Intraoperative Carotid Artery Duplex Scanning in a Modern Series of 650 Consecutive Primary Endarterectomy Procedures


Purpose
Thromboembolic complications after carotid endarterectomy are frequently associated with technical defects. We analyzed the effect of intraoperative duplex scanning in detection of significant but clinically unsuspected technical defects and residual common carotid artery (CCA) disease as a potential source of postoperative transitory ischemic attack (TIA) and stroke.

Methods
From April 2000 to April 2003, 650 consecutive primary carotid endarterectomy procedures were performed in 590 patients at a single institution by two vascular surgeons. Patients included 335 men (57%) and 255 women (43%). Indications for surgery were asymptomatic internal carotid artery (ICA) stenosis (>80%) in 464 patients (71%). All procedures were performed with the patient under general anesthesia, with synthetic patch angioplasty in 644 (99.1%). Major technical defects at intraoperative duplex scanning (>30% luminal internal carotid artery stenosis, free-floating clot, dissection, arterial disruption with pseudoaneurysm) were repaired. CCA residual disease was reported as wall thickness (0.7-4.8 mm; mean, 1.7 ± 0.7) and percent stenosis (16%-67%; mean, 32% ± 8%) in all cases. Postoperative 30-day TIA, stroke, and death rates were analyzed.

Results
There were no clinically detectable postoperative thromboembolic events in this series. All 15 major defects (2.3%) identified with duplex scanning were successfully revised. These included 7 intimal flaps, 4 free-floating clots, 2 ICA stenoses, 1 ICA pseudoaneurysm, and 1 retrograde CCA dissection. Diameter reduction ranged from 40% to 90% (mean, 67 ± 16%), and peak systolic velocity ranged from 69 to 497 cm/s (mean, 250 ± 121 cm/s). Thirty-one patients (5%) with the highest residual wall thickness (>3mm) in the CCA and 19 (3%) with the highest CCA residual diameter reduction (>50%) did not have postoperative stroke or TIA. Overall postoperative stroke and mortality rates were 0.3% and 0.5%, respectively; combined stroke and mortality rate was 0.8%. One stroke was caused by hyperperfusion, and the other occurred as an extension of a previous cerebral infarct. No patients had TIAs. Two deaths were caused by myocardial infarction, and one death by respiratory insufficiency.

Conclusion
We believe intraoperative duplex scanning had a major role in these improved results, because it enabled detection of clinically unsuspected significant lesions. Residual disease in the CCA does not seem to be a harbinger of stroke or TIA.

Comments
The authors found that routine use of intraoperative ultrasound imaging helped them to improve their results during CEA surgery. Duplex scanning helped them to identify defects during surgery so revisions were able to be made at that time.
Cost-effectiveness of Intraoperative Imaging in Carotid Endarterectomy


Objective
There has never been a large, randomized controlled trial to assess the impact of intraoperative imaging on the success of carotid endarterectomy (CEA). This comparison involves cost-effectiveness analysis.

Methods
We constructed a decision-analytic model to compare effectiveness and costs of intraoperative ultrasound (IUS) and completion angiography as adjuncts to CEA. Data on procedural mortality, morbidity, and costs were obtained from the English-language literature. The review included a total of 52 reports, encompassing more than 22,000 patients. The main components of costs were those of the monitoring interventions and the care of perioperative stroke.

Results
Mean perioperative outcome without completion imaging is approximately 96.7% of what it would be in the absence of perioperative stroke or death. IUS and completion angiography each result in approximately 2% improvement in expected outcome. Mean perioperative costs are $396.50 for IUS, $721.30 for no monitoring, and $840.90 for completion angiography. Because IUS is significantly more effective at detecting technical errors that would likely result in perioperative stroke than no imaging and is significantly less costly than angiography, this strategy dominates the other two (i.e., it provides greater effectiveness at lower cost).

Conclusion
Although surgical complications are uncommon, IUS substantially lowers the rate of perioperative stroke and mortality and thus is significantly more cost-effective than either completion angiography or no operative imaging.

Comments
The conclusion from this study strongly supports the patient benefits of performing IUS because it lowers the rate of perioperative stroke and mortality. Furthermore, the authors demonstrate that intraoperative ultrasound is clearly the most cost effective method of quality control in CEA surgery.

Redistribution of Blood Flow after Carotid Endarterectomy


Objectives
We wanted to characterize the immediate effect of endarterectomy on flow of the arteries composing the extracranial carotid artery system.

Methods
Transit time ultrasound probes were used to measure flow through the carotid bifurcation in 48 patients undergoing endarterectomy. Maximum single-diameter stenosis affecting the internal carotid artery (ICA) was determined by angiography. The significance of differences between means were determined by t tests and analysis of variance; linear and nonparametric correlation analyses were also applied to analyze the relation between stenosis and several flow-derived parameters.

Results
Common carotid artery flow significantly increased (p=0.0043) from a mean value of 264 ± 99 ml/min to 314 ± 98 ml/min, corresponding to an average percent increase of 34.3% ± 71.3%. ICA flow increased from 128 ± 69 ml/min to 173 ± 66 ml/min (p<0.0001), with an average percent increase of 74.9% ± 114.9%. External carotid artery (ECA) flow decreased from 129 ± 61 ml/min to 106 ± 49 ml/min (p=0.0098), representing an average percent decrease of -5.2% ± 48.2%. The difference between ECA and ICA mean flow changes is highly significant (p<0.001). The percent change in ECA flow did not correlate with preoperative stenosis. We noted, however, a positive correlation between stenosis and the ECA/ICA flow ratio before endarterectomy (Spearman r=0.31, p=0.032), indicating that more severe stenosis led to a greater distribution of blood into the ECA. The ECA/ICA flow ratio fell from an initial value (ECFbef/ICFbef) of 1.52 ± 1.74 before endarterectomy to 0.69 ± 0.37 (ECFaft/ICFaft) after endarterectomy (p=0.0006).

Conclusions
The data are consistent, with the ECA being an important collateral path for cerebral perfusion when ICA stenosis exists. When endarterectomy relieves bifurcation stenosis, common carotid artery blood flow is redistributed 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.

Comments
This study illustrates the use of TTFM in research to characterize the immediate effects of endarterectomy on flow of the arteries composing the extracranial carotid artery system. For those interested in the details, we recommend reading the whole article. The authors point out that TTFM cannot detect intima flaps or other technical defects when flow is unimpeded. They suggest considering using duplex ultrasound in routine assessment of carotid artery surgery.
Intraoperative Duplex Ultrasonography in Carotid Endarterectomy: The Impact on Indication for Immediate Revision and Intermediate-Term Outcome

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Background
Thromboembolic complications in relation to carotid endarterectomies (CEA) are frequently associated with technical errors. We analyzed prospectively the impact of intraoperative duplex ultrasonography (IODS) in CEA on immediate revision and postoperative results.

Patients and Methods
We have observed 70 patients with 74 CEA. Indications for surgery were asymptomatic high grade stenosis (70-99%) or symptomatic stenosis of > 50%. IODS findings were related as “relevant”, “minor”, or “normal”. Relevant findings were immediately repaired. Peri- and postoperative neurological events were analyzed in Duplex Scans controls in a median length of follow-up of 17.3 months. Outcome of patients with “minor” findings (group A) were compared with patients having “normal” or corrected “relevant” findings (group B).

Results
In 8/74 cases (11%) we found relevant findings leading to immediate revision. In 25/74 (34%) cases minor findings were detected which were not revised. In group A (n=25, 34%) two asymptomatic occlusions and one recurrent high grade stenosis were found during follow-up. In group B (n=49, 66%) we detected two high and two low grade stenosis. The 30 day death and stroke rate was 1.4% (n=1).

Conclusions
IODS is a sensitive method to detect immediately pathological findings. Its correction seems to reduce the incidence of early occlusions and therefore early neurological events.

Comments
Lack of revision of clinically unrecognized technical defects may cause postoperative stroke. To perform quality assessment during surgery, one can perform intraoperative duplex ultrasonography (IODS) with the Medistim VeriQ CT™, which is a more convenient method than the one used in this study.

Changes in Internal Carotid Blood Flow after CEA Evaluated by Transit-Time Flowmeter

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Aim
The aim of this study was to investigate whether there was an association between the degree of the stenosis of the internal carotid artery (ICA) and postoperative increase of blood flow.

Methods and Materials
In 200 out of 660 patients undergoing carotid endarterectomy (CEA) for a high-degree ICA stenosis, pre-operatively a bilateral selective carotid and intracerebral angiography was performed. The degree of the ipsilateral and contralateral stenosis was digitally assessed by using computer software according to the CC-Index. Intraoperatively, the pressure ratio over the stenosis (ICA/CCA) was measured by direct arterial puncture. Blood flow in the ICA was measured before and after CEA with an ultrasound flowmeter using the transit-time principle. These findings were correlated to the degree of stenosis revealed by angiographic analysis and the pressure ratio.

Results
Before CEA the median blood flow in the ICA was 171 ml/min (range 620 ml/min) with a significant (p<0.001) post-operative increase to 250 ml/min (range 875 ml/min). The median relative increase of flow (post-flow-pre-flow/pre-flow) was 42%. The pre-CEA flow volumes were dependent on the degree of stenosis and also the pressure ratio. The increase of flow following CEA correlated better with pressure ratio (r=-0.435, p<0.001), than the stenosis severity (r=0.319, p<0.001). Analysis of variance identified only the pressure gradient as an independent determinant of flow changes following CEA.

Conclusions
The blood flow increase following CEA is mainly determined by the pressure gradient across the stenosis.

Comments
According to this paper, Cerebral Hyperperfusion Syndrome (CHS) accounts for up to 35% of all perioperative neurological events, and is believed to be due to impairment of the cerebral vessel autoregulation with maximal vasodilatation in the chronically under-perfused brain tissue. This study shows the importance of measuring blood flow after CEA surgery to be prepared to treat CHS.
Will Carotid Thromboendarterectomy Remain Competitive? Influence of Intraoperative Duplex Ultrasound Quality Control

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Background
Thromboendarterectomy (TEA) and stenting are in competition for treatment of carotid artery lesions. Both treatment modalities have to improve significantly. The goal of the study was to evaluate the influence of routine intraoperative duplex ultrasound examination.

Methods
In a continuous prospective study, 575 patients underwent 620 carotid operations. Intraoperative duplex ultrasound examination was performed prior to wound closure: 9.5% had significant contralateral ICA stenoses and 6.7% ICA occlusion; 8.5% presented special lesions. An eversion TEA was performed in 20.5% while 78.5% underwent conventional TEA with patch plasty and graft interposition in 1%. Intraoperative quality control revealed unexpected lesions in 10% requiring immediate repair.

Results
The combined morbidity/mortality rate (MMR) of the total series was 2.6%. Women had an elevated risk (4.2%) in comparison to men (1.9%). The risk of elder patients (>75 years, n=151) was remarkably low. The neurological complication rate of the total series was 1.6% and the incidence of major strokes 1.1%.

Conclusions
Routine intraoperative duplex ultrasound examination of the carotid reconstruction allows early diagnosis and immediate correction of morphologic as well as hemodynamic lesions. Competing with stent placement a further reduction of complications of carotid TEA seems to be possible and necessary.

Comments
As this is a very large retrospective study with >600 CEA operations enrolled, the fact that there is a 10% immediate revision rate strongly underscores the importance of performing systematic intraoperative quality control.