Direct intracavernous obliteration of high-flow carotid-cavernous fistulas

FABIAN ISAMAT, M.D., ENRIQUE FERRER, M.D., AND JORGE TWOSE, M.D.

Service of Neurosurgery, Hospital de Bellvitge Princeps d'Espanya, University of Barcelona, Barcelona, Spain

Four cases of high-flow carotid-cavernous sinus fistula (CCF), three of them posttraumatic and one spontaneous, have been treated by a direct surgical approach to the cavernous sinus. The CCF's were obliterated by the introduction into the cavernous sinus of muscle fragments and/or fibrin sealant. In the three cases with a preoperatively patent internal carotid artery (ICA), the CCF was occluded and the ICA flow preserved. One of these also had a posttraumatic false aneurysm that enclosed the two avulsed ends of a transected intracavernous ICA. This was treated by cervical ICA ligation following resolution of the CCF. A fourth patient, who had previously undergone an unsuccessful ICA trapping procedure elsewhere, also obtained a good result. The case histories and the surgical technique are presented. Direct intracavernous obliteration with muscle fragments and fibrin sealant fulfills the criteria for treatment of high-flow CCF's: occlusion of the arteriovenous fistula and preservation of the ICA circulation. While this surgical technique is a therapeutic option in some cases, it appears to have precise indications in others.

KEY WORDS: carotid-cavernous fistula, carotid artery, cavernous sinus, surgical technique

Carotid-cavernous fistulas (CCF's) have traditionally been classified as either traumatic or spontaneous. Nonetheless, the most important implications of a CCF are those related to the anatomical and hemodynamic characteristics of the fistula. Parkinson and particularly Barrow, et al., have proposed a classification based on these aspects. Those CCF's belonging to Parkinson's Type I or to Barrow's Type A are direct communications between the internal carotid artery (ICA) and the venous plexus of the cavernous sinus. They are high-pressure high-flow shunts due to a tear in the wall of the intracavernous part of the ICA and are usually of traumatic origin. The clinical manifestations are generally abrupt and severe. They may include exophthalmos, chemosis, extracocular palsies, headaches, trigeminal dysesthesias, visual loss, and a disturbing bruit synchronous with the pulse. Massive epistaxis, although uncommon, can be fatal.

Spontaneous resolution of these high-flow CCF's is very rare, and thus they require treatment which should ideally occlude the fistula while maintaining the patency of the ICA to avoid cerebral ischemia. At the present time, intra-arterial detachable balloon catheter techniques are used in an effort to preserve the ICA circulation. Nonetheless, failure to enter the cavernous sinus or to maintain the ICA open is not uncommon. We are presenting our experience with high-flow CCF's treated by direct surgical obliteration of the cavernous sinus with biological materials such as muscle and fibrin sealant.*

Case Reports

Case 1

This 32-year-old man was involved in a traffic accident on May 20, 1982. He was admitted to the hospital with severe head and thoracic injuries (Glasgow Coma Scale (GCS) score of 4).

Examination. X-ray films of the skull showed extensive left frontobasal and orbital fractures. He was treated conservatively and his neurological condition slowly improved. He was transferred to the neurosurgical ward 1 month after the accident. At that time he was completely disoriented and had a left peripheral facial paralysis and a partial left ophthalmoplegia. Two months after admission, he developed left exophthal-
Direct obliteration of carotid-cavernous fistulas

FIG. 1. Case 1. Internal carotid arteriograms, anteroposterior view. Left: The left high-flow carotid-cavernous fistula (CCF) is seen filling from the left internal carotid artery (ICA). In this study, both ICA's were injected simultaneously. The venous outlet of the cavernous sinus was through both ophthalmic veins. Right: Postoperative ICA arteriogram after direct and open obliteration of the cavernous sinus. The ICA flow has been preserved and the CCF is occluded.

mos with chemosis, the ophthalmoplegia became complete, and a bruit was noted at the left fronto-orbital region. Four-vessel angiography demonstrated a left high-flow CCF, which filled only through the left ICA (Fig. 1 left).

Operation. The following week, the left cavernous sinus was opened and plugged with small pieces of muscle. There was immediate disappearance of the bruit and a progressive reduction of the exophthalmos and the ophthalmoplegia until they were completely normal. Postoperative angiography showed the disappearance of the CCF with preservation of the ICA flow (Fig. 1 right). The patient has remained asymptomatic.

Case 2

This 62-year-old man was admitted to the hospital on December 30, 1983, a few hours after a severe head injury.

Examination. He was unconscious, responding only to painful stimuli, and showing paresis of the right arm (GCS score of 7). X-ray films of the skull documented an extensive frontobasal fracture with left orbital displacement. Computerized tomography (CT) showed bilateral frontotemporal hemorrhagic contusions, intracranial air, and proptosis of the left eye which could not be evaluated clinically due to marked periorbital edema. With conservative treatment, the patient rapidly improved to a normal neurological condition except for a complete left ophthalmoplegia, with exophthalmos and chemosis, and total blindness of the left eye. He complained of a constant left orbital bruit synchronous with the pulse.

Four-vessel selective angiography showed a high-flow left CCF which filled from the left ICA. A large false aneurysm was associated with the CCF (Fig. 2 left). Drainage was through the enlarged ophthalmic veins and via a large net of cortical and meningeal veins to the sagittal and transverse sinuses. While treatment was being planned, the patient suddenly had a massive epistaxis, which was controlled by emergency nasal tamponade with a double-balloon cannula. The following day, occlusion of the fistula with an intra-arterial balloon catheter was attempted unsuccessfully, creating a transient dysphasia and right hemiparesis.

Operation. This procedure was followed 48 hours later by a direct approach to the cavernous sinus via a left pterional craniotomy. The left ICA was temporarily occluded at the neck and intracranially while the cavernous sinus was opened, plugged with several fragments of muscle, and injected with fibrin sealant.

Postoperative Course. The patient was free of bruit, and the chemosis, exophthalmos, and ophthalmoplegia improved rapidly. By the 3rd day, a very faint bruit could again be heard occasionally by the examiner, although not by the patient. A control carotid angiogram showed complete disappearance of the CCF and the restoration of the intracranial ICA blood flow. The large false aneurysm was still present, engulfing the two
F. Isamat, E. Ferrer and J. Twose

ends of the completely transected intracavernous ICA (Fig. 2 right). The cervical ICA had an almost complete stenotic occlusion at its origin and was therefore ligated at the neck. The faint bruit disappeared. A control digital angiogram could not demonstrate filling of the false aneurysm and showed a normal intracranial circulation by cross-flow. The patient has maintained a complete regression of the cavernous sinus syndrome.

Case 3

This 33-year-old woman was admitted to the Neurosurgical Service on February 2, 1984. She had a 4-month history of a mild bruit synchronous with the pulse on the left ear and had had left frontal dysesthesias for 3 months. In December, 1983, after a transient but acute left frontal headache, she developed progressive left exophthalmos and an intense left orbital bruit. Forty-eight hours before admission, the patient exhibited diplopia, left ophthalmoplegia, an increase in the exophthalmos, and chemosis. There was no previous history of head trauma or of other relevant conditions.

Examination. Plain x-ray films of the skull were normal, and CT showed a large dilatation of the left cavernous sinus and ophthalmic veins, with proptosis of the left eye. Selective angiography of both internal and external carotid arteries and of the vertebral artery demonstrated a left high-flow CCF. The fistula filled through the left ICA, with drainage through the ophthalmic veins and a net of corticotemporal veins. There was no evidence of dural arteriovenous malformation or of other vascular anomalies.

Operation. The left cavernous sinus was exposed through a pterional craniotomy. With the ICA temporarily occluded intracranially and at the neck, the cavernous sinus was opened, filled with muscle fragments, and injected with fibrin sealant. Postoperatively, the bruit disappeared and the patient had a complete regression of the exophthalmos, chemosis, and ophthalmoplegia, with full recovery of eye movements. A control digital arterial angiogram showed complete disappearance of the CCF with preservation of the ICA flow. The patient has remained symptom-free.

Case 4

This 55-year-old woman sustained a very severe head injury in a traffic accident in 1957. She had a fronto-basal fracture, immediate right eye blindness, and an acute left pulsating exophthalmos with complete ophthalmoplegia but with preservation of vision. It was reported that a CCF was demonstrated angiographically and treated at that time by left cervical ICA ligation. Due to the progression of the exophthalmos and the persistence of a constant bruit she underwent surgery again in 1964 at another hospital, this time with intracranial ICA clipping, again without success. Two months prior to her referral, she had a massive epistaxis which was controlled by emergency nasal tamponade. She was referred to our service on July 2, 1984.
Direct obliteration of carotid-cavernous fistulas

Examination. The patient had a disfiguring left exophthalmos with huge enlargement of the angular and frontal veins, chemosis, and complete ophthalmoplegia with preservation of visual acuity in this side. The right eye was blind and internally fixed by retraction. An intense bruit could be heard even from a distance. A CT scan showed an enormous left cavernous sinus with marked enlargement of the ipsilateral ophthalmic and periorbital extracranial veins. Selective arterial digital angiography demonstrated a high-flow left CCF which filled through the vertebral circulation via the left posterior communicating artery. The clip at the left ICA was distal to the posterior communicating artery. The left ICA was occluded at the neck.

Operation. On July 5, 1984, the left cavernous sinus was approached via a pterional craniotomy. The ICA was exposed and a dilated posterior communicating artery was identified and temporally clipped. The lateral wall of the bulging cavernous sinus was punctured and a total of 12 ml fibrin sealant was injected intracavernously. The bruit disappeared immediately. Gradually the exophthalmos, chemosis, dilatation of the facial veins, and ophthalmoplegia subsided, while vision of the left eye was preserved. Control digital arteriography demonstrated complete disappearance of the CCF. Since then, the patient has been symptom-free with complete recovery of all left eye movements and a remarkably good cosmetic result.

Surgical Technique

All the patients were operated on under general anesthesia without hypotension or hypothermia. In addition to routine intraoperative monitoring, a Doppler ultrasound transducer is fixed extracranially to record the bruit. The ICA is first isolated in the neck and surrounded by an elastic band to allow later temporary occlusion. This is followed by a standard pterional craniotomy. The cavernous sinus is exposed by opening the sylvian fissure and gently elevating the temporal and frontal lobes. The supraclinoid ICA and the free margin of the tentorium are exposed and dissected until identification of the entrance of the third and fourth cranial nerves into the cavernous sinus, as described by Parkinson.18-20 Due to the distension of the cavernous sinus by the fistulous rent, Parkinson's triangular area (formed by the third and fourth cranial nerves running together within the dural roof of the cavernous sinus toward the superior orbital fissure and the ophthalmic division of the fifth cranial nerve in the inferior lateral dural wall) is widely spread, particularly at its posterior base. It is then safe to open the cavernous sinus without injuring these nerves if the incision is carried parallel to and beneath the point of entry of the third nerve, as has been shown by Parkinson18-20 and others.14,24

At this stage, a temporary clip is placed at the supraclinoid ICA proximal to the posterior communicating artery and the cervical ICA is occluded with the elastic band. A 10-mm incision is then made in the lateral wall of the cavernous sinus, and small, elongated, crushed muscle fragments from the temporal muscle are introduced into the sinus until there is resistance to further introduction and no Doppler signals are received following the removal of the transient ICA occlusions. Prior to the withdrawal of the temporary trapping, fibrin sealant is injected intracavernously and over the dural incision for a closure without the necessity for sutures.

Discussion

Parkinson18-20 has shown that it is possible to open the lateral wall of the cavernous sinus and not disturb the intracavernous arterial and venous components. He described the cavernous sinus as a plexus of veins that incompletely surrounds the ICA, with bare spaces between the artery and the veins. He concluded that a CCF is a direct pathological connection between the artery and one of the veins of a truly Hunterian type, as in arteriovenous shunts in the rest of the body. Therefore, he was able to treat CCF's by opening the cavernous sinus and occluding the fistulous tract without interfering either with the artery or the veins. In this type of high-flow arteriovenous CCF, the arterialized venous blood will leave the cavernous sinus through the distended anatomical exits, particularly via the ophthalmic veins. This causes the well-known radiological and clinical pictures of this disorder.

An intracavernous posttraumatic false aneurysm, on the other hand, is a CCF in which the torn ICA flows directly into one of the bare perivascular spaces within the sinus. Radiologically, this appears as a direct ICA rent flowing into a distended cavernous sinus with little or no venous drainage. This can occur either alone or in combination with an arteriovenous shunt. Case 2 is such an example, in which a completely transected intracavernous ICA feeding a large false aneurysm could be demonstrated following the resolution of the intracavernous arteriovenous fistula. Sbeih and O’Laoire24 have reported the only previously published case of a CCF associated with a totally severed intracavernous ICA, and they believed that one case of Dandy and Folli5 and one of Parkinson18 suggested the same condition.

Fatal complications are uncommon in untreated CCF's. Hemorrhage, either intracranial or into the sphenoid sinus, is rare but life-threatening. Two of our patients, Cases 2 and 4, had massive epistaxis that required emergency tamponade of the nasopharynx and posterior choanal region. The triad of extensive frontobasal fracture, posttraumatic blindness, and severe epistaxis has been considered pathognomonic for the presence of an intracavernous false aneurysm.11 This was so in our Case 2.

Treatment of high-flow CCF's should be contemplated in the majority of cases since spontaneous resolution is extremely rare. Indications requiring treatment include intracranial hemorrhage, massive epistaxis, vis-
ual deterioration (either secondary to the reduction of ocular arterial perfusion or to intraocular venous hypertension and glaucoma), and the neurological deficits due to a steal syndrome of arterial blood from the brain. Less urgent indications depend on the severity of the symptoms; they include the annoyance of the bruit, the restoration of the orbital contents, the need for reestablishment of oculomotor functions, the intensity of the headaches, and the desire to achieve a good cosmetic result.

If treatment of a high-flow CCF is indicated, the aim should be to obliterate the fistulous rent while preserving the ICA flow, so as to avoid cerebral ischemia. A selective and complete angiographic study of the internal and external carotid arteries and the vertebral arteries should be performed to establish the most appropriate treatment, since the definition of a high-flow high-pressure CCF is an angiographic assessment.

Carotid ablative procedures should not be attempted as a first procedure in the treatment of a CCF. Although good results have been reported with intra- and extracranial ICA trapping combined with muscle embolization and with intraluminal ICA occlusion by a balloon catheter, these techniques sacrifice the ICA and may create early or late cerebral ischemia. Other surgical techniques have attempted to preserve the ICA. Endarterial navigation of free muscle embolus or the introduction of a catheter with the injection of fast-solidifying plastic materials have been used successfully, but may cause distal embolic complications. Direct surgical approach to the cavernous sinus, such as intrasinus clipping of the fistula as advocated by Parkinson, thrombosis induced by electrical current as proposed by Hosobuchi, or introduction of thrombogenic wires as reported by Mullan, have had favorable results while preserving the patency of the ICA. Nonetheless, all these techniques are complex and difficult to reproduce in a usual neurosurgical setting.

The introduction by Serbinenko of detachable balloon catheters has changed the treatment of high-flow CCF’s. Debrun et al., have obtained total obstruction of CCF’s treated with detachable balloons in over 90% of their cases; however, they could not preserve the ICA flow in 41% of these patients. Other published series report similar or even greater morbidity. The appearance of intracavernous pseudoaneurysms following later balloon deflation has been observed not infrequently. Although at present the treatment of choice for a high-flow CCF seems to be the endovascular detachable balloon technique, this procedure is not free of serious risks.

Direct muscle plugging of the cavernous sinus with sparing of the ICA flow has been successfully used by Lapras et al., in two patients (unpublished data, 1983). However, without adequate hemodynamic control, the surgical opening of the lateral wall of the cavernous sinus may result in a jet of arterialized blood that makes the introduction of muscle material quite awkward. In our cases with a patent ICA, temporary occlusion of the ICA intracranially and in the neck appropriately solved this problem.

Fibrin sealant consists primarily of fibrinogen and Factor XIII with a fibrinolysis inhibitor that, when in contact with a solution containing thrombin and calcium chloride, causes fibrinogen to transform into fibrin in a manner similar to the physiological coagulation process. Rapid solidification takes place a few seconds after mixing equal volumes of the two components. The intraluminal injection of fibrin sealant has been effective for occlusion, by thrombosis and later sclerosis, of experimentally created aneurysms (JR Moringlane, et al., unpublished data, 1985). The intrasinus application of this biological glue adds fast thrombogenic induction as well as support to the fragments of muscle introduced into the cavernous sinus.

In Case 4, the ICA had already been sacrificed in the cervical portion as well as intracranially. Accordingly there was no possibility of endarterial navigation. This case was treated exclusively by direct intracavernous injection of fibrin sealant after placement of an intracranial clip. This procedure was followed by a dramatic resolution of the cavernous sinus syndrome, while preserving vision in the only functioning eye.

Direct obliteration of the cavernous sinus using muscle and fibrin sealant has been effective and has fulfilled the criteria of occluding the fistulous rent with preservation of the ICA flow. The follow-up period of our patients ranged from 18 months to over 3 years, without recurrence. This surgical approach should be considered for treatment of high-flow CCF’s. Unsuccessful and repeated attempts to introduce a detachable balloon catheter into a CCF may traumatize the ICA wall, producing stenosis or occlusion of the artery. Prior to inducing this morbidity an alternative treatment such as the one presented here should be considered. Those patients with CCF’s already treated ineffectively by ICA occlusion or ligation are good subjects for direct intracavernous obliteration with muscle and fibrin sealant or with fibrin sealant alone if the supraclinoid carotid artery has already been clipped.

References

Direct obliteration of carotid-cavernous fistulas


