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Management of giant intracranial ICA aneurysms with combined extracranial-intracranial anastomosis and endovascular occlusion

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✓ Nine patients with giant internal carotid artery (ICA) aneurysms (> 2.5 cm in diameter) were subjected to a combined extracranial-intracranial (EC-IC) bypass procedure and endovascular ICA occlusion during 1987 and 1988. The procedures were performed under one anesthetic. In all cases the collateral circulation had been judged insufficient on the basis of a strict preoperative testing protocol including: cerebral panangiography, electroencephalography, somatosensory potential recording, and cerebral blood flow monitoring during manual compression of the ICA in the neck. There were four intracavernous ICA aneurysms, four carotid-ophthalmic artery aneurysms, and one supraclinoid ICA aneurysm. All patients showed symptoms and signs of compression of the surrounding nervous structures. In the five cases of intradural lesions, the artery was occluded at the level of the aneurysm neck, so the ophthalmic artery had to be occluded. There was, nevertheless, no case of worsening of vision following surgery, and all nine patients showed significant improvement following the combined procedure. A combined EC-IC bypass procedure and endovascular ICA occlusion allows for immediate verification of the surgical results and appears to be a worthwhile method for treating giant intracranial aneurysms.

KEY WORDS • **aneurysm, giant** • **extracranial-intracranial bypass** • **occlusion** • **endovascular surgery** • **anastomosis, arterial** • **balloon catheter**

OCCLUSION of the internal carotid artery (ICA) has been used for treating intracranial carotid aneurysms for a long time. Currently, this is the method considered almost exclusively in treating giant intracranial aneurysms with an intracavernous location and/or an unclippable large neck. Therapeutic occlusion of the ICA is usually preceded by careful assessment of the collateral circulation. Some years ago, extracranial-intracranial (EC-IC) bypass procedures were proposed in order to increase the collateral reserve in patients with functionally insufficient collateral circulation who were scheduled to undergo therapeutic ICA occlusion.[2,6,7,17] This combination of ICA occlusion and EC-IC anastomosis is usually performed as a two-stage procedure, in which the bypass is carried out first and the ICA is occluded subsequently either gradually or abruptly.

The "N.N. Burdenko" Institute of Neurosurgery pioneered endovascular surgery[15] and has had extensive experience in the definitive endovascular treatment of intracranial aneurysms.[9] In cases of giant unruptured aneurysms of the ICA, an attempt at occluding the lesion with a balloon catheter without affecting flow in the parent artery involves a significant risk of subsequent embolism. It has thus become our policy to occlude the ICA in the treatment of giant intracavernous aneurysms as well as those giant intradural ICA aneurysms which, if directly clipped, would pose a considerable surgical risk for the patient. We have performed a routine EC-IC bypass procedure prior to gradual ICA occlusion in the neck in patients who were unlikely to tolerate direct ICA occlusion. Since 1987, however, we have changed our protocol in these cases and have started performing a single-stage procedure for EC-IC bypass and endovascular ICA occlusion in patients with a giant unruptured ICA occlusion and signs of functionally insufficient collateral circulation.

Clinical Material and Methods

During 1987 and 1988, nine patients with giant unruptured intracranial aneurysms were treated with

FIG. 1. Cerebral angiograms showing a giant partially thrombosed right internal carotid artery aneurysm (*upper* and *lower right*). There is no filling of the right A_1 segment of the anterior cerebral artery. Contralateral carotid *(lower left)* and vertebral *(upper left)* angiograms during Matas' test show faint opacification of the posterior communicating artery and of the proximal right middle cerebral artery.

EC-IC bypass procedures and balloon-catheter occlusion* of the ICA in a one-stage operation. These patients were considered unfit for direct aneurysm treatment mainly due to the large size of the lesions (> 2.5 cm in diameter). The patients varied in age from 18 to 60 years (average 39 years). There were two men and seven women, all showing symptoms and signs of progressive involvement of the surrounding structures. Two patients also showed signs of subarachnoid hemorrhage. The lesions were located in the cavernous segment of the ICA in four cases, at the origin of the ophthalmic artery in four, and in the supraclinoid segment in one.

The preoperative investigative protocol is summarized in Table 1. Angiography demonstrated the anatomical characteristics of the circle of Willis and supplied evidence of the absence (or significant hypoplasia) of one or more collateral vessels (Fig. 1) in five cases. The collateral circulation was, however, considered to be functionally inadequate in all cases. The criteria for evaluating the collateral reserve were based on the results of various investigations during Matas' test and temporary ICA occlusion. These are described in detail in a separate paper.[10]

The EC-IC bypass procedure was performed first. As a rule, the parietal branch of the superficial temporal artery was used and anastomosed to an M_3 cortical branch of the middle cerebral artery. No more than six to eight interrupted stitches were used, and the anastomosis was eventually glued with Beriplast.† As soon as the surgical wound was closed, the patient was transferred to the angiographic suite while still anesthetized and both the control angiogram and the endovascular procedure were performed under continuous electro-

* Serbinenko balloon catheter manufactured by Neiron, Moscow, Russia.

† Beriplast manufactured by Behring, Hamburg, Federal Republic of Germany.

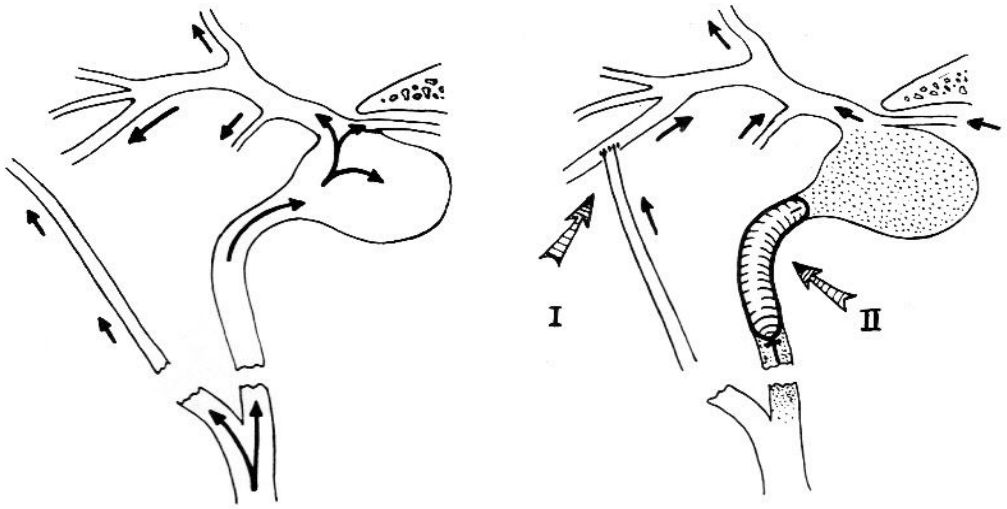

FIG. 2. Drawings of the operative technique in cases of intracavernous aneurysms. The anastomosis is performed first (I) then the occlusion procedure (II). *Arrows* indicate the direction of blood flow before *(left)* and after *(right)* occlusion of the internal carotid artery. The balloon is positioned close to the proximal part of the aneurysmal neck.

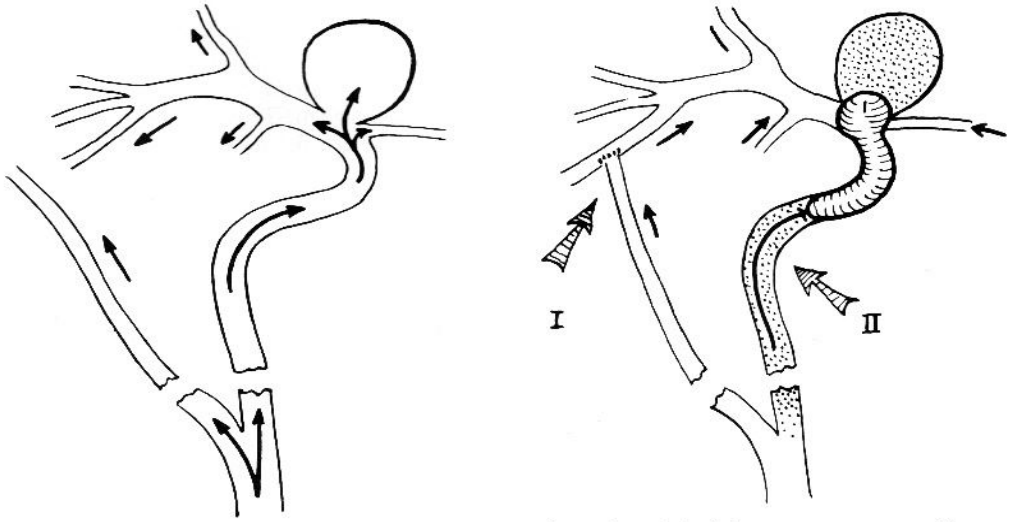

FIG. 3. Drawings of the operative technique in cases of carotid-ophthalmic artery aneurysm. The anastomosis is performed first (I) then the occlusion procedure (II). *Arrows* indicate the direction of blood flow before *(left)* and after *(right)* the occlusion procedure. The balloon is positioned in such a manner as to occlude the internal carotid artery, the aneurysm, and the ophthalmic artery. Following surgery there is a reverse flow into the ophthalmic artery through the external carotid artery collateral vessels.

encephalographic (EEG) and somatosensory evoked potential (SSEP) monitoring. For this purpose, the ICA was directly punctured in the neck and a Serbinenko balloon catheter was directed as close as possible to the proximal part of the neck of the aneurysm (Fig. 2). In cases of carotid-ophthalmic aneurysms and supraclinoid aneurysms, the catheter was placed so as to occlude the orifice of the ophthalmic artery (Fig. 3). After ICA occlusion tolerance was tested and the patency of the

TABLE 1

Preoperative diagnostic routine

computerized tomography before and after contrast enhancement
cerebral panangiography*
transcranial Doppler sonography*
electroencephalography*
somatosensory evoked potential recording
cerebral blood flow inhalation study*

* During these investigations the Matas' test was routinely performed.

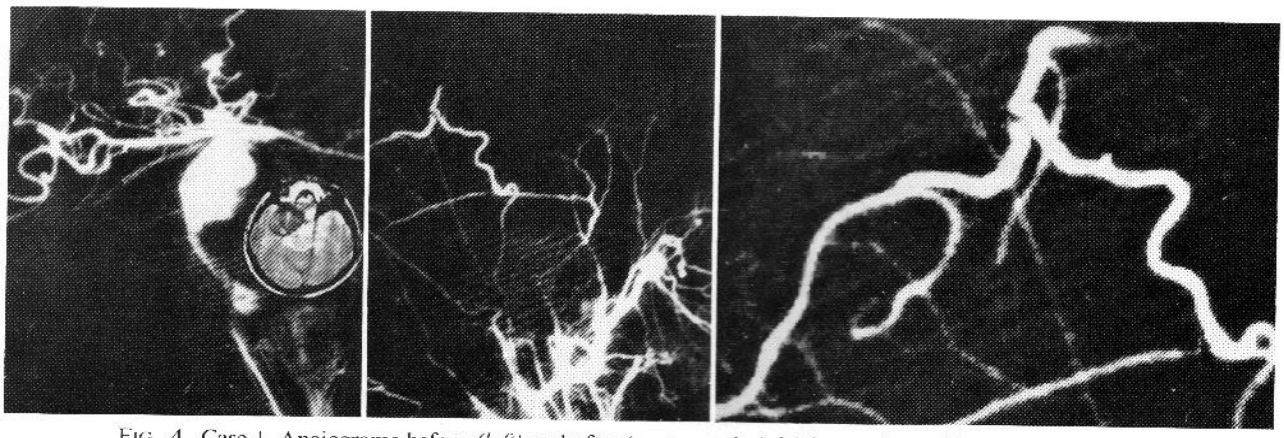

FIG. 4. Case 1. Angiograms before *(left)* and after (*center* and *right*) internal carotid artery occlusion and extracranial-intracranial bypass. Note the disappearance of the vascular lesion on the control angiograms, as well as good patency of the anastomosis. The preoperative computerized tomography scan is shown *(left, inset)*.

bypass assessed, the balloon was definitively inflated and left in place. A final control angiogram was then carried out, and the procedure terminated.

Results

No intraoperative or postoperative complications occurred in this series. In particular, no visual dysfunction was noted following surgery. In all cases, the flow of contrast material through the bypass was significantly augmented following occlusion of the ICA, and exclusion of the aneurysms from the circulation could be verified immediately. The EC-IC anastomosis was checked postoperatively by means of angiography and Doppler sonography, and appeared to be patent in all cases. Angiography confirmed the disappearance of the lesion and a striking regression in the size of the lesions was noted in the late postoperative computerized tomography (CT) scan. This was clearly related to clinical improvement.

The four patients with carotid-cavernous aneurysms showed significant regression of their ophthalmoplegia and pain in the trigeminal nerve distribution. One patient (Case 1), who suffered from blindness in one eye, showed no improvement in visual function although the remaining symptoms and signs improved remarkably.

Illustrative Case Reports

Case 1

This 19-year-old man was admitted for progressive left ophthalmoplegia, decreasing vision in the left eye eventually leading to total blindness, and a 1-year history of pain in the trigeminal nerve distribution on the left side. Angiography showed a giant left intravenous carotid artery aneurysm, as well as a hypoplastic A_1 segment of the right anterior cerebral artery (Fig. 4 *left*). Slowing of the EEG tracing and an increase in the SSEP latency was observed after a few minutes of manual ICA compression on the neck. This was reflected in the monitored cerebral blood flow data. An EC-IC bypass procedure was accordingly performed and a Serbinenko catheter was introduced into the left ICA up to the level of the aneurysm. Temporary occlusion of the ICA and of the aneurysm made it possible to verify the disappearance of the lesion and the patency of the bypass, as well as the tolerance to ICA occlusion. There was a rapid improvement in all symptoms except for the blindness. Postoperative angiography showed the bypass functioning well, with no filling of the aneurysm (Fig. 4 *center* and *right*). At his 1-year follow-up examination, the patient was well except for the same restriction in his oculomotion and left eye blindness.

Comment

As mentioned earlier, there were no signs of visual impairment following surgery in any of the remaining cases, in spite of the fact that the ophthalmic artery was occluded together with the aneurysm.

Case 2

This 40-year-old woman was admitted for evaluation of decreased vision of 6 months' duration. Visual acuity was 1/100 in the right eye, and there was a mild symmetrical restriction of the visual fields. Angiography and CT showed a giant carotid-ophthalmic artery aneurysm, which was considered unfit for direct clipping (Fig. 5 *upper pair*). Following a combined EC-IC bypass procedure and endovascular ICA occlusion (Fig. 5 *lower left*) there was gradual although significant improvement. One year after surgery, visual acuity was 80/100 in the right eye and the visual fields were full; CT scanning demonstrated a significant decrease of the

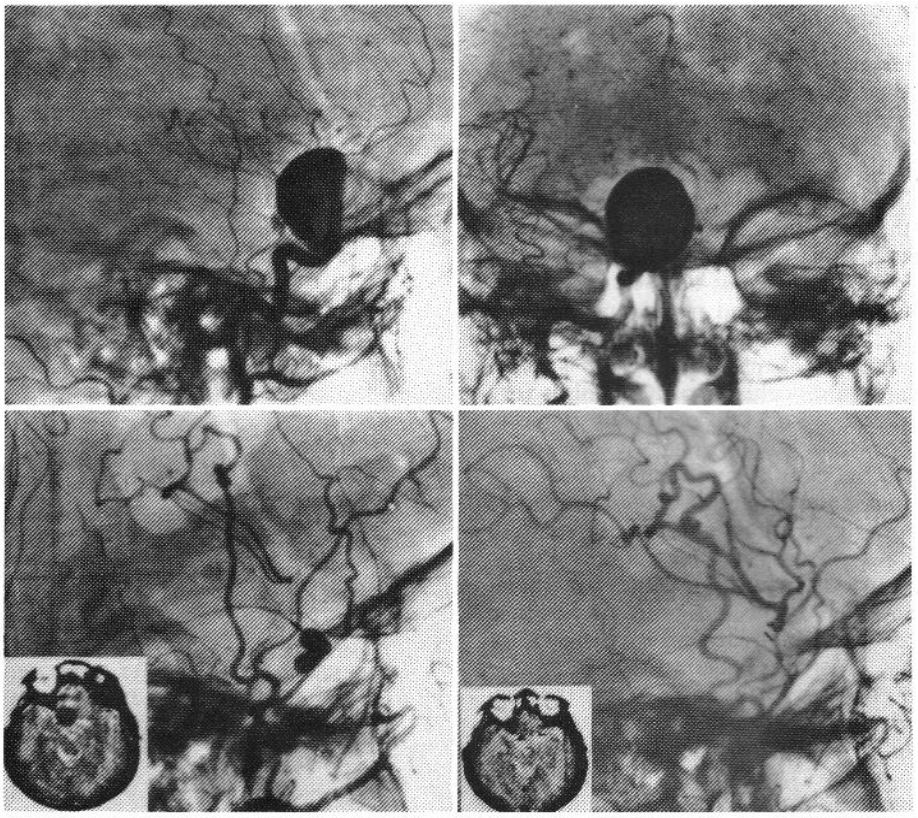

FIG. 5. Case 2. *Upper Pair:* Angiograms before internal carotid artery occlusion and extracranial-intracranial bypass showing a giant partially thrombosed carotid-ophthalmic artery aneurysm. *Lower Left:* The size of the aneurysm is better appreciated on the computerized tomography (CT) scan *(inset)*. The intraoperative angiographic control showed good bypass patency and no filling of the aneurysm. Note the balloon *in situ* is still filled with contrast material. *Lower Right:* One year after operation, the CT scan *(inset)* and angiogram show the virtual disappearance of the lesion. The bypass is functioning extremely well.

lesion, and angiography showed no filling of the lesion and good functioning of the bypass (Fig. 5 *lower right*).

Discussion

The best treatment for intracranial aneurysms is definitive exclusion from the circulation by either direct clipping or endovascular occlusion of the aneurysmal neck. Direct clip ligation of giant intracranial aneurysms is still today a formidable challenge involving a significant risk of morbidity and mortality even in experienced hands.[4,18,19,22] As regards the management of intracavernous vascular aneurysms, direct surgery within the cavernous sinus represents a recently opened frontier, the role of which is still being evaluated.[3] Endovascular surgery of intracavernous vascular lesions is a well-accepted form of treatment, and endovascular occlusion of intracranial arterial aneurysms has become a realistic possibility in recent years[9,20] The risk of subsequent embolism is, however, significant when the parent artery is left open with giant ICA aneurysms.[9,20] We believe that giant intracavernous aneurysms of the intradural ICA, which are not amenable to clipping without significant surgical risk, are better treated by definitive ICA occlusion.

Occlusion of the ICA in otherwise untreatable ICA aneurysms is a well-accepted form of treatment,[2,13,21] and EC-IC bypass surgery was proposed some years ago[4,6,7,16,17] in order to increase the collateral reserve in cases in which collateral circulation was likely to be insufficient. In our series of patients, the collateral reserve was carefully tested preoperatively and found to be inadequate.

In cases of giant aneurysms treated with ICA occlusion and EC-IC bypass surgery, the latter procedure was performed first and the ICA was subsequently occluded in the neck by means of an open technique, either progressively with Silverstone's clamp[6,11,17] or Drake's tourniquet,[4] or abruptly.[5,8,12] There was usually an interval of a few days between the two procedures, although some authors[6,14] have recommended shortening this interval in order to establish rapidly a favorable

pressure gradient for the development of the anastomosis.

Our extensive experience with endovascular surgery has allowed us to establish strict guidelines for monitoring neurological functions during occlusion of major brain vessels. Depending on the results, the vessel may or may not be subsequently occluded. These principles were easily transferred to cases of giant intracranial ICA aneurysms, with the following advantages over the management protocols that we also used in the past: 1) the patient's discomfort is reduced, as the two procedures are performed in one session and invasiveness is lessened due to the fact that no open manipulation of ICA is required; 2) the efficacy of the EC-IC bypass is tested prior to, and not after, the occlusion of ICA (this is very important); 3) tolerance of ICA occlusion is easily verified by intraoperative monitoring; 4) exclusion of the aneurysm from the circulation is immediately verified; and 5) optimal management of the lesion may be obtained with a multiple-balloon catheter if required, although this was not the case in these patients. In our opinion, this combined treatment for giant intracranial ICA aneurysms appears to be a significant advance compared to other forms of treatment exclusively applied to date. We must once again stress that this technique should be reserved for cases where the surgical risk of direct clipping is considered unjustifiably high and the collateral circulation has been judged insufficient.

It is remarkable that none of these patients with intradural lesions showed visual impairment following balloon-catheter occlusion of the aneurysm together with the ophthalmic artery itself. This indicates that the collateral circulation to the central retinal artery may be sufficient in most cases for adequate collateral filling of the territory supplied by the occluded ophthalmic artery. This is very important, since occlusion of the latter vessel is mandatory in order to exclude any possibility of retrograde filling of the aneurysm with persistence of the lesion and/or possible embolism. Intraoperative angiography allowed for immediate verification of lack of filling of the lesion and good functioning of the bypass. Good surgical results were verified by postoperative control angiography and Doppler sonography. Serial postoperative CT scanning demonstrated progressive shrinkage of the thrombosed aneurysms, which paralleled the clinical improvement.

Ischemic complications may occur following therapeutic ICA occlusion for intracranial aneurysms[13] even though complemented by EC-IC anastomosis.[6,8,11,16,17] We have observed no complications of this kind in an admittedly small group of patients, and no case of postoperative aneurysm rupture in a follow-up period averaging 1 year. Massive hemorrhage from a previously unruptured giant carotid aneurysm[11] and the formation of a giant "pseudoaneurysm"[8] have been reported to occur following combined ICA occlusion and EC-IC bypass surgery. In these cases, however, persistent filling of the lesion had been noted on postoperative angiography. In such situations, transcranial exposure of the lesion and trapping should be considered.[1]

In conclusion, combined EC-IC bypass surgery and endovascular balloon-catheter occlusion of the ICA is an effective method of treating giant intracranial ICA aneurysms. This technique appears to offer several significant advantages over the "classical" method of performing EC-IC bypass followed by either gradual or abrupt surgical occlusion of the aneurysmal neck.

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