External Carotid Endarterectomy: Indications, Techniques, and Results

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 Naturally occurring collateral pathways connecting the external carotid artery branches and the intracranial cerebral circulation are well recognized and have been demonstrated anatomically, angiographically, and physiologically by various flow detection devices. Under normal circumstances, all internal carotid artery blood flow is directed intracranially, and flow through the collateral pathways is from intracranial vessels to the external carotid artery branches. Similarly, ocular blood supply is derived predominantly from the internal carotid artery via the ophthalmic artery. Thus, normally the external carotid arteries do not contribute significantly to intracranial or ophthalmic blood flow. In the case of internal carotid artery occlusion, the direction of flow in the collateral pathways reverses, and flow courses from the external carotid branches to the intracranial branches of the internal carotid artery. Thus, with occlusion of the internal carotid artery, the external carotid artery may become an important source of blood flow to the brain.

Occlusive or atheromatous changes in the external carotid artery can lead to transient ischemic episodes or amaurosis fugax when they are ipsilateral to an occluded internal carotid artery. These symptoms arise by the same physiologic mechanisms observed with the internal carotid artery, that is, embolization or hyperperfusion. A number of investigators have demonstrated the potential for increasing cerebral blood flow in patients with ipsilateral internal carotid artery occlusion and external carotid artery stenosis by external carotid endarterectomy.1-3 Embolization to the external carotid artery from the blind cul-de-sac of an occluded internal carotid artery can also be relieved by external carotid artery endarterectomy.

This chapter focuses on the indications, techniques, and results for external carotid endarterectomy performed alone for symptoms of cerebral or ophthalmic ischemia with ipsilateral internal carotid artery occlusion.

INDICATIONS

The indications for external carotid endarterectomy include (1) ipsilateral transient ischemic attacks (hemispheric or ocular) or stroke in patients with occlusion of the ipsilateral internal carotid artery and severe external carotid artery stenosis;4-6 (2) ipsilateral transient ischemic attacks (hemispheric or ocular) or stroke and occlusion of the ipsilateral internal carotid artery and moderate stenosis of the external carotid artery with ulceration;7 (3) ipsilateral transient ischemic attacks (hemispheric or ocular) or stroke, with a nonsignificant ipsilateral external carotid artery and thrombus within the cul-de-sac of the occluded ipsilateral internal carotid artery (Table 53-1).5-8 The most clear-cut indication for external carotid artery endarterectomy is monocular amaurosis fugax in patients with ipsilateral internal carotid artery occlusion and a microembolic source in the origin of the external carotid artery or the occluded carotid sinus. Other less clear indications for external carotid artery endarterectomy include nonlateralizing hemispheric transient ischemic attacks, global ischemia, adjunctive procedure to extracranial-intracranial (EC-IC) bypass, and asymptomatic stroke prophylaxis.6,9,10 Reports in the literature have not always clearly defined the indications for external carotid artery endarterectomy.

PATIENT SELECTION

Selection for external carotid artery endarterectomy among patients with clear indications has relied on diagnostic arteriography and duplex sonography for confirmation of appropriate lesions of the ipsilateral internal and external carotid arteries. In patients with less clear indications for external carotid artery endarterectomy, adjunctive studies, such as radiolabeled xenon (133Xe) cerebral perfusion scans, have been utilized to aid the selection process. Patients with a severe reduction in total cerebral blood flow, as evidenced by the 133Xe scan, and with bilateral internal carotid artery occlusion and external carotid artery stenosis can occasionally be treated with carotid endarterectomy.

TABLE 53-1. Indications for External Carotid Artery Endarterectomy

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Anatomy</th>
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<tbody>
<tr>
<td>Ipsilateral transient ischemic attack</td>
<td>Ipsilateral ICA Occlusion</td>
</tr>
<tr>
<td>Ipsilateral stroke</td>
<td>Ipsilateral ICA Occlusion</td>
</tr>
<tr>
<td>Ipsilateral transient ischemic attack</td>
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<tr>
<td>Ipsilateral stroke</td>
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</tr>
<tr>
<td>Ipsilateral transient ischemic attack</td>
<td>Ipsilateral ICA Occlusion</td>
</tr>
<tr>
<td>Ipsilateral stroke</td>
<td>Ipsilateral ICA Occlusion</td>
</tr>
<tr>
<td>Global ischemia</td>
<td>Ipsilateral and contralateral ICA Occlusion</td>
</tr>
</tbody>
</table>

ECA, external carotid artery; ICA, internal carotid artery.
ally benefit from external carotid artery endarterectomy to increase total cerebral blood flow. Successful external carotid artery revascularization can return blood flow, as measured by "Xe scan, to normal in 80 percent of these patients. In spite of these findings, the role of external carotid artery reconstruction in relieving nonlateralizing symptoms, presumably secondary to hypoperfusion, is unclear and not an entirely proven indication. Nonetheless, blood flow measurement by "Xe scan may be helpful.

**TECHNIQUES**

External carotid endarterectomy, as with internal carotid artery endarterectomy, can be performed under general or local anesthesia, depending on surgeon preference. Continuous invasive blood pressure monitoring is preferred. The carotid artery bifurcation is exposed through one of two standard approaches: a transverse midcervical incision or a longitudinal incision along the anterior border of the sternocleidomastoid muscle. Systemic anticoagulation with intravenous heparin is recommended prior to initiation of arterial occlusion. Technical considerations of importance in external carotid endarterectomy include mobilization and control of the branches of the external carotid artery, sufficient to extend the arteriotomy up the external carotid artery beyond the distal edge of the plaque. Placement of the arteriotomy can be varied, with the understanding that the goals of the procedure are to exclude the cut-de-sac of the occluded internal carotid artery as an embolic source, to perform a standard thromboendarterectomy of the external carotid artery, and to close the arteriotomy without narrowing the external carotid artery. Since the external carotid artery becomes an important source of collateral cerebral blood flow with internal carotid artery occlusion, some surgeons have recommended selective use of an intraluminal shunt during external carotid artery revascularization.

Such shunting is technically difficult because of the many side branches, the small size, and the distal tapering of the external carotid artery. We have not found intraluminal shunting to be necessary based on continuous electroencephalographic (EEG) monitoring data.

Three general techniques of external carotid artery endarterectomy meet these goals. Our preferred technique begins primarily with amputation of the occluded internal carotid artery, whose distal end is ligated or oversewn. The arteriotomy is extended from the origin of the internal carotid artery along both the common and external carotid arteries. Thromboendarterectomy is performed as previously described, with either primary closure or patch angioplasty (Fig. 53-1). Patch angioplasties with the use of prosthetic materials (Dacron and polytetrafluoroethylene), vein, and endarterectomized internal carotid artery have been described.

This technique of external carotid artery endarterectomy eliminates the internal carotid artery cut-de-sac, allows direct visualization of the endpoint of the endarterectomy, and allows the incision to be closed primarily or with patch angioplasty.

A second technique begins with a standard arteriotomy in the common carotid artery, which is then extended along the external carotid artery. Thromboendarterectomy is performed in standard fashion. The origin of the internal carotid artery is then occluded intraluminally with interrupted sutures at its starting point. The arteriotomy is then closed primarily, or if necessary, with patch angioplasty with any of the materials described (Fig. 53-2).

A third technique includes internal carotid artery angioplasty as an adjunct to closure of the endarterectomized external carotid artery. The internal carotid artery is mobilized beyond the bifurcation and ligated at the distal limit of the dissection. A Y-shaped arteriotomy is performed, with its base on the common carotid artery and the arms extending along both the internal and external carotid arteries. Standard thromboendarterectomy is performed to include all surfaces. The spatulated, transected internal carotid stump is then tapered to close the external carotid arteriotomy, facilitating a tapered transition from the common to the external carotid artery (Fig. 53-3).

**RESULTS**

The first report of external carotid endarterectomy ipsilateral to an internal carotid artery occlusion is credited to BB Jackson. This article is interesting for its prose and its description of external carotid angioplasty using the stump of the internal carotid artery, but it describes a procedure performed for thrombosis of the common and external carotid arteries in the face of long-standing internal carotid artery occlusion, with excellent results, rather than discussing external carotid endarterectomy in regards to current indications. During this same period, the Baylor group was performing external carotid endarterectomy forhemispheric ischemic symptoms, both transient and fixed, in patients with ipsilateral internal carotid occlusion and stenosis of the origin of the external carotid artery. Ten patients were reported, nine of whom had external carotid endarterectomy and Dacron patch angioplasty, and one of whom had thromboendarterectomy of both the common and external carotid arteries. Five of these patients had adjunctive vascular reconstruction of the contralateral carotid system. All patients were relieved of symptoms through 5 years of follow-up, although a 10 percent 30-day mortality was reported.

Subsequent experience with external carotid endarterectomy for symptomatic occlusion of the internal carotid artery, while uncommon compared with the experience with internal carotid endarterectomy, was notable for conflicting results provided by combining multiple small series of mixed patient populations. The problem with these results is that they included multiple adjunctive surgical procedures with external carotid endarterectomy, performed on patients with variable preoperative neurologic deficits that increased the perioperative stroke and mortality rates. More acceptable results have been obtained when external carotid endarterectomy alone was performed to relieve specific hemispheric or retinal symptoms (Table 53-2).

Connolly and Stemmer reported an operative series of 45 patients with internal carotid artery occlusion, ipsilateral external carotid artery stenosis, and symptoms of ipsilateral hemispheric ischemia. All patients underwent external carotid endarterectomy, and half of the patients underwent attempts at ipsilateral internal carotid artery thromboendarterectomy. Unfortunately, the morbidity and mortality rates for the majority of these procedures were not reported. The
authors did observe improved symptoms and durability of the external carotid endarterectomy in nine of these patients, with a 2- to 5-year follow-up.

The remnant internal carotid artery "stump" observed following occlusion of this vessel was recognized as a potential source of embolic phenomena in 1978. Nine cases of ipsilateral hemispheric transient ischemia or ipsilateral amaurosis fugax or both were recognized in patients with remotely occluded internal carotid arteries and a remnant "stump" greater than 5 mm in length. Seven of these patients underwent carotid bifurcation endarterectomy and either removal or obliteration of the internal carotid artery stump. Among those seven patients, there were no perioperative strokes, all symptoms were improved or resolved, and one patient had a fatal myocardial infarction 2 weeks after the operation.

The remaining two patients were observed; one underwent chronic anticoagulation and died from myocardial infarction 18 months later.

Correlation of successful external carotid artery revascularization ipsilateral to an internal carotid artery occlusion with improved regional cerebral blood flow was established in 1981. Eight patients with internal carotid artery occlusion, ipsilateral external carotid artery stenosis, and ipsilateral hemispheric ischemic symptoms underwent external carotid endarterectomy with no postoperative strokes or mortality, all with improved or resolved symptoms. "Xe
External carotid artery endarterectomy as performed through an arteriotomy on the common carotid artery, and extended onto the external carotid artery. After removal of the plaque, the internal carotid artery orifice is obliterated with suture, as illustrated. The arteriotomy can be closed primarily or with a patch.

Authors concluded that although external carotid artery endarterectomy was technically easy, its use should be recommended with caution. Further review of these data identified several potential modifiers of the results. Only 29 patients had unilateral external carotid artery endarterectomy alone. The remaining 20 patients had additional procedures, including EC-IC artery bypass, inflow bypass from the supra-aortic trunks, and bilateral external carotid artery endarterectomies at the same operation. The majority of perioperative strokes and the only perioperative death occurred among these 20 patients.

Enthusiasm for external carotid endarterectomy was tempered by the cautionary report of Haustuk and coworkers. On the surface, they reported a 13.8 percent perioperative stroke rate and a 2.7 percent perioperative mortality rate in a series of 49 external carotid artery revascularizations. The inhalation cerebrography was obtained preoperatively and postoperatively in five of these patients, with improvement in the postoperative mean regional cerebral blood flow rate in all patients and normalization of the mean regional cerebral blood flow rate in 80 percent of these patients.
patients. Among the 29 patients undergoing external carotid artery endarterectomy alone, there were no perioperative deaths, and 2 perioperative strokes (6.8%). One of these strokes occurred 3 days postoperatively in a patient who was maintained perioperatively and postoperatively on an intra-aortic balloon pump.

Similar information was provided by the Cleveland Clinic with their report of 42 external carotid artery revascularizations performed in 36 symptomatic and 6 asymptomatic patients. Among the 30 patients who had external carotid endarterectomy alone, the 30-day combined stroke and mortality rate was 0 percent. Among the 12 extended procedures requiring adjunctive EC-IC bypass, supra-aortic trunk inflow bypass, or external carotid artery reoperation, there were five perioperative neurologic events and one perioperative death, for a 30-day combined stroke and mortality rate of 50 percent.

A collective review published in 1987 attempted to further define the role of external carotid artery endarterectomy in patients with ipsilateral internal carotid artery occlusion and ipsilateral hemispheric or retinal ischemic symptoms. Twenty-three series of external carotid artery revascularizations were reviewed, and all cases with procedures other than external carotid artery endarterectomy or bypass were excluded from further review. Analysis of 195 external carotid artery endarterectomies and 23 external carotid artery bypasses identified postoperative resolution of ischemic symptoms in 83 percent and marked symptomatic improvement in 7 percent of patients. The 30-day combined perioperative stroke and mortality rate was 7 percent, although several of these cases were from the Halstuk series, and could be discounted for reasons cited earlier, lowering the combined stroke and mortality rate to 5 percent. The best results were identified in patients undergoing external carotid artery revascularization for indications of retinal ischemia or specific ipsilateral hemispheric ischemia. A separate retrospective review of 24 published series of external carotid artery reconstructions identified 192 operations in which external carotid endarterectomy was not associated with other procedures; the 30-day combined stroke and mortality rate was 1.6 percent.

More recently, small series of patients have been retrospectively reviewed for outcome following external carotid artery endarterectomy for ipsilateral internal carotid artery occlusion and symptoms of ipsilateral hemispheric or retinal ischemia. In three compiled series, 28 patients underwent external carotid endarterectomy, all experienced resolution of preoperative symptoms, and the 30-day combined stroke and mortality rate was 0 percent. Another series reviewed 16 patients with visual ischemic disturbances, ipsilateral internal carotid artery occlusion, and external carotid stenosis. One patient underwent external carotid artery bypass and 15 patients underwent external carotid artery endarterectomy, with no perioperative deaths, strokes, or retinal ischemic episodes. All patients were relieved of ocular ischemia postoperatively, and two patients suffered recurrent amaurosis fugax when their repairs thrombosed, one at 24 and one at 53 months postoperatively.

External carotid artery endarterectomy performed in patients with ipsilateral internal carotid occlusion and nonlateralizing symptoms of hemispheric ischemia has been infrequent with poor results identified to date. Combining the series and review of Sterpetti and associates, 18 of 36 patients (50%) undergoing external carotid artery endarterectomy for nonlateralizing symptoms were found to have relief from symptoms postoperatively. Most recently, a series of 21 external carotid artery endarterectomies in patients with ipsilateral internal carotid artery occlusion and symptoms of either ipsilateral amaurosis fugax (14) or ipsilateral hemispheric ischemia (7) was reported. The operations were performed safely, with no deaths or new strokes within 30 days of operation. Interestingly in this series, 14 percent of patients with amaurosis fugax and 71 percent of patients with hemispheric ischemia were not improved after external carotid endarterectomy. The patency and durability of external carotid endarterectomy were better when patch angioplasty was used than when primary closure was used.

**CONCLUSION**

Patients with internal carotid artery occlusion can develop ipsilateral amaurosis fugax and ipsilateral transient ischemic

<table>
<thead>
<tr>
<th>Study*</th>
<th>Patients, n</th>
<th>Mortality, n (%)†</th>
<th>Stroke, n (%)†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fisher et al</td>
<td>11</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Floriani et al</td>
<td>6</td>
<td>0</td>
<td>0</td>
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<td>Sattani et al</td>
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<td>0</td>
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<td>22</td>
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<td>Street et al</td>
<td>15</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Rash et al</td>
<td>19</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Boonje et al</td>
<td>11</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Lamberth et al</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
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<td>29</td>
<td>0</td>
<td>2 (6.8)</td>
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<td>0</td>
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<td>7</td>
<td>1 (14.3)</td>
<td>0</td>
</tr>
<tr>
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<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Zarins et al</td>
<td>9</td>
<td>1 (11.1)</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>208</td>
<td>2 (0.9)</td>
<td>3 (1.4)</td>
</tr>
</tbody>
</table>

*For full bibliographic information, see reference list at end of chapter.
†30-day perioperative rate.
attacks. In this setting, the external carotid artery becomes an important source of collateral blood flow to the ipsilateral eye and cerebral hemisphere. Atherosclerotic occlusive disease of the external carotid artery can lead to the development of flow-limiting stenoses as well as ulcerating plaques. When these occlusive disease changes are associated with ipsilateral internal carotid artery occlusion, they can serve as a source of emboli to the ipsilateral eye and cerebral hemisphere. The occluded internal carotid artery stump can also serve as a source of emboli.

In patients with an occluded internal carotid artery, ipsilateral external carotid artery endarterectomy can improve cerebral and retinal perfusion or eliminate an embolic source. The successful endarterectomy should exclude the stump of the endarterectomized internal carotid artery. Patch angioplasty of the arterectomized external carotid artery is recommended.

External carotid artery endarterectomy is indicated for the treatment of ipsilateral amaurosis fugax or ipsilateral transient ischemic attacks in the presence of an ipsilateral internal carotid artery occlusion and either an ipsilateral significant external carotid artery stenosis or ulcerated plaque or in the presence of an internal carotid artery stump with thrombus. Morbidity and mortality rates for external carotid artery endarterectomy are acceptable and are improved by adjunctive bypass procedures and contralateral cerebral revascularization procedures performed in association with the external carotid artery endarterectomy. The role of external carotid artery endarterectomy in relieving nonlateralizing symptoms of cerebral ischemia is incompletely defined, and the procedure likely is of little benefit.

REFERENCES