Revascularization of the external carotid artery

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The existence of naturally occurring anastomotic channels between the external carotid artery branches and the intracranial cerebral circulation is well recognized and these channels can be demonstrated anatomically, angiographically, and physiologically by various flow detection devices. Under normal circumstances, when the internal carotid arteries are patent, the direction of flow is from the intracranial to extracranial vessels and the external carotid artery does not contribute to the intracranial circulation. However, when the internal carotid artery becomes
occluded, the direction of flow reverses in the anastomotic channels and the external carotid artery becomes a source of blood flow to the brain. It has been suggested that extracranial to intracranial anastomotic channels may account for up to 30% of cerebral blood flow in patients with bilateral internal carotid artery occlusion.1

Thus, since the external carotid artery supplies blood flow to the brain when the internal carotid artery is occluded, it itself may become the source of symptoms of cerebral ischemia. These symptoms arise by the same physiologic mechanisms produced by the internal carotid artery, that is, embolization or hypoperfusion, and are manifested by amaurosis fugax, transient hemispheric ischemia, completed strokes, or symptoms of decreased global perfusion, such as syncope.

Symptomatic patients with angiographically demonstrated internal carotid occlusion and external carotid stenosis may be candidates for external carotid endarterectomy to relieve symptoms. Hemodynamic significance of external carotid lesions should be objectively assessed preoperatively by measuring cerebral blood flow using radiolabeled xenon. Normally, patients who are asymptomatic with internal carotid artery occlusion have 133Xe cerebral blood flow values within the normal range. Superimposed external carotid artery stenosis usually results in abnormal 133Xe blood flow measurements that can be returned to the normal range with external carotid revascularization in 80% of patients.2 Patients with normal 133Xe cerebral blood flow should be evaluated carefully for other potential causes of their symptoms before attributing them to the external carotid artery. Occasionally, occlusion of the internal carotid artery leaves a cul-de-sac in the carotid sinus, which may be the site of active thrombus formation and platelet aggregation. Emboli from the cul-de-sac may produce symptoms of amaurosis fugax and hemispheric ischemia without the presence of a significant external carotid lesion,3 but this is unusual.

Most properly selected patients are relieved of their symptoms following external carotid revascularization as the sole procedure. Only a few patients with external carotid stenosis require subsequent extracranial/intracranial cerebral bypass and these patients can be identified by continuing abnormality of 133Xe cerebral blood flow and continuing symptoms following external carotid endarterectomy. Patients with bilateral internal carotid artery occlusion and diminished cerebral blood flow in both hemispheres usually respond to unilateral external carotid revascularization with an increase in flow in both hemispheres. This fact is probably related to the rich anastomotic network in the external carotid distribution.

Technical considerations of importance in external carotid endarterectomy include mobilization and control of the branches of the external carotid artery and extension of the common carotid arteriotomy onto the external rather than internal carotid artery. Endarterectomy is performed in the usual manner, after which the internal carotid artery is transected and closed as a separate longitudinal arteriotomy that obliterates the carotid sinus cul-de-sac. The external carotid artery is then usually closed with a patch angioplasty. Since the external carotid artery is an important source of flow to the brain in patients with internal carotid occlusion, some investigators have recommended the use of an intraluminal shunt during operations to revascularize the external carotid artery. Such shunting is technically difficult because of the small size of the external carotid artery and multiple branchings, and we have thus far found it unnecessary to use a shunt on the basis of intraoperative EEG monitoring data.

Patients with common carotid occlusion usually have associated internal carotid occlusion. Such patients will almost invariably have patency of the external carotid artery. Selective injection and delayed filming techniques may be necessary to demonstrate retrograde fill of the branches of the external carotid artery. Such patients, when symptomatic, usually have decreased 133Xe cerebral blood flow and usually benefit from subclavian—external carotid artery bypass. Common carotid arteriotomy and endarterectomy are usually not necessary and bypass can usually be readily performed to a patent portion of the distal external carotid artery. The proximal anastomosis should be placed on the subclavian artery distal to the thyrocervical trunk so that this collateral network is not clamped during the operation.

Although seemingly a simple operation, external carotid revascularization has a 2% mortality rate and a 14% neurologic complication rate based on collective results from 21 patient series reporting 162 patients.4 This, in part, represents the extensive nature of the extracranial occlusive disease present in these patients and points out that external carotid endarterectomy cannot be taken lightly. Careful attention must be paid to patient selection and evaluation and to the technical considerations of the operation.

Finally, the external carotid artery must be considered when performing a standard carotid bifurcation endarterectomy. Although the end point of
the internal carotid endarterectomy is always carefully visualized and distal intima sutured when necessary, the external carotid artery is usually blindly endarterectomized with an uncontrolled distal break point. Although an imprecise external carotid endarterectomy is of little clinical significance in patients with patent internal carotid arteries, residual external carotid plaques frequently produce postendarterectomy bruits in the neck and such lesions may become important if there is an early or late occlusion of the internal carotid artery. Although external appearance and palpation of the external carotid pulse are of little use, intraoperative Doppler ultrasound, intraoperative real-time imaging, and intraoperative angiography can detect defects in the external carotid artery following endarterectomy. If any external carotid artery lesion is detected, the external carotid artery can be readily clamped without disturbing the common or internal carotid artery and the defect repaired through a separate arteriotomy with patch closure. This separate controlled endarterectomy of the external carotid artery does not significantly add to operative time and should be a routine consideration in standard carotid endarterectomy.

REFERENCES
Discussion

**Dr. Rex Ross** (Los Angeles, Calif.). I would like to address this question to Dr. Zarins. Dr. Zarins, you mentioned the use of the xenon flow studies that may be equivocal in helping to identify a patient who may be a candidate for reconstruction of the external carotid artery. I would like to suggest two procedures that will give you a great deal of information concerning the need for reconstruction of an obviously diseased external carotid artery. The first procedure is periorbital Doppler studies, including bilateral carotid compression maneuvers. The second procedure is ocular pneumoplethysmography (OPG-Gee) to measure retinal artery pressure. These two noninvasive tests performed together almost invariably will identify a cerebral hemisphere that is dependent on the external carotid artery.

**Dr. Zarins.** Yes, I believe those are good points. Certainly, the anastomotic channels between the external carotid artery and the intracranial circulation can be assessed by the techniques you have described and I believe that they are useful additional measures to the xenon blood flow test. I did not mean to imply that the xenon study is the only study that should be performed. Certainly, the techniques that you have described are important for the complete evaluation of the patient.

**Dr. Moore.** Dr. Ehrenfeld, do you perform external carotid endarterectomy when there is total occlusion of the internal carotid artery and, if so, how do you make the decision as to whether this is an appropriate operation?

**Dr. Ehrenfeld.** We certainly perform these operations, but I must emphasize the importance of doing them carefully. A number of years ago we wrote a paper that addressed pathways of embolization with internal carotid occlusions. A failed attempt at external carotid artery reconstruction can lead to stroke and blindness as was previously mentioned in Dr. Zarins' presentation. To be sure of the technical result of the operation I like to open well onto the external carotid artery to get direct visual control of the end point. If I am concerned, I will use a patch angioplasty and, if necessary, insist upon completion angioplasty to be certain of the technical result. It is also important to obliterete the cul-de-sac of the occluded internal carotid artery to prevent embolization from that source.

**Dr. Moore.** With respect to the preoperative noninvasive evaluation of patients prior to external carotid endarterectomy, I have not found the duplex scan to be particularly helpful in this instance other than to confirm the presence of a totally occluded internal carotid artery. Likewise, an OPG-Gee will only demonstrate the pressure gradient that you would expect to be present with a known total occlusion of the internal carotid artery. I believe the most important contribution to preoperative evaluation that we have heard this morning are those comments by Dr. Zarins with respect to xenon blood flow studies. I believe that his data are exciting and for the first time he has given us a method of preoperative selection of those lesions that are likely to result in increased cerebral blood flow following carotid endarterectomy.

**Dr. Zarins.** Dr. Moore, I would like to make one comment on the duplex scanner that I have found to be helpful in these circumstances. In those patients that may have common carotid occlusion, the duplex scan can identify a patent external carotid artery. Therefore, if you are considering a subclavian–external carotid artery bypass, the information gained from duplex scanning can help assure the presence of a patent carotid artery.

**Dr. G. Patrick Clagett** (Dallas, Tex.). I would like to...
ask Dr. Diaz a question. The natural history of a totally occluded carotid artery is not good. The latest report suggests a stroke rate of up to 8% per year in follow-up. Do you think the EC-IC bypass will change the natural history of the patient with a totally occluded carotid artery, and ultimately is there a place for a prophylactic EC-IC bypass in these patients?

Dr. Diaz. Those are both very good questions and we really do not have a definite answer for you yet. As you are all aware, the International Cooperative Study is supposed to release its data by the end of 1985. So far, in nearly 495 bypasses we have only had two patients who have had strokes following successful operations; however, we do not have a control group. We cannot correlate these results with a medically managed group of patients. Prophylactic bypasses are currently a very controversial topic and a very debated question. If I had a patient who was young, healthy, and otherwise had no significant problems, I would probably proceed with a prophylactic bypass. On the contrary, an elderly, poor-risk patient would not outlive his stroke risk, and therefore I would be less likely to recommend prophylactic operation.

Dr. Ramon Berguer (Detroit, Mich.). Dr. Zarins mentioned the value of the duplex scanner in identifying an external carotid artery in those patients who have both common and internal carotid artery occlusions. In our experience we have never seen a patient in whom exploration does not reveal a patent external carotid artery.

My second comment has to do with the suggestion of performing a carotid-carotid bypass, that is, using one carotid artery to revascularize the other. I would like to suggest an alternative: the transection of a common carotid artery low in the neck and then retroesophageal transposition to the contralateral common carotid artery. This technique does not require an interposition graft. The retroesophageal approach is indeed the shortest distance across the neck.

Dr. P. Kevin Zirkle (Norfolk, Va.). I would like to address this question to Dr. Zarins. Since December 1983, we have operated on two patients for external carotid stenosis and presumed internal carotid occlusion. Both of these patients appeared to have totally occluded internal arteries on late subtraction films. Yet both patients were found to have small but patent internal carotid arteries at the time of exploration. I would wonder how common this finding is and how one definitively establishes occlusion of the internal carotid artery preoperatively?

Dr. Moore. This is a terribly important observation and an excellent question. I would like to poll the panel as to their opinion.

Dr. Zarins, how many times have you found a patent internal carotid artery during the course of operation in which you planned to revascularize only the external carotid artery?

Dr. Zarins. I have found that to be the case only once. I think that it is an extremely unusual occurrence if you have good angiographic films. If the arteriogram demonstrates a clear stump of the internal carotid artery with a cul-de-sac, I believe that in those circumstances you can be 100% sure that the internal carotid artery is occluded distally. On the other hand, if you do not see such a clear, sharp cul-de-sac, there may in fact be a patent internal carotid artery. That possibility should be anticipated and you must be aware of it so that it is appropriately explored at the time of operation.

Dr. Moore. Dr. Ehrenfeld, what has been your experience?

Dr. Ehrenfeld. Dr. Stoney, my associate, has had this happen twice. I believe that we are more likely to identify a patent internal carotid artery with the use of digital subtraction angiography, particularly arterial subtraction angiography, than with the use of conventional angiography.

Dr. Moore. Dr. Ehrenfeld, that is certainly an appropriate comment. There is no doubt that digital subtraction angiography will improve the visualization of the "string sign," which will call attention to the actual patency of the internal carotid artery. In our own experience I can recall about six instances in which the internal carotid artery was patent when we had not anticipated this anatomic condition on the basis of an angiographic finding. It is a relatively infrequent occurrence but it does occur frequently enough that the first maneuver one should do after exposing the carotid bifurcation is to open the internal artery distal to the plaque to determine patency as evidenced by back-bleeding. If back-bleeding is present, then one should obtain an operative angiogram through the internal carotid artery to make sure that there is an intracranial connection and that there is no evidence of distal thrombus that might be dislodged with restoration of normal blood flow. When this happens, however, it is certainly a big "win" because one then needs to proceed with the conventional bifurcation endarterectomy, restoring normal blood flow to the internal carotid artery rather than a collateral enhancement procedure via the external carotid artery.

Along the same line, I would like to address another question to the panel: If you are presented with a patient who has either global or hemispheric symptoms in whom there is a radiologically apparent total occlusion of the internal carotid artery diagnosed with a good angiogram, no evidence of a "string sign," and only a minimal lesion present in the external carotid artery, how do you make a decision between repair of this potentially embolic source vs. proceeding with a primary EC-IC bypass?

Dr. Diaz. Under the conditions that you have described, we do not believe that there is much point in attempting to explore the carotid bifurcation. If the external carotid artery is normal or nearly normal, we would prefer to proceed directly with an EC-IC bypass.

Dr. Ehrenfeld. I would be guided by the x-ray features; if there appeared to be enough external carotid ste-
nosis, I would proceed with that operation. If not, I would leave it alone and allow the neurosurgeon to proceed with EC-IC bypass.

Dr. Robert B. Smith III (Decatur, Ga.). If you were presented with a patient who is experiencing embolic transient ischemic attacks from an ulcerated lesion of the proximal left common carotid artery, do you advocate ligating the common carotid artery proximal to the placement of a subclavian-carotid bypass graft?

Dr. Moore. The operation that I would do in that setting would be to divide the left common carotid artery and perform a carotid-subclavian artery transposition. This avoids the parallel flow and the risk of continued embolization. Dr. Zarins, would you like to comment on that question?

Dr. Zarins. Yes, I agree that you should eliminate the embolic source but you should also be sure that you have not missed another embolic source at the carotid bifurcation.

Dr. Stephen Anos. Dr. Zarins, you quoted a stroke rate of 14% with external carotid endarterectomy. Do you believe that is caused by low flow or emboli? If it is related to low flow, might a shunt lessen that stroke rate?

Dr. Zarins. In our experience with 20 revascularizations, we have had one stroke and that occurred 1 week postoperatively during a period of hypotension. We performed an angiogram on that patient and the repair was intact. I believe that these patients have a lot of disease, and many strokes may or may not be related directly to operative repair.

With respect to the question of shunt use, we do intraoperative EEG monitoring and we have not found any abnormalities during cross-clamping nor have we had any intraoperative problems to indicate the need for a shunt. It is technically difficult to use a shunt during external endarterectomy because the vessel is small and has many branches. From a technical point of view, I would prefer not to use a shunt.

Dr. Robert Courbier (Marseille, France). I would like to ask two technical questions. First, Dr. Ehrenfeld, do you use a left thoracotomy for subclavian artery repair? The second question is addressed to Dr. Moore. I was a little surprised to see that you never use a subclavian-subclavian bypass. In our experience, it is a very simple operation with a mortality rate that is virtually nil and the patency of the subclavian-subclavian bypass is much better than with the axillo-axillary bypass. Have you any reason for this preference?

Dr. Ehrenfeld. Dr. Courbier, we do use the left anterolateral thoracotomy exposure for the left subclavian artery and find it quite satisfactory. It is somewhat less well tolerated by the patient than a median sternotomy, but the exposure is excellent and it allows you to perform endarterectomy of the subclavian and the vertebral orifices under direct vision. The only technical difficulty that I find is the end point. This is often beyond the vertebral orifice and may be handled with tacking sutures or approached from the neck by transection and reanastomosis.

Dr. Moore. With regard to the subclavian-subclavian graft, that is a well-described procedure. We have used it on occasion. It is most appropriately used for revascularization for innominate artery occlusion and I believe that I have already expressed myself earlier by saying that lesions of the innominate artery are best approached by a direct transmediastinal rather than an extra-anatomic repair.

The subclavian-subclavian bypass, as reported in the literature, has about the same patency rate as the axilloaxillary bypass. It has the advantage of not bringing a graft across the sternum and utilizing a graft that will be shorter in length.

Dr. Giovanni Deriu (Padova, Italy). Dr. Diaz, when there is inaccessible stenosis of the internal carotid artery, is an EC-IC bypass helpful in preventing stroke when the inaccessible stenosis does not proceed to occlusion or do you ligate the carotid artery at the time of bypass?

Dr. Diaz. We cannot answer this question because we do not have a control group. In our experience the patients on whom we have operated who have had siphon stenosis or stenosis of the petrous portion of the carotid artery have not had a single stroke following EC-IC bypass in approximately 30 cases. This does not mean that the operation has solved the problem. It could mean that we have changed the flow pattern and have prevented an embolization. We have seen two patients in whom the internal carotid artery went on to asymptomatic occlusion following EC-IC bypass.

Dr. Moore. We have now reached the end of our allotted time for this morning’s session. I would like to take this opportunity to thank the audience for your enthusiastic participation and to thank the panel for an excellent discussion.