Carotid cavernous fistula: direct repair with preservation of the carotid artery

Technical note

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The techniques and advantages of the direct approach to carotid cavernous fistulas with repair of the fistula and preservation of the carotid artery are discussed with illustrative case reports. The surgical significance of the anatomy of the parasellar venous structures and their relationship to the carotid artery are discussed. Two points emphasized are that it is possible to operate within the cavernous sinus and still be outside both the venous and arterial components of the fistula, and that, by one means or another, the carotid should be preserved.

Key Words: carotid cavernous fistula, direct repair, carotid artery, parasellar venous plexus, hypothermia

The carotid cavernous fistula has been recognized for nearly as long as arteriovenous fistulas of the extremities, but as Hamby states, "... its management remains unsatisfactory. As in other parts of the body the fistula itself should be attacked rather than attempting piecemeal progressive ligation of its feeding arteries." Treatment of arteriovenous fistulas of the extremities has progressed from single vessel ligation to multiple vessel ligation and then to bloc resection; now repair of the fistula with preservation of the artery is the accepted treatment.

Several years ago we became interested in the possibility of a direct approach to carotid cavernous fistulas that had persisted after all other methods had failed. Knowledge of the surrounding anatomy and the exact nature of the collateral circulation available to this segment was essential. The collateral circulation has now been described and we have now created an approach that does not damage adjacent cranial nerves. We have used it successfully in seven cases.

In our early work we were guilty of perpetuating the concept that the cavernous sinus was a large trabeculated venous cavern surrounding the carotid artery and the sixth nerve (Fig. 1). Both Hamby and Travers doubted this concept, and even in our first case we noted that the fistula made a direct connection between the carotid and an adjacent venous channel (Fig. 2). It is interesting that Hamby's book contains an excellent diagram of this anatomy ascribed to Nelaton, the same surgeon who is credited as being the first to devise and use the catheter, a modification of which was designed to eventually play an important role in the treatment of these fistulas. In subsequent work using venous corrosion specimens we have shown that in fact the parasellar venous pathways form an irregular plexus of varying sized venous channels, dividing and coalescing and incompletely surrounding the carotid artery (Fig. 3). The fistula consists of a short endothelialized tangential opening between adjacent arterial and venous lumina, and thus differs in no way hemodynamically from spontane-
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Fig. 1. Diagram of the original concept of the carotid cavernous fistula. The entire space within the dural walls of the “cavernous sinus” was considered to be a venous cavern surrounding the carotid. Hence any rupture of the carotid spilled directly into this surrounding venous cavern.

ous or traumatic arteriovenous fistulas elsewhere in the body. This concept is important for two reasons. It means that these fistulas can be repaired with a single clip, ligature, or suture, it also means that the surgeon can work within the space commonly known as the “cavernous sinus” and yet be outside both the arterial and venous components of the fistula.

The participating artery may be the carotid (Type I) or one of its branches (Type II). The adjoining venous channels become so dilated, thickened, tortuous, and adherent that they resemble the carotid artery itself.

After our first case of intracavernous obliteration of the persistent fistula we realized that it would be possible to repair either type of fistula and preserve the continuity of the carotid. We have now had two cases of carotid cavernous fistulas in which no prior trapping had been performed.

Case Reports

Case 1

On September 10, 1970, this 26-year-old pilot suffered a basilar fracture with bilateral spinal fluid otorrhea, a crushed chest, and multiple limb fractures in an accident. When he recovered consciousness 4 days later, a total left ophthalmoplegia and right-sided sixth and seventh cranial nerve palsies were evident; he was unable to open his left eye or close his right eye. There was bilateral chemosis and conjunctival injection, more marked on the left. He had a pulsating ophthalmus on the left with a loud bruit audible over the entire head and neck. Routine stereoscopic angiography combined with cine-angiography localized a brisk fistula coming from the inferior lateral aspect of the carotid just beyond its emergence from the foramen lacerum (Fig. 4 upper left and right). There was immediate filling of the left superior and inferior orbital veins and later filling of the superior and inferior petrosal, right parasellar, and right orbital veins, thus accounting for the bilateral conjunctival injection. The patient had a persistent pyrexia from the time of his accident, probably due to bacterial endarteritis at the site of the fistula.

Operation. On October 7, 1970, with the use of Mannitol and lumbar puncture drainage and complete circulatory femoral bypass with cooling to 8°C to 10°C a left subtemporal approach was performed. The bridging veins normally between the floor of the middle fossa and the undersurface of the temporal lobe were dilated to 5 mm in diameter and turgid with blood under arterial pressure (Fig. 5 upper left). The Sylvian veins were equally large and formidable. The temporal lobe was elevated with minimal retraction, exposing the tentorial margin and the third and fourth cranial nerves. There were huge, dilated, tortuous veins about...
these structures and over the margin of the tentorium in areas where venous structures are not normally apparent. The pump was then stopped and an incision 2 cm in length was made in the triangular space parallel to and approximately 3 mm beneath the projected course of the third nerve (Figs. 5, 6, and 7). The cavernous sinus retractor was then inserted and the operating microscope swung into place. A vascular tangle was encountered consisting of channels entirely indistinguishable as to type of vessel and direction of flow, even though the site of the fistula was known (Fig. 5 upper right). Eventually the wall of the carotid was identified and gradually separated from adjacent veins down to the point of the fistula. A clip was placed across the fistula but tore through, and it was eventually necessary to close the opening in the arterial wall with interrupted 7.0 silk sutures. The wall of the cavernous sinus was then closed with 4.0 silk and the pump restarted. There was no further venous engorgement in the area. The total time of circulatory arrest was approximately 55 minutes.

*Postoperative Course.* Bruit and exophthalmus disappeared immediately. The patient regained consciousness more slowly than previous cases but was eventually up and about the ward looking after himself in all respects. Transient aphasia cleared within 6 weeks. Immediate postoperative angiograms revealed a normal carotid circulation. There was a small blister deformity at the site of the anastomosis (Fig. 4 lower left). Two months later angiography revealed a normal vessel contour. Within 6 months, the preoperative left third nerve palsy and right facial palsy had disappeared. This was due to the passage of time rather than the result of surgery, but demonstrated that the third nerve had been preserved during surgery. Postoperative vision was normal in both eyes, but the preoperative bilateral sixth nerve palsy persist to

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**Fig. 3.** *Left:* A venous corrosion specimen from a series to be published, showing the left carotid artery (*black*) going through the parasellar plexus of veins (*white*) commonly referred to as the "cavernous sinus." The right carotid is also visible slightly out of focus to the right. The two superior orbital veins are going to the upper left of the photograph and the two ophthalmic arteries are visible departing from the carotids and going forward. Notice that considerable portions of the carotid are not covered with venous pathways. *Right:* Another venous corrosion specimen viewed from above. (Arteries are in *black* and veins in *white.*) The tip of the *central white arrow* lies within the space of the hypophysis. The rectangular space immediately behind this represents the area occupied by the dorsum sellae. The tip of the *arrow on the right* lies within the opening of the foramen rotundum. On the left, the ophthalmic artery is intact up to its terminal branches behind the globe and following it along is the superior orbital vein with many of its branches. In the right lower corner of the photograph, the distal portion of the right sigmoid sinus is well preserved and a shorter segment of the left is also visible. The irregular plexiform nature of the venous pathways in the parasellar region is evident with coalescence into larger veins superiorly. In this particular specimen the venous channels down the dorsum are fused into a thin sheet superiorly. Note in both figures that there is no self-evident boundary that could be assigned to a "cavernous sinus" either inferiorly or anteriorly. Note also that portions of the carotid in both specimens are completely bare of any surrounding venous channels.
date. The extensive basilar fracture presumably caused permanent nerve damage.

Case 2

This 20-year-old woman was referred by Dr. William Campbell of Indianapolis, because of severe recurring headaches until February, 1971, when she suddenly became aware of a rhythmical bruit, cessation of her headaches, and engorgement of the left eye. An angiogram had revealed early filling of the veins about the carotid and parasellar regions (Fig. 8) with one vein filling momentarily a considerable distance posterior to the posterior clinoid. The rest of the venous spillage was directed anteriorly. The referring physician's suspicion that this represented spontaneous communication between a branch of the meningohypophyseal artery and the parasellar venous structures was confirmed by cine-angiography and simultaneous biplane stereoangiography.

Operation. On October 29, 1971, with the use of circulatory bypass and profound hypothermia, a left temporal craniotomy was performed. The region of the cavernous sinus was exposed with ease; there was only one small bridging vein well medial on the temporal lobe going straight down to the lateral wall of the cavernous sinus and this was coagulated and sectioned. The third nerve approached at an unusual angle but the estimated intradural course was determined and the usual incision made in the lateral wall of the cavernous sinus and this was coagulated and sectioned. The third nerve approached at an unusual angle but the estimated intradural course was determined and the usual incision made in the lateral wall of the cavernous sinus. Even after the pump had been stopped there was some troublesome bleeding but this was corrected by additional elevation of the head of the table. The retractor was inserted and the operating microscope swung into position. The carotid

FIG. 4. Case 1. Upper Left: Preoperative angiogram showing extensive filling of the vessels in the parasellar region (cavernous sinus) and on out into the supraorbital and infraorbital veins as well as into the superior and inferior petrosal veins. Upper Right: Subtraction film from same angiogram. Lower Left: Postoperative film showing the obliteration of the fistula with preservation of the internal carotid artery. The small blister at the site of the repair had disappeared 2 months later leaving no deformity in the wall.
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was eventually mobilized from the most anterior portion of the parasellar region down the posterior curve as far as the level of the sixth nerve; any adherent vessels encountered were coagulated and sectioned. An abnormal vessel that arose from the carotid laterally at the midportion of the forward curve was presumed to be a branch of the meningohypophyseal artery. The course of this vessel was not toward any structure normally supplied by the meningohypophyseal artery, it was inseparable from vessels continuing on in the parasellar venous plexus and this connection was obliterated and sectioned. Another vessel coming from the undersurface of the carotid at this same level was also coagulated and divided. The pump was then started, and we were able to visualize the exposure with ease by simply packing the two corners of the incision in the lateral wall of the cavernous sinus. The carotid became normally turgid and its entire length in the parasellar region was then inspected again with a blunt hook. There was no longer any evidence of a fistula. The dural incision in the triangular space was closed with 4.0 silk and the surface bleeding controlled as administration of heparin ceased. The remainder of the craniotomy was closed in layers without a drain. During closure the anesthetist was quite certain he could still hear a bruit. Later on in the recovery room, the bruit was not audible but the following evening it was. The postoperative angiogram re-

![Image](https://example.com/image1.png)

**Fig. 5. Case 1.** *Upper Left:* Artist's sketch of operative exposure. On the left descending vertically is the greatly engorged Sylvian vein running down beneath the medial third of the sphenoid ridge. The next structure to the right is the optic nerve and immediately behind that is the supraclinoid portion of the carotid and next the third and fourth cranial nerves. The line of the incision is indicated in the triangular space of the lateral wall of the cavernous sinus. At the right hand side of the exposure is a vein bridging from the undersurface of the temporal lobe to the tentorium.

*Upper Right:* A realistic diagram of the tangled appearance of the adherent, dilated, thickened, vascular channels as it first appears upon retraction of the incision in the triangular space. The third and fourth nerves are indicated as just visible beneath the upper margin and the sixth nerve crosses the field inferiorly.

*Lower Right:* A greater magnification indicating the appearance after the vessels have been teased apart. The veins which would normally overlay the carotid and obliterate it from view are not shown. The carotid itself is shown following its normal curvature upward and anteriorly to the left whereas the venous channels are indicated as a tangle of multiple curved branches. The thread is looping around the fistula.
revealed a considerable narrowing of a portion of the carotid just proximal to its entrance into the cavernous sinus but there was no evidence of any fistula (Fig. 8 lower left). After the second day no bruit could be heard.

Postoperative Course. Postoperatively, the patient had a left total ophthalmoplegia and some minimal aphasia, both of which disappeared completely. She was given a battery of psychological tests similar to those given preoperatively and was considered normal in all respects by April, 1972. A postoperative angiogram on November 2, 1971, showed release of the marked spasm previously noted although there was still some slight narrowing. It was assumed that the bruit audible postoperatively had been produced by this short segment of spasm.

Discussion

The luxuries of time, space, and procedure available to the general surgeon correcting arteriovenous fistulas of the extremities are not available to the neurosurgeon working within the cavernous sinus. There is no access to normal arterial wall within this tight little compartment of exquisitely sensitive anatomy commonly called the "cavernous sinus." The neurosurgeon is therefore required to make a rapid excursion through the tightly packed tangle of abnormally dilated, thickened, adherent veins to the underlying arterial wall as he dissect his way to the fistula. His best assets are familiarity with the anatomy, the operating microscope, and an accurate preoperative localization of the fistula in order that he waste no time teasing apart venous channels at a distance from the lesion but which in texture and size resemble the artery in their midst that he is seeking to define and preserve.

The risks of the enabling procedures, namely, the hypothermia and circulatory bypass and arrest, although formidable to contemplate, are relatively minimal in the hands of competent vascular and anesthetic teams. Under appropriate conditions this procedure is probably just as safe as the average general anesthesia of comparable duration.

Quite possibly in the future we will be able to operate upon this region without circulatory arrest. As long as one recognizes the true anatomy of the region and can re-
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main outside the venous channels it is theoretically possible to have enough dry exposure to perform the surgery even in the presence of a brisk fistula leak. If this exposure could be combined with balloon catheter techniques then there would be an even greater possibility of performing closure of the fistula without circulatory arrest.

Serbinenko who has catheterized the carotid and intracranial arteries for over 15 years has demonstrated repeatedly his ability to place the balloon of one of his catheters at the site of a fistula and then obliterate the fistula. If this were to be done preoperatively with localization of the balloon by contrast media (part of Serbinenko's technique) then the surgeon could be operating with the fistula obliterated and a continuing circulation. Moreover, palpation of the balloon would lead the surgeon rapidly to the exact site of the fistula and to identification of the arterial wall amongst the camouflage of the distended, thick-walled surrounding venous channels. It will be difficult for any one to realize the confusion that can exist between the arterial and venous walls until he has operated on one of these cases.

Conclusions

These cases demonstrate that by direct approach the carotid cavernous fistula can be repaired with preservation of the internal carotid artery as well as the ad-

Fig. 8. Case 2. Upper Left: Preoperative angiogram showing a much less active fistula with slower filling. Upper Right: Subtraction film from later film showing extensive orbital vein engorgement. Lower Left: Postoperative angiogram showing obliteration of the fistula with preservation of the continuity of the carotid. The narrowing of the internal carotid just at its point of emergence from the foramen lacerum had returned to normal caliber at angiogram 2 weeks later.
jacent cranial nerves. The technique is exacting. No one should try this approach before he has had repeated practice on cadavers, verifying all the landmarks, making incisions in the triangular space, freeing up the carotid and its branches within the cavernous sinus, and then closing the dural opening in the triangular space. We are certain that the future procedure of choice, when more conservative measures such as tethered emboli, or retrograde wire coagulation, have failed, will be this sort of direct attack on the fistula. Preservation of the carotid is essential since its obliteration is a considerable sacrifice regardless of the age of the patient.

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