Management of carotid-cavernous fistulas by surgery combined with interventional radiology

Report of two cases

BRIAN M. TRESS, M.B., B.S., F.R.A.C.R., F.R.C.R.,
KENNETH R. THOMSON, M.B., CH.B., M.R.A.C.R.,

Departments of Radiology and Ophthalmology, The Royal Melbourne Hospital, and Departments of Neurosurgery and Cardiovascular Surgery, The Royal Children's Hospital, Melbourne, Victoria, Australia

Two cases of carotid-cavernous fistulas were successfully treated by standard interventional radiology techniques after otherwise inaccessible vessels were surgically exposed. In the first case, an internal carotid artery (ICA), which had previously been ligated as part of an attempted surgical "entrapment" procedure, was recanalized to permit passage of a detachable balloon catheter to the fistula, resulting in its obliteration. In the second case, an enlarged superior ophthalmic vein was exposed and isolated to facilitate retrograde catheterization of the cavernous sinus and obliteration of a dural fistula between the ICA and the cavernous sinus by steel Gianturco coils. The methods and complications of both procedures are discussed.

KEY WORDS • carotid-cavernous fistula • balloon catheter occlusion • therapeutic embolization

MANY surgical methods of treating carotid-cavernous fistulas have been described. Some of the methods described more recently preserve the patency of the internal carotid artery (ICA). An extension of standard angiographic techniques has been used to develop an alternative method of treatment. This technique involves introducing balloon catheters by percutaneous endarterial or venous routes into the cavernous sinus. Cyanoacrylate, injected via calibrated-leak balloons into the cavernous sinus, has resulted in successful obliteration of some carotid-cavernous fistulas. Release of one or more balloons from a detachable balloon catheter within the sinus has resulted in obliteration of the fistulas with preservation of the ICA in the majority of cases.

Two new methods of approach, both of which combine surgical exposure of vessels to permit passage of a detachable balloon catheter and standard radiological obliterative techniques, are described.

Case Reports

Case 1

This 15-year-old girl had undergone ligation procedures of the right supraclinoid portion of the ICA and the right internal, external, and common carotid arteries in the neck after muscle embolization for a posttraumatic carotid-cavernous fistula. After ligation, she sustained an optic nerve injury, leading to blindness in the right eye, and developed diabetes insipidus in the early postinjury period.

Admission. The patient presented 2 years after the ligation procedures for evaluation of a recurrent right-sided bruit, pulsatile proptosis, and chemosis. A right subclavian angiogram revealed that the ICA had been reconstituted approximately 1 cm proximal to its entrance into the carotid canal by profuse collateral vessels arising from muscular branches of vertebral, occipital, and ascending pharyngeal arteries, probably via the ICA vasa vasorum (Fig. 1). The reconstituted ICA emptied directly into an aneurysmal right cavernous sinus, which drained via the superior ophthalmic and cerebral cortical veins.

Operation. The ICA was occluded at its origin in the neck. The dissection was extended 3 cm distal to the origin of the ICA and a dilating probe was inserted into it. Recanalization of the ICA was thus established,
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allowing access for the detachable balloon catheter. Two balloons were introduced into the cavernous sinus and a third into the cavernous carotid artery, obliterating both the sinus and ICA. More proximal occlusion of the ICA was assured by releasing two stainless steel coils into the segment of the artery within the carotid canal. An intraoperative angiogram revealed no opacification of the ICA distal to the carotid canal, or of the cavernous sinus (Fig. 2).

Postoperative Course Following the procedure, the patient developed a complete right third nerve palsy and partial palsies involving the right ninth, 10th, and 12th cranial nerves. For 2 weeks she had severe pain in the right eye. The bruit disappeared, and over the next few months the palsies involving the third, ninth, 10th, and 12th nerves resolved completely.

Case 2

This 48-year-old man with moderate hemophilia (Factor VIII assay 4%) had for 8 years been monitored for a carotid-cavernous fistula caused by trauma to the forehead 1 year before his original presentation. There was left-sided proptosis of 10 mm, a bruit audible to patient and surgeon, a large visible pulsatile superior ophthalmic vein in the upper eyelid, enlarged arterialized conjunctival veins, and raised intraocular pressure. The latter was caused by reduced aqueous outflow from the left eye. Despite treatment with eye drops of pilo-

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carpine, epinephrine, and timolol, and oral acetazolamide, pressure control was incomplete. After 5 years the beginning of glaucomatous changes in the optic disc was seen, and there was established glaucomatous cupping by 9 years after onset of the fistula. To prevent worsening of the glaucoma and ultimate visual deterioration, it was decided to attempt detachable balloon obliteration of the fistula.

Admission. Angiography revealed that the fistula was of the meningeal arteriovenous type. An enlarged meningo-hypophyseal trunk emptied directly into the left cavernous sinus, which drained via a markedly hypertrophied and moderately elongated superior ophthalmic vein into the anterior facial vein (Fig. 3). An external carotid artery angiogram revealed several enlarged tortuous branches of the internal maxillary artery—emptying into the cavernous sinus and superior ophthalmic vein (Fig. 4, left). These were embolized with particulate Ivalon, and a stainless steel coil was released into the distal external carotid artery (Fig. 4, right). Attempts to manipulate a detachable balloon catheter into the meningo-hypophyseal trunk failed, due to its relatively small size. It was decided that, rather than obliterating the fistula by the release of a large balloon into the cavernous carotid artery and thereby also obliterating the ICA, an attempt should be made to obliterate the sinus via the superior ophthalmic vein.

Operation. With the patient under general anesthe-
sia, the hypertrophied superior ophthalmic vein deep to the left eyelid was exposed and a No. 8 French sheath was manipulated over a Sachs small J guide wire almost to the cavernous sinus. A detachable balloon catheter was introduced into the cavernous sinus, but the uninflated balloon detached prematurely. A No. 5 French untapered polyethylene catheter was then manipulated through the sheath into the cavernous sinus, and three stainless steel coils were released into the cavernous sinus, obliterating it. Immediately prior to the release of the stainless steel coils, a test injection via the sheath to determine its exact relationship to the cavernous sinus resulted in rupture of the distal superior ophthalmic vein and extravasation of contrast medium into the retrobulbar space (Fig. 5).

The eye became more proptosed and hard, and the pupil was fixed and dilated. Decompression of the eye was immediately performed by anterior chamber paracentesis with a No. 25 needle, and the orbit was decompressed by opening the infracoibial septum. The pupillary reaction recovered. An ICA angiogram at the end of the procedure showed complete obliteration of the cavernous sinus and ophthalmic veins (Fig. 6). The meningo-hypophyseal trunk and its proximal branches were still opacified. Factor VIII, 2000 units, was administered intravenously during and after the procedure.

Postoperative Course. The bruit had disappeared postoperatively, but there was complete sixth nerve
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**Fig. 4. Case 2.** Left: Left external carotid arteriogram showing several enlarged branches of the internal maxillary artery (arrows) emptying directly into the cavernous sinus and superior ophthalmic vein (arrowheads). Right: The distal external carotid artery has been embolized with particulate Ivalon. A coil (arrow) obliterates the proximal external carotid artery.

Discussion

The current technique of choice for the treatment of traumatic carotid-cavernous fistulas is detachable balloon embolization, because of its potential to occlude the fistula and preserve patency of the ICA without the need for a craniotomy. Our first case represents one of the potential complications of the traditional entrapment surgical approach. After supraclinoid ICA ligation, the introduction of any particulate emboli, be it muscle, Gelfoam, or Ivalon sponge, is relatively uncontrolled, in that it relies on the vagaries of carotid flow and anatomy. In Case 1 the injected muscle fragments had passed through the fistula into the cavernous sinus. Unless the fistula is occluded at the time of the initial procedure, it appears that it can remain patent, using the most microscopic of collateral vessels. Open dissec-

**Fig. 5. Case 2.** Test injection via the No. 8 French sheath in the superior ophthalmic vein (arrow) causing rupture of the vein, with extensive extravasation of contrast medium into the retrobulbar space.
tion and recanalization of the ICA was the only possible method of gaining access in Case 1 to allow detachable balloon obliteration of the fistula. Craniotomy was thus avoided.

Case 2 represents a dural arteriovenous shunt between meningeal branches of the internal and external carotid arteries and the cavernous sinus. Newton and Hoyt suggested that most so-called “spontaneous” carotid-cavernous sinus fistulas are dural shunts. The indication for treating this patient after 9 years was the progressively increasing intraocular pressure, which threatened to ultimately cause blindness. Although it was not possible to occlude the enlarged meningohypophyseal trunk by a detachable balloon, the fistula could easily have been obliterated by detaching a large balloon within the cavernous carotid artery, at the cost of loss of patency of the ICA. As the patient was only aged 48 years and his venous anatomy appeared suitable, an attempt to obliterate the cavernous sinus via the superior ophthalmic vein was indicated. The inferior petrosal vein has previously been successfully used as a means of access to the cavernous sinus via femoral vein catheterization. Reported attempts at retrograde catheterization of the superior ophthalmic vein through the facial and angular vein have failed because of the sharp angles of the vein at the level of the trochlea of the superior oblique muscle. The only reported case we know of in which the superior ophthalmic vein had been successfully cannulated in the treatment of a carotid cavernous fistula is that of Peterson, et al., who ablated by electrothrombosis the cavernous sinus of a 21-year-old patient with a traumatic carotid-cavernous fistula by means of a copper wire introduced into the cavernous sinus under x-ray control via the supraorbital vein and a Teflon cannula. Although the ICA spontaneously thrombosed 3 days later in that case, the technique has been carried out successfully in two further cases with preservation of ICA patency (WE Peterson, personal communication, 1983).

Although the meningohypophyseal trunk itself was not obliterated in Case 2, the aims of reducing the intraocular pressure and eliminating the bruit were achieved. It is possible that a fistula between meningeal branches and basilar pterygoid plexus may ultimately develop, but this may be asymptomatic. A detachable balloon occlusion within the cavernous carotid can still be used should that prove necessary.

The ninth, 10th, and 12th nerve palsies in Case 1 are thought to have resulted from traction exerted upon them during the difficult surgical exposure of the distal ICA in the neck. These palsies have recovered completely. The third nerve palsy was most likely due to direct compression by the inflated balloons. This complication was noted as a transient phenomenon in 20% of Debrun’s cases. In Case 2, the complication of rupture of the ophthalmic vein into the retrobulbar region may have been avoided, had it been realized that the large sheath completely filled the superior ophthalmic vein. In addition, it may not be necessary to introduce the sheath as close to the sinus as it was, nor to inject more than 1 to 2 cc of contrast medium to establish its position.

These two cases illustrate that, by careful surgical exposure in appropriate cases, the practical application
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of detachable balloon catheters and Gianturco coils in the treatment of carotid cavernous fistulas can be extended further. The complication that occurred in Case 2 further emphasized the need for the closest possible collaboration between radiologist and surgeon, a principle common to all aspects of interventional radiology.

References

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Address reprint requests to: Brian M. Tress, F.R.A.C.R., F.R.C.R., University of Melbourne, Department of Radiology, The Royal Melbourne Hospital, Victoria, Australia 3050.