Venous rupture during transvenous approach to a carotid-cavernous fistula

Case report

**WESLEY A. KING, M.D., GRANT B. HIESHIMA, M.D., AND NEIL A. MARTIN, M.D.**

Divisions of Neurosurgery and Neuroradiology, School of Medicine, University of California, Los Angeles, California

An attempt at transfemoral transarterial balloon occlusion of a high-flow spontaneous carotid-cavernous fistula was unsuccessful because the carotid artery rent was too small for this approach. During a subsequent transvenous approach to the cavernous sinus through the jugular vein, the inferior petrosal sinus was perforated. A minor subarachnoid hemorrhage occurred before the tear could be sealed by the deposition of three Gian-turco coils in the vein. The patient was taken to the operating room for emergency obliteration of the fistula and petrosal sinus in order to remove the risk of further hemorrhage. Under the guidance of intraoperative digital subtraction angiography, isobutyl-2-cyanoacrylate was injected directly into the surgically exposed cavernous sinus. Successful obliteration of the fistula was achieved with preservation of the carotid artery, and the angiography catheter was removed safely from the petrosal sinus. Although initially after surgery the patient had nearly complete ophthalmoplegia, at her 1-year follow-up examination she had normal ocular motility and visual acuity. The transvenous approach to the cavernous sinus and alternative methods of treatment of carotid-cavernous fistulas are discussed.

**KEY WORDS** • carotid-cavernous fistula • cavernous sinus • transvenous approach • isobutyl-2-cyanoacrylate • interventional neuroradiology

A variety of therapeutic strategies have been employed in the treatment of carotid-cavernous fistulas. \(^1\,3\,4\,6\,7\,10\,13\,15\,17\,19\,22\) Trapping of the carotid artery above and below the fistula or intentional balloon-catheter occlusion of the carotid artery at the fistula has been carried out. These procedures are not entirely satisfactory because of the attendant risk of cerebral or retinal ischemia and because collateral channels from the ophthalmic or cavernous carotid artery may continue to fill the fistula.

The goal of contemporary treatment of these lesions is occlusion of the arteriovenous communication with preservation of the internal carotid artery. A number of techniques have been used to accomplish this goal. These include: 1) surgical opening of the cavernous sinus (with or without temporary carotid artery occlusion) and direct repair of the carotid artery defect, or packing the sinus; \(^1\,13\,15\,26\) 2) surgical exposure of the cavernous sinus wall with introduction of thrombogenic material (wires, isobutyl-2-cyanoacrylate (IBCA)) through a needle placed into the sinus without incision of the sinus wall; \(^12\,15\,17\) and 3) introduction of polymer or detachable balloons into the sinus, usually via the arterial route but occasionally via the venous route, using interventional neuroradiological techniques. \(^1\,6\,7\,22\)

The intravascular approach, when feasible, is the treatment of choice. However, complications may occur in the course of this treatment. \(^2\,7\) These complications include distal embolization of the detachable balloon or of thrombi generated by the catheter, intracavernous pseudoaneurysm formation following balloon deflation, and cranial nerve palsies.

This report describes an attempt at transvenous balloon occlusion of a carotid-cavernous fistula with perforation of a draining venous channel. Surgical exposure of the cavernous sinus and introduction of IBCA into the sinus under digital subtraction angiography was successful in occluding the fistula, thus removing the risk of subsequent hemorrhage from the disrupted vein. The clinical course and surgical technique are presented.

**Case Report**

This 71-year-old right-handed woman underwent right nephrectomy for nonmetastatic renal-cell carci-
noma. Upon awakening from anesthesia she noted a left-sided cranial bruit. Over the subsequent week of recuperation she developed progressive left-sided headache, proptosis, and diplopia with persistent nausea and vomiting.

**Examination.** A loud bruit was noted over the left orbital and left temporal regions. The eye was proptotic with chemosis and conjunctival injection. No neck stiffness was appreciated. Neurological examination showed the patient to be alert and completely oriented. She had anisocoria, with the left pupil larger than the right, although both pupils were briskly reactive. Left-sided ptosis with limited adduction, elevation, depression, and abduction were consistent with partial third and sixth cranial nerve palsies. The remainder of the neurological examination was normal.

Cerebral angiography demonstrated a high-flow internal carotid-cavernous fistula (Barrow Type A) (Fig. 1).2 The fistula drained into the superior ophthalmic vein, the superior petrosal sinus, and multiple superficial sylvian veins. Also visualized was an unruptured posterior communicating artery aneurysm and an aneurysm of the anterior communicating artery. It was believed that the etiology of the spontaneous fistula was rupture of a cavernous carotid artery aneurysm.

**Operations.** The patient was transferred to the University of California, Los Angeles, Medical Center for balloon occlusion of the carotid-cavernous fistula. A transfemoral transarterial approach was not successful because the cavernous sinus could not be entered through the small rent in the carotid artery. The following day a transvenous approach was attempted. An angiography sheath was inserted percutaneously into the left jugular vein and a catheter was positioned in the left jugular vein catheter and advanced superiorly into the inferior petrosal sinus. The balloon catheter, however, could not be placed over the sinus as a marker, and contrast material was injected into the left carotid artery to establish the position of the cavernous sinus (Fig. 2 left). Intraoperative digital subtraction angiography† was performed using the system described by Foley, et al.3 An attempt was made to place a detachable balloon into the cavernous sinus through its lateral dural wall. An angiography sheath was inserted into the anterior portion of the sinus. The balloon catheter, however, could not be advanced into the main chamber of the fistula, presumably because of septations within the sinus.

After the sheath was removed and hemostasis established with Surgicel, a No. 18 spinal needle was inserted into the anteroinferior portion of the sinus. In order to confirm its position and to be sure that reflux into the carotid artery would not occur, contrast material was injected through the needle into the sinus (Fig. 2 center). A small amount of IBCA (0.2 cc) was then injected into the anteroinferior compartment after the needle was flushed with dextrose solution. The use of real-time subtraction fluoroscopy enabled visualization of the IBCA during injection as a further safeguard against reflux into the arterial system. Repeat carotid angiography demonstrated occlusion of the anteroinferior compartment and absence of filling of the ophthalmic

---

* Gianturco coils manufactured by Cook, Inc., Bloomington, Indiana.

† DXR-Angioplan supplied by OEC-Diasonics, Salt Lake City, Utah.
Transvenous repair of carotid-cavernous fistula

FIG. 2. Intraoperative angiograms showing the position of the spinal needles (arrows). Left: Digital subtraction angiogram with injection into the internal carotid artery. The spinal needle has been positioned over the anteroinferior compartment of the cavernous sinus. Center: Injection through the needle into the anteroinferior compartment of the cavernous sinus. Filling of the superior ophthalmic and sylvian veins is apparent. Note that there is no reflux into the arterial system. Right: Injection into the internal carotid artery. After injection of IBCA into the anteroinferior and posterosuperior compartments, there is no apparent flow through the fistula. The needle can be seen in the posterosuperior compartment.

vein. This procedure was repeated in the posterosuperior compartment. The final intraoperative carotid angiogram demonstrated nearly complete obliteration of the fistula. There was no drainage into the sylvian veins or the ophthalmic vein, and, most importantly, no drainage into the inferior petrosal sinus (Fig. 2 right). Patency of the internal carotid artery was preserved. When the needle was withdrawn from the cavernous sinus, there was no bleeding. The jugular catheter was removed and there was no clinical damage.

Postoperative Course. Upon awakening from anesthesia, the patient was found to have complete left ophthalmoplegia and ptosis, and the left pupil was nonreactive. There was no other neurological deficit. No bruit could be detected by the patient or by the examiner. She remained neurologically stable until discharge from the hospital. At her 1-year follow-up examination her cranial nerve function had recovered and there was no bruit. Her visual acuity was normal, there was no diplopia or ptosis, and the eye was normal in appearance.

Discussion

Interventional neuroradiological techniques have provided a significant advance in the treatment of carotid-cavernous fistulas. Occlusion of the fistula can be accomplished by endovascular navigation of detachable balloons into the cavernous sinus through the defect in the carotid artery. The balloons, when inflated and detached in the sinus, can obliterate permanently the pathological arteriovenous shunt. This technique avoids many of the risks and the longer convalescence that accompany surgical procedures for treatment of these lesions. However, it has not always been possible to preserve patency of the carotid artery while excluding the fistula because of difficulties in positioning the balloons in the sinus through the rent in the carotid artery. Debrun, et al., were successful in preserving the carotid artery in only 59% of these procedures. Furthermore, the transarterial approach may be complicated by premature detachment or by early or late deflation with embolization of the balloon into the intracranial arteries, causing cerebral ischemic damage.

When the transarterial approach has been unsuccessful, the cavernous sinus has been approached by the venous route. Mullan reported using a balloon catheter introduced from the internal jugular vein through the inferior petrosal sinus to occlude fistulas, but he was successful in only one of five attempts. Debrun, et al., employed a similar technique in 12 cases, were successful in reaching the sinus in five, and totally occluded the fistula in only one. In one of their cases, obstruction of the posterior sinus resulted in increased shunting through the ophthalmic veins with worsening of ocular symptoms. In some cases, the anterior sinus has been approached through the ophthalmic vein, but this technique has also met with limited success. Halbach, et al., described a variety of transvenous occlusive techniques, including the use of coil emboli delivered through microcatheters. They recorded a higher rate of success: occlusion of the fistula was accomplished via the venous route in 11 of 14 cases. One patient suffered a fatal intracranial hemorrhage following subtotal transvenous occlusion of the fistula with diversion of the flow into the cortical veins.

In the case reported here, a transfemoral approach to
the sinus was undertaken after a transarterial attempt to enter the fistula was unsuccessful. An approach through the ophthalmic vein was not tried because of the tortuosity of the vessel and because the vein was stenosed at its junction with the sinus. During manipulation of the catheter in the intracranial venous system, the sinus was perforated. Because this vein was draining the carotid-cavernous fistula and was therefore exposed to an increased intravascular pressure, the risk of massive subarachnoid hemorrhage was high. Fortunately, the hole in the vein was occluded by coils, providing time for emergency surgical treatment.

The goal of surgery was to occlude both the posterosuperior and the anteroinferior compartments. The posterosuperior compartment drained into the disrupted vein, and its obliteration was necessary to protect from bleeding at the site of the injury. Occlusion of the anteroinferior compartment was essential to prevent worsening of ocular symptoms that would occur due to redirection of the shunt flow caused by blockage of the posterior route drainage. In order to avoid the risks and difficulties of opening the arterialized sinus, it was decided to use a modification of the technique described by Samson, et al., after an attempt at transdural balloon insertion was unsuccessful. The use of intraoperative digital subtraction angiography was particularly valuable in locating the site of puncture of the dural wall for entry into the desired area of the sinus. The capacity for real-time subtraction was quite helpful in adjusting the speed and amount of IBCA injection in order to minimize the risk of reflux into the carotid artery. With this technique, both anterior and posterior routes of drainage could be occluded.

There is controversy over the safety of injecting IBCA, primarily focused on its possible carcinogenicity; however, IBCA has been used successfully and without evidence of clinical carcinogenicity for more than 10 years for neurovascular applications. In this case, IBCA was employed because of its unique ability to be delivered with precision through a needle into the desired region of the sinus. In this instance, the efficacy of IBCA in facilitating safe treatment of a life-threatening complication serves to justify its use. The development and availability of new polymerizing agents, such as the biological tissue adhesive (fibrin sealant) employed by Isamat, et al., for treatment of carotid-cavernous fistulas, should provide more acceptable alternatives.

The transvenous route to the cavernous sinus has been stated to be desirable in that it is extremely safe. This case illustrates a potential complication of the transvenous approach that may be life-threatening. Selection of this approach should take into account its variable rate of success and its risks. The transfemoral transarterial approach to carotid-cavernous fistulas appears to be the initial technique of choice given its high rate of success and relatively low risk. The transjugular approach should probably be reserved for specifically appropriate cases: those with a posteriorly draining fistula in which the inferior petrosal sinus is favorably configured. Direct surgical exposure of the sinus, with either opening and packing of the sinus or introduction of thrombogenic material through the wall of the sinus, should be considered as an option in cases in which the fistula cannot be closed without occluding the carotid artery.

This case serves to underline the need for a close working relationship between the interventional neuroradiologist and the neurosurgeon. Percutaneous endovascular techniques have provided a significant improvement in the treatment of complex neurovascular disorders. However, the potential for function-threatening and life-threatening complications requires the immediate availability of personnel and facilities for the surgical management of the unusual mishap.

References
15. Mullan S: Experiences with surgical thrombosis of intra-
Transvenous repair of carotid-cavernous fistula