Outcome of the External Carotid Artery Following Carotid Endarterectomy with Added External Carotid Artery Eversion Endarterectomy

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Objective: To study the results of eversion endarterectomy of the external carotid artery (ECA) performed as part of standard CEA at a tertiary referral center using duplex ultrasonography.

Materials and Methods: Sixty patients (18 women and 42 men) who underwent 65 carotid endarterectomies at Waikato Hospital between January 2006 and July 2007 for significant internal carotid artery (ICA) disease were studied. The procedure also included eversion endarterectomy of the ECA with sharp transection at eversion end point. Preoperative and postoperative duplex scans were performed for all patients using Acuson (USA) ultrasound machine and by one sonographer. Postoperative follow-up scans at periods between 6 weeks and 18 months were reviewed and analyzed with Ascer et al. Doppler ultrasound-scan peak systolic velocity (PSV) criteria.

Results: Preoperative scans revealed significant bifurcation disease involving both ICA and ECA in all patients. The first post operative scan, done six weeks post-operatively, revealed one incomplete ECA endarterectomy, resulting in moderate (50%–74%) stenosis, while the rest had no evidence of residual ECA disease at the site of ECA endarterectomy. Over the post-operative period, sixteen (24.6%) ECA lesions and no occlusions were reported. The degree of ECA stenosis ranged from moderate to severe with PSVs ranging from 120 to 461 cm per second. All ECA lesions were ostial. Only 3 (18.7%) lesions were detected in the first nine months post operatively. Fifteen lesions were smooth and regular on duplex, while one had features of irregular residual stenosis. Eight (50%) were isolated ECA lesions, while the rest was associated with either ICA restenosis or occlusion.

Conclusion: ECA disease progression detected by Duplex ultrasound following eversion endarterectomy, as a part of CEA, commonly happens after 9 months and results in recurrent ECA stenosis, in most cases. Timing and features of the lesions suggest an intimal reaction as the aetiology in most cases. Eversion endarterectomy of the ECA does not predispose to ECA occlusion.

Key words: external, carotid, eversion, endarterectomy, duplex

INTRODUCTION

The role of the external carotid artery as a major contributor to collateral blood flow to the brain once the internal carotid artery (ICA) is occluded or stenosed is well established. The progression of the external carotid artery (ECA) disease following CEA and its neurological outcome has been the subject of some debate with some suggesting that ECA endarterectomy predisposes to ECA occlusion.
This is particularly relevant with the advent of ICA stenting where the role of ECA is completely overlooked.

In this retrospective study, we aimed to follow the progression of ECA disease following CEA with added ECA eversion endarterectomy by duplex ultrasound. Timing of appearance and ultrasonographic features of ECA lesions are evaluated as an indication of possible etiology.

**Materials and Methods**

The study group consisted of 60 patients (18 women and 42 men) who underwent 65 CEAs at Waikato Hospital between January 2006 and July 2007. The mean age was 67 years (range 59 to 78). All patients included in the study had significant bifurcation disease with stenosis in both internal and external carotids.

All patients had standard CEA for high grade ICA stenosis (symptomatic in 68% and asymptomatic in the rest).

The most common risk factor was smoking (66%). Other risk factors included diabetes mellitus (24%), hypertension (63%), and coronary artery disease (64%).

The CEA technique involved transmedial endarterectomy of the common and internal carotids ending with eversion of the proximal ECA as far as possible without opening the artery. To avoid intimal flaps, we released the occluding ECA clamp and then performed a sharp transection of the endpoint. Should the plaque break off with eversion, no further action was taken. All patients had patch repair of the carotid endarterectomy site.

Preoperative and postoperative duplex scans were performed for all patients using the same machine and by the same technologist. Postoperative follow-up scans at periods between 6 weeks and 18 months were reviewed and analyzed with Ascer et al. Doppler ultrasound-scan PSV criteria: $<150 \text{ cm/s} \leq 50\%$ stenosis, $150 \text{ cm/s} \text{ to } 250 \text{ cm/s} = 50\% \text{ to } 74\%$ stenosis, and $250 \text{ cm/s} = 75\%$ stenosis.$^1$

Data analysis is presented as the mean and a range or a nominal value with a percentage.

**Results**

No deaths or significant neurologic deficits were reported during the study period.

Preoperative scans revealed the distribution of disease detailed in Table 1. No vessel occlusions were detected preoperatively.

The first postoperative scan done six weeks postoperatively reported widely patent CEA site in all. One patient had incomplete ECA endarterectomy resulting in moderate (50%–74%) stenosis while the rest had no evidence of residual ECA disease at the site of endarterectomy.

Subsequent follow-up scans revealed sixteen (24.6%) ECA lesions in 16 patients (12 men and 4 women).

The degree of stenosis included 5 (31.2%) external carotids with $<50\%$ stenosis and a mean PSV of 134 cm per second (range 120 to 148), and 7 (43.84%) with moderate stenosis (50% to 74%) and a mean PSV of 176 cm per second (range 154 to 241). Severe stenosis (>74%) was present in 4 (25%) external carotids with a mean PSV of 312 cm per second (range 262 to 461). The distribution into different degrees of stenosis is shown in Fig. 1.

All ECA lesions were ostial. Only 3 (18.7%) lesions were detected in the first 9 months postoperatively. Eight (50%) were isolated ECA lesions: 7 were associated with mild ($<50\%$) ICA restenosis and 1, with moderate (50% to 70%) ICA restenosis.

**Discussion**

The importance of the ECA has been well documented as a source of collateral flow to the brain. Fearn et al. demonstrate that the ipsilateral ECA contributes at least 10% to 15% of middle cerebral blood flow in patients with severe ICA stenosis. The most important of these extracranial-to-intracranial collaterals is through the

<table>
<thead>
<tr>
<th>ECA Disease</th>
<th>Associated ICA Disease</th>
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<tbody>
<tr>
<td>Degree of Stenosis</td>
<td>Number of Vessels</td>
</tr>
<tr>
<td>50%–74%</td>
<td>6</td>
</tr>
<tr>
<td>&gt;74%</td>
<td>59</td>
</tr>
<tr>
<td>50%–70%</td>
<td>1</td>
</tr>
<tr>
<td>&gt;70%</td>
<td>58</td>
</tr>
</tbody>
</table>
ECA, collateralizing primarily through the periorbital plexus.2, 3)

Technical perfection is of paramount importance in performing carotid artery surgery, perhaps more than any other vascular reconstructive procedure, because of the potential danger of devastating perioperative stroke.4)

The importance of ECA patency was further emphasized by a study by Paty et al., where they found that treatment of external carotid disease, when flow cannot be restored to the ICA, also increases stroke-free survival, as compared with natural history data of up to 20% per year risk of recurrent stroke after nonoperative management of the ICA occlusion.5)

ECA occlusion or intimal flap after CEA presents as a potential source for either chronic embolization or a site for extended thrombosis and embolization in the acute situation.5, 6)

Amongst some technical variables in performing CEA, the method of removing plaque at the ECA has not been subject to a uniform approach, with a simple transection of the plaque at the orifice, blind endarterectomy into the lumen of the artery, or eversion endarterectomy; all being potential options for completing the endarterectomy in this area.1, 6)

The ECA is not usually treated in the same meticulous manner as the ICA during endarterectomy of the carotid bifurcation, where it is mostly endarterectomized in a blinded fashion. Undoubtedly, the rationale for this is to minimize the operative time, and specifically, the duration of carotid occlusion.2)

While the results of endarterectomy of ICA and common carotid artery have been excellent, scattered reports of less than acceptable short- and long-term results have been noted when these approaches are taken with the ECA. A partial explanation for this may be differences in the flow characteristics of the ECA, vis a vis the ICA and CCA, as well as the techniques utilized in handling the endpoint in the traditional approach to the ECA.7)

Our operative technique of performing the endarterectomy involves the use of regional anesthesia or general anesthesia with an ICA stump pressure measurement, selective shunting, and a standardized procedure (see methods) that includes a sharp ECA plaque transaction.

Carotid duplex scans were performed by the same vascular technologist using the same machine at Waikato Hospital vascular laboratory. The interpretation of ECA disease was obtained from cross-sectional and longitudinal B-mode ultrasound imaging, as well as from Doppler PSV measurements, based on the measurements of Ascer et al., who contributed a set of duplex-scan PSV criteria for ECA stenosis, on the basis of the magnetic resonance angiography of 60 arteries: 

- $<150 \text{ cm/s}$ = 50% stenosis, 150 cm/s to 250 cm/s = 50% to 74% stenosis, and $\geq 250 \text{ cm/s}$ = $\geq 75\%$ stenosis.1, 6)

Ascer et al. reported a 100% ECA patency rate and an 18% incidence rate of 50% stenosis and a 10% incidence rate of 75% residual or operatively produced ECA stenosis in the first month after CEA with simple transection of the plaque at the ECA orifice.1)

Our results were comparable with those of only one patient, having what seemed to be residual plaque from surgery detected by the first post operative scan, done within 6 weeks after surgery.

When endarterectomy relieves bifurcation stenosis, common carotid artery blood flow is redistributed.

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**Fig. 1** The distribution into different degrees of stenosis.
preferentially to the ICA at the expense of ECA flow, consistent with a change in the relative resistances of the two vessels resulting from operative reconstruction.\textsuperscript{8,9)} The timing of recurrence of most stenoses during a 9- to 18-month period, in addition to the ostial location, would suggest intimal hyperplasia and recurrent disease as primary etiologies.

Further research in the area with linkage to clinical outcome is needed.

**CONCLUSION**

Duplex ultrasonography shows that the ECA stays patent following CEA with eversion endarterectomy of the ECA and sharp transection of endarterectomy endpoint but is prone to recurrent stenosis. The timing of the stenosis indicates intimal hyperplasia and disease progression as possible etiologies.

Our data further supports previous work in this field, which suggests the stability of the ECA plaque and the low likelihood of its progressing to an occlusion.

**REFERENCES**