Medical Imaging
Royal University Hospital
University of Saskatchewan,
Saskatoon
Canada

M Kelly
MD

K Meguro
MD, FRCS (C)

Division of Neurosurgery
Royal University Hospital
University of Saskatchewan
Saskatoon
Canada

Introduction

Indirect carotid-cavernous fistulae (CCFs) or dural arteriovenous fistulae of the cavernous sinus are relatively uncommon lesions treated primarily by endovascular means.

Indirect CCFs acquire blood supply from dural branches of the internal carotid artery (ICA), external carotid artery (ECA) or dual supply from both arteries. The cause is often unknown, but they may be associated with pregnancy, trauma, sinusitis, surgical procedures, or cavernous sinus thrombosis.[1] Symptoms are related to the degree of arteriovenous shunting and the route of venous drainage. Venous drainage via the superior ophthalmic vein produces ocular symptoms; most frequently, conjunctival injection (red eye), glaucoma, diplopia, proptosis and decreased visual acuity. Indirect CCF can be treated by manual extracranial compression or transarterial and/or transvenous endovascular techniques. The venous route is usually through the inferior petrosal sinus.[1] The superior ophthalmic vein (SOV) approach is another valuable alternative endovascular route. We report on a case of indirect CCF treated successfully using the SOV approach.

Case report

A 53-year-old woman presented with a 4-month history of pulsatile headaches, tinnitus and hyperaemia of both eyes. She had a 2-month history of blurred vision and diplopia in all gaze positions. There was no history of head trauma. The patient was otherwise healthy and was a non-smoker.

Physical examination revealed conjuctival chemosis without proptosis. She had arterialisation of the conjuctival blood vessels. Prominent exophthalmos was noted. There was no anisicoria. Visual acuity was 20/40 in the right eye and 20/25 in the left eye. Fundal examination revealed retinal blot haemorrhages and bilateral optic nerve cupping. The patient had bilateral raised intraocular pressures. The remainder of the neurological and physical examination was unremarkable.

She was investigated with magnetic resonance imaging (MRI) and magnetic resonance angiography of the brain performed at an outside institution. This was reported as normal.

Cerebral angiography demonstrated a Barrow Type D indirect CCF supplied by meningeal branches of the left ICA and both ECAs via accessory and middle meningeal, superficial temporal and ascending pharyngeal branches (Fig. 1).

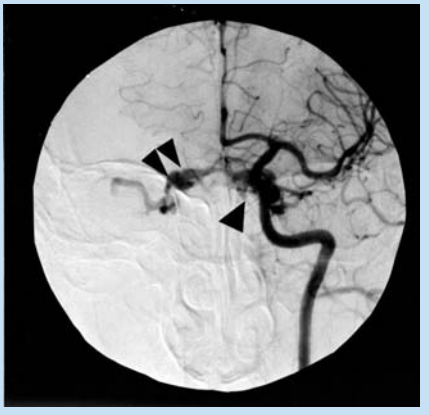

Fig .1a. Left common carotid angiogram, AP view, showing the carotid-cavernous fistula. Note opacification of the left cavernous sinus (arrow) and filling of the right cavernous sinus (double arrows).

Drainage from the cavernous sinus was via both superior ophthalmic veins. There was no cortical venous drainage or drainage to the inferior petrosal sinus from the cavernous sinus.

Attempted manual carotid artery

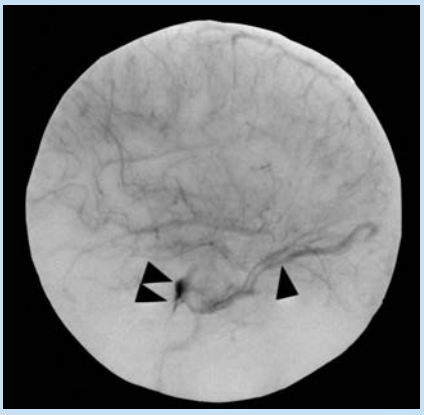

Fig. 1b. Left common carotid angiogram, delayed phase lateral view, showing prominent venous drainage from the cavernous sinus (double arrows) through both SOVs (arrow).

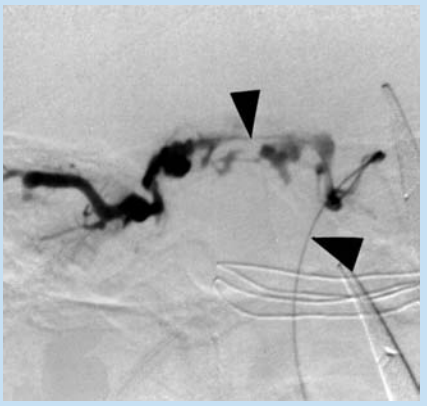

Fig. 2. AP view of cavernous sinus venogram via microcatheter (arrow) passed through the SOV.

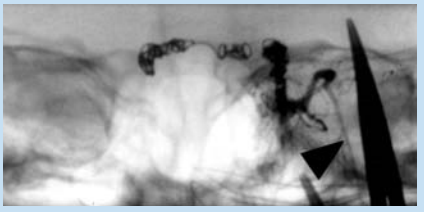

Fig. 3. AP view of cavernous sinus venograms performed via microcatheter passed through the SOV (arrow). Note coils in both cavernous sinuses.

compression treatment performed by the patient was ineffective.

Transarterial embolisation via the external and internal carotid arterial feeders was not used as it was feared that this might promote multiple new feeders if the fistula occlusion was incomplete (as is often the case), together with the risk of potential complications associated with transarterial procedures.

Transvenous embolisation via the inferior petrosal sinuses was therefore attempted. Transfemoral venous catheterisation of the origin of the left inferior petrosal sinus using a 5 French H1 (Cook) catheter was performed initially. However a FasTracker-18 microcatheter (Target-Boston Scientific) could not be advanced further into the inferior petrosal sinus. Similarly cannulation of the right inferior petrosal sinus also failed.

Therefore, a microsurgical approach under general anaesthesia was performed in the operating room, with direct exposure of the left SOV via a 2 cm skin incision in the upper left eyelid and opening of the orbital septum. The SOV was exposed and secured with a vascular loop. The SOV was punctured using a 4 French micropuncture set (Target-Boston Scientific), which was also used as a sheath for introducing a microcatheter. The sheath was temporarily fixed with a suture and attached to a side-arm adaptor allowing continuous flushing of the sheath with saline. The patient was then transferred to the vascular suite for embolisation. A FasTracker-18 microcatheter with a 0.014 microguidewire were navigated through the left SOV, left cavernous sinus and into the right cavernous sinus under fluoroscopic guidance (Fig. 2). Seven platinum Tornado microcoils (Cook, Bloomington IL, USA) were deployed in the right cavernous sinus. The catheter was then withdrawn back into the left cavernous sinus and proximal segment of the left SOV where further microcoils were deposited. A total of 27 microcoils of 4/2 mm and 3/2 mm diameter were placed in both cavernous sinuses and the origin of the left SOV (Fig. 3). Systemic heparinisation was omitted in order to promote thrombosis of the cavernous sinus and reduce the likelihood of bleeding. Control angiography of both common carotid arteries following embolisation showed occlusion of the fistula (Fig. 4). After embolisation, the cannula was removed from the SOV and the SOV was ligated with 3-0 silk thread. The

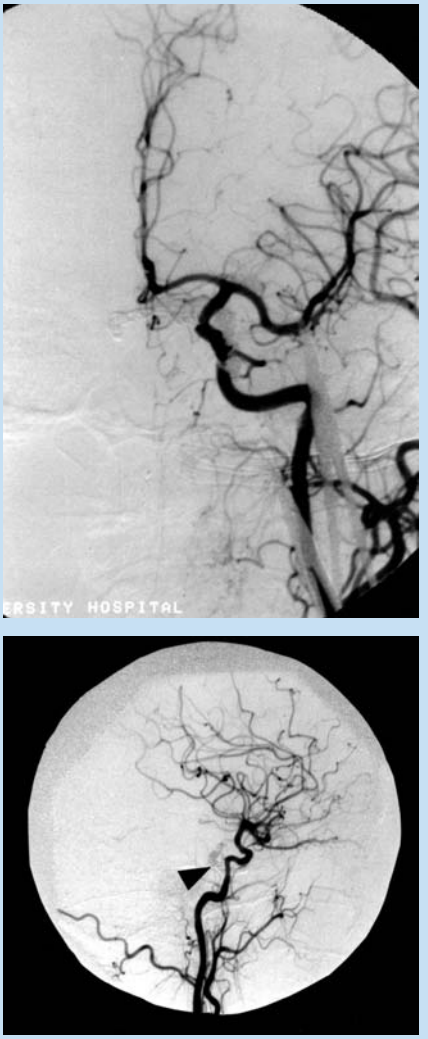

Fig. 4a. Anteroposterior and (b) lateral left common carotid angiograms after embolisation. The fistula is obliterated completely. Multiple coils can be seen in both cavernous sinuses (arrow).

skin incision was closed with subcutaneous 5-0 vicryl suture.

The postprocedural course was uneventful.

The congestion of the eye and the intracranial noise disappeared. The patient was discharged from the hospital in satisfactory condition. On follow-up, the diplopia and 6th nerve palsy were found to have resolved and the visual symptoms had improved. The glaucoma had also resolved, with normal intraocular pressures measured at 4 months' follow-up.

Discussion

Indirect CCFs are rarely life threatening. Spontaneous regression of indirect CCFs is not uncommon, with reported incidence ranging from 9.4% to 46%.[2] Because of the usually benign nature of this disease, attempted conservative treatment by means of carotid/jugular compression is recommended initially. In cases with rapidly deteriorating ocular symptoms and/or cortical venous drainage more urgent interventional therapy is necessary.

There are three methods of embolising CCFs: (*i*) transarterial; (*ii*) transvenous; and (*iii*) direct with surgical exposure of the cavernous sinus.

Transarterial embolisation of the supplying ECAs is often attempted initially using polyvinyl alcohol particles or liquid adhesives. Arterial embolisation alone is seldom successful as it is often incomplete with development of multiple additional feeders despite apparent initial success.[3] The use of small particles or liquid adhesives carries the risk of cranial nerve palsies and tissue necrosis. Small arterial feeders originating from the ICA can be endovascularly inaccessible or dangerous to catheterise. Arterial embolisation may play a role as an adjunct to venous embolisation, by decreasing the magnitude of the shunt.

Transvenous embolisation is probably the preferred option in the majority of patients with dural arterio-venous malformations (AVMs) including indirect CCF.[1,3] This allows preservation of the ICA. The specific approach depends on the venous drainage route from the cavernous sinus and the location of the distended part of the cavernous sinus. The cavernous sinus is most easily accessed through the inferior petrosal sinus (IPS) via a femoral or internal jugular vein access.[1,4] If the IPS approach is not possible or has failed, an anterior transvenous approach to the cavernous sinus through the SOV is a good alternative.

Other transvenous approaches described to date include those via the superior petrosal sinus, pterygoid plexus and through the cortical veins.[1,5,6] Teng *et al.*[7] described the transorbital approach with percutaneous puncture and catheterisation of the SOV. Direct percutaneous puncture of the cavernous sinus through the superior orbital fissure has also been reported.[8,9] Many interventional radiologists consider the latter two techniques to have an unacceptably high risk of intraorbital haematoma. Derang[10] strongly discourages direct puncture of the SOV or angular vein without surgical exposure of the vein. The risk of damaging the vein or creating an intraorbital hematoma is felt to be greatly reduced by microsurgical exposure of the vein. Transfemoral cannulation of the SOV through the facial vein may be a safe and elegant alternative approach, but can be difficult due to unfavourable venous anatomy, lack of venous distention or the presence of venous stenoses. Small and tortuous facial and angular veins often do not allow use of detachable balloons. This technique can be modified by using internal or external jugular vein approaches.[11,12] The anterior approach to the cavernous sinus through the SOV is usually performed after surgical exposure of the SOV or the angular vein. The SOV surgical route was first described in 1969 and later refined.[11] Surgical loops are applied proximal and distal to the site of the intended venous puncture. The vein can be then catheterised with a microcatheter or small sheath. The surgical exposure and catheterisation of the SOV can be difficult, and a vein that appears very large at angiography can be surprisingly elusive in the surgical field. Potential complications of the SOV approach include haemorrhage from the surgical cut-down, rupture of the SOV, damage to the trochlea or other orbital structures and infection. Although anatomically venous, the draining veins are arterialised in fistulae and so behave and bleed as arteries do. Current opinion supports use of the surgical SOV approach only when transfemoral venous access has failed.[1,3,13,14] In patients without alternatives this approach can be very effective. Surgical exposure permits direct visualisation and immobilisation of the SOV with less risk of rupture of the vein than with percutaneous puncture. The more direct approach should also need fewer catheter manipulations. A variety of microcoils, detachable microcoils and detachable balloons can be used via this approach. Orbital haemorrhage can also be addressed more directly. Perforation of one of the ophthalmic

veins with a micro-guidewire may occur during catheterisation. As long as the leak is sealed quickly with coils the haematoma should resolve within a few days. Other risks include over-distention of the cavernous sinus by coils causing cranial nerve palsies (mainly the VIth nerve). Dural dissection or penetration rarely occur. In conclusion, we find that retrograde catheterisation of the SOV following surgical exposure appears to be a safe, direct, controlled and efficient way of accessing the cavernous sinus, allowing endovascular coil occlusion of dural cavernous fistulae with excellent angiographic and clinical results. This technique is recommended for use in patients with indirect CCFs in the following circumstances: (*i*) progression of ocular symptoms with decreasing visual acuity; (*ii*) arterial supply via multiple feeders from the ECA and meningeal branches of the ICA; and (*iii*) when the inferior petrosal sinus route fails.

Acknowledgements

The authors wish to thank M Conlon (Department of Ophthalmology) for his help in management of the patient, A Dangor (Department of Anaesthesiology) for anaesthesia administered during the angiographic procedure, and S J Beningfield and I Duncan for assistance with the manuscript.

References

1. Halbach V, Higashida R, Hieshima G, Harding C, Yang P. Transvenous embolization of direct carotid cavernous fistulas. *Am J Neuroradiol* 1988; **9:** 741-747.
2. Komiyama M, Morikawa K, Fu Y, Yagura H, Yasui T, Baba M. Indirect carotid-cavernous sinus fistula: transvenous embolization from the external jugular vein using a superior ophthalmic vein approach. A case report. *Surg Neurol* 1990; **33:** 57-63.
3. Quinones D, Duckwiler G, Gobin Y, Goldberg A, Vinuela F. Embolization of dural cavernous fistulas via superior ophthalmic vein approach. *Am J Neuroradiol* 1997; **18:** 921-928.
4. Miller N, Monstein L, Debrun G, Tamargo R, Nauta H. Treatment of carotid-cavernous sinus fistulas using a superior ophthalmic vein approach. *J Neurosurg* 1995; **83:** 838-842.
5. Chun G, Tomsick T. Transvenous embolization of a direct carotid cavernous fistula through the pterygoid plexus. *Am J Neuroradiol* 2002; **23:** 1156-1159.
6. Bellon R, Liu A, Adler A, Norbash A. Percutaneous transfemoral embolization of an indirect carotid-cavernous fistula with cortical access to the cavernous sinus. *J Neurosurg* 1999; **90:** 959-963.
7. Teng M, Guo W, Huang C, Wu C, Chang T. Occlusion of arteriovenous malformation of the cavernous sinus via the superior ophthalmic vein. *Am J Neuroradiol* 1988; **9:** 539-546.
8. Teng MM, Lirng JF, Chang T, *et al.* Embolization of carotid cavernous fistula by means of direct puncture through the superior orbital fissure. *Radiology* 1995; **194:** 705-711.
9. Benndorf G, Bender A, Campi A, Menneking H, Lankish W. Treatment of a cavernous sinus dural arteriovenous fistula by deep orbital puncture of the superior ophthalmic vein. *Neuroradiology* 2001; **43:** 499-502.
10. Derang J, Ying H, Long Y, Reifa S, Qiming W, Yimu F. Treatment of carotid-cavernous fistulas retrograde via the superior ophthalmic vein. *Surg Neurol* 1999; **52:** 286-293.
11. Biondi A, Milea D, Cognar C, Ricciardi K, Bonneville F, van Effenterre R. Cavernous sinus dural fistulae treated by transvenous approach through the facial vein: Report of seven cases and review of the literature. *Am J Neuroradiol* 2003; **24:** 1240-1246.
12. Naito I, Magarisawa S, Wada H. Facial vein approach by direct puncture at the base of the mandible for dural carotid-cavenous fistula. *Interventional Neuroradiology* 2002; **8:** 67-70.
13. Monsein L, Debrun G, Miller N, Nauta H, Chazaly J. Treatment of dural carotid-cavernous fistulas via the superior ophthalmic vein. *Am J Neuroradiol* 1991; **12:** 434-439.
14. Cheng K, Chan C, Cheung Y. Transvenous embolization of dural carotid-cavernous fistulas by multiple venous routes: A series of 27 cases. *Acta Neurochir* 2003; **145:** 17-29.