Flow Velocities in the External Carotid Artery Following Carotid Revascularization

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WHAT THIS PAPER ADDS

The ipsilateral ECA can potentially provide an important collateral pathway for retinal and cerebral blood flow in the presence of occlusion or severe stenosis of the ICA, especially in patients with an incomplete circle of Willis. Progression of disease in the ECA due to treatment of a stenotic ICA lesion during CAS or CEA could jeopardize collateral blood flow. Limitation of ECA patency might be a further argument against carotid artery stenting when a progression of stenosis is observed following CAS. We therefore studied the flow velocities in the ECA following CAS and CEA.

Objective: To study the changes in peak systolic velocities of the ipsilateral external carotid artery (ECA) following carotid revascularization.

Methods: All patients randomized to carotid artery stenting (CAS) or carotid endarterectomy (CEA) in the International Carotid Stenting Study (ICSS; ISRCTN25337470) in our center were included. Peak systolic velocities (PSV) were assessed with duplex ultrasound (DUS) at baseline, at 30 days, and at 12 and 24 months after treatment. Our primary outcome measure was the change in blood flow velocities in the ECA (ΔPSV_{ECA}). Secondary outcome measure was the prevalence of post interventional ECA occlusion.

Results: Of 270 patients enrolled in ICSS at our center, 224 patients (mean age, 68.8 years; 154 males) were included in the present study (116 CAS, 108 CEA). Baseline PSV in the ipsilateral ECA was similar between the groups. Following CAS, PSV gradually increased during follow-up, whereas PSV remained relatively stable after CEA; mean difference of PSV between CAS and CEA: 23 cm/s (95% CI, −5 to 52), 58 cm/s (95% CI, 27−89), and 69 cm/s (95% CI, 31−107) at 30 days, 12 months, and 24 months. One new ECA occlusion occurred after CAS and two after CEA.

Conclusion: Blood flow velocities in the ipsilateral ECA increase significantly after CAS but not after CEA. However, this does not lead to a higher rate of ECA occlusion in the first 2 years after revascularization. We conclude that CAS is not inferior to CEA in preserving the ECA as a possible potential collateral pathway for cerebral blood supply within 2 years following revascularization.

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INTRODUCTION

Carotid artery stenting (CAS) has been considered as an alternative to carotid endarterectomy (CEA) in the treatment of carotid artery disease.[1] In addition to inferior 30-day outcome regarding stroke and death rates following CAS compared with CEA,[2] recurrent stenosis and its management are reported disadvantages of stenting. Other possible disadvantages might be the covering of the orifice of the external carotid artery (ECA), or leaving the stenosis at the ECA origin untreated with stenting compared with optional ECA endarterectomy during CEA.

In many CAS cases, the stent is placed from the internal carotid artery (ICA), extending into the common carotid artery (CCA), thereby covering the origin of the ECA. Progression of disease in the ECA due to treatment of a stenotic ICA lesion during CAS or CEA could, if the ICA subsequently

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occludes, jeopardize collateral blood flow, especially in patients with an incomplete circle of Willis.[3–6] In contrast to the ICA, evaluation of development of ECA stenosis has been reported rarely.[7–9] As far as we know, only two (non-randomized) studies have been published so far concerning the effect of carotid stent placement on the ipsilateral ECA immediately after the procedure and during follow-up.[8,10] These studies report stenosis rates of the ECA ranging from 38% to 65% after 2 years of follow-up. The fate of the ipsilateral ECA following CEA has been investigated with[7] and without[9] additional endarterectomy of the ECA. Restenosis rates with blind endarterectomy of the ECA were reported as 40% after 2 years of follow-up while only 7% developed ECA stenosis after ICA endarterectomy without endarterectomy of the ECA.

In a previous study concerning flow velocities in the ICA in a comparable cohort, we observed increased peak systolic velocities in the ICA following stenting compared with CEA.[11] In order to analyze whether this relatively larger increase in flow velocities following CAS as opposed to flow velocity change after CEA also occurs in the ECA, we analyzed the changes in blood flow velocities in the ipsi- and contralateral ECA following either CAS or CEA within a cohort of the randomized controlled International Carotid Stenting Study (ICSS) during 2 years of follow-up.

METHODS

Patients

All patients in the present study were participants in the International Carotid Stenting Study (ICSS; ISRCTN25337470) at the University Medical Center Utrecht, the Netherlands, enrolled between September 2003 and October 2008. ICSS is an international, multicenter, randomized, controlled, open, clinical trial, comparing the risks, benefits, and cost-effectiveness of CAS and CEA in patients with a recently symptomatic ICA stenosis $\geq$50%. Patient criteria, randomization, and the results of an interim safety analysis have been described elsewhere.[2,12] Baseline demographic, clinical, and carotid imaging data were collected as part of ICSS. Randomization in ICSS was stratified by center, with minimization for sex, age, contralateral occlusion, and side of the randomized artery. The degree of carotid stenosis was assessed by duplex ultrasound scanning (DUS) in all patients and confirmed with either CT angiography (CTA) or MR angiography (MRA) prior to enrolment.

Carotid endarterectomy procedure

A vascular surgeon who had been approved by the Credentials Committee performed CEA. Shunts or patches were selectively used as required by the operating surgeon. In our vascular center, endarterectomy of the ICA was performed using a longitudinal arteriotomy with eversion endarterectomy of the ECA. Premedication (aspirin, statin, dipyridamol) was started prior to the procedure at the outpatient clinic and continued indefinitely during follow-up.

Carotid angioplasty and stenting procedure

A designated interventionalist performed CAS with percutaneous transluminal interventional techniques using femoral access. The type of stent and use of a cerebral protection device (CPD) were applied at the discretion of the interventionalist. Premedication (combination of aspirin, clopidogrel, and statin) was prescribed at a minimum 3 days prior to stenting to cover the period of stenting, and clopidogrel was prescribed for a minimum of 12 weeks afterwards. Aspirin and statin were continued indefinitely.

Duplex ultrasound scanning

DUS of the ipsilateral and contralateral carotid arteries was performed in a single vascular laboratory before randomization and at 1 month and 1 and 2 years after treatment (HP/Agilent, Sonos 2500 or 4500, Andover, MA, USA). At each time point the ipsilateral and contralateral PSV of ICA (PSV_{ICA}), ECA (PSV_{ECA}), and CCA (PSV_{CCA}) were recorded. The DUS criteria for the ICA used in our vascular laboratory are based on the modified strandness criteria (mild stenosis, $<$50% [PSV $<$ 125 cm/s]; moderate stenosis, 50—69% [PSV $>$ 125—230 cm/s], significant stenosis, 70—99% [PSV $>$ 230 cm/s] and occlusion).[13]

Outcome measures

Our primary outcome measure was the pattern of changes in blood flow velocities reflected by the change of PSV in the ECA following carotid revascularization. Our secondary outcome measure was the progression of ECA stenosis to occlusion.

Statistical analysis

We compared mean differences (MD) between treatment groups in the changes in PSV with a *t* test for equality of means. Cox regression analysis was performed to calculate hazard ratios. Effect estimates are accompanied by corresponding 95% confidence intervals (CI). A *p* value $<$.05 was considered statistically significant for all analyses.

RESULTS

Patients and follow-up

A total of 270 patients were enrolled in ICSS at our center, of whom 136 were randomized to CAS and 134 to CEA. Forty-six patients were excluded from the present study due to the following reasons: incomplete pre-interventional DUS ($n = 32$); ICA occlusion prior to revascularization ($n = 7$); death between randomization and actual revascularization ($n = 3$); or no intervention performed because of recent myocardial infarction ($n = 4$). Therefore, in total 116 CAS and 108 CEA patients remained for analysis in the present substudy. There were no significant differences in baseline characteristics between the two groups (Table 1). During follow-up all 224 patients completed follow-up at 30 days. A flow chart of the included patients during follow-up is shown in Fig. 1.