Carotid Endarterectomy Surgery with the Aid of VeriQ C™ Imaging and Transit Time Flow Measurements

A collection of abstracts illustrating the advantages of combining TTFM and intraoperative imaging in the quality assessment of carotid surgery

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

Aleksic M, et. al
Eur J Vasc Endovasc Surg
2006; 31: 14-17
University of Cologne, Cologne, Germany

Objective
To investigate whether there was an association between the degree of stenosis of the internal carotid artery (ICA) and post-operative 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 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/preflow) was 42%. The pre-CEA flow volumes correlated better with pressure ratio ($r=-0.435$, $p<0.001$), than with the stenosis severity ($r=0.319$, $p<0.001$). Analysis variance identified only the pressure gradient as an independent determinant of flow changes following CEA.

Conclusion
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 handle a CHS.

Improvement of Carotid Blood Flow After Carotid Endarterectomy-evaluation Using Intraoperative Ultrasound Flow Measurement

Eckstein, et. al
Eur J Vasc Endovasc Surg
2003; 25: 168-174.

Objective
To examine the relationship between the degree of extra cranial internal carotid artery (ICA) stenosis and changes in the ipsilateral ICA blood flow after carotid endarterectomy (CEA).

Methods
In a prospective study we studied 51 patients with unilateral 60-99% ICA stenosis (median degree 84%, asymptomatic stenosis n = 13, symptomatic stenosis n = 38). The degree of ICA diameter stenosis was determined by ex-vivo plastination of the surgically removed atherosclerotic specimen and video-assessed planimetry. Intraoperative transit time ultrasound flow measurements of the carotid arteries were performed before and after CEA. Blood flow changes were assessed by mathematical approximations. Statistics were done by use of the Wilcoxon signed Rank test.

Results
Common carotid artery (CCA) and ICA median blood flow increased after CEA from 370 and 130 ml/min to 450 and 282 ml/min, respectively ($p<0.001$). The relative increase of the ICA blood flow was 5% and 18% for 60-69% and 70-70% ICA stenosis (n.s.) but 70% and 247% for 80-89% and 90-99% stenosis ($p<0.001$ each). Mathematical evaluation (fourth-polynomial function) determined a significant increase of carotid blood flow after CEA in ICA stenosis of > 82.3%.

Conclusion
In the absence of severe contralateral ICA occlusive disease, a significant increase of ipsilateral ICA blood flow by CEA can be expected in patients with an ICA stenosis of > 82.2% (linear degree of stenosis, ECST criteria).

Comments
The data confirms that CEA of an unilateral ICA stenosis with a diameter reduction ≥ 80% will result in a significant increase of ipsilateral carotid blood flow. Therefore, even when there is only a unilateral stenosis, blood flow should be measured after CEA surgery in order to be prepared to handle Cerebral Hyperperfusion Syndrome (CHS).

Redistribution of Blood Flow after Carotid Endarterectomy

Gordon, et. al
J Vasc Surg
Oct 1995; 22: 349-360.

Objectives
We wanted to characterize the immediate effects 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 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 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% 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 the 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 (ECFbef/ICFbef) after endarterectomy ($p=0.0006$).

Conclusion
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 flow is redistributed preferentially to the ICA at the expense of the ECA flow, consistent with a change in the relative resistances of the two vessels resulting from operative reconstruction.

Comments
This study from 1995, 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 ultrasonography in routine assessment of carotid artery surgery.

Intraoperative Duplex Ultrasonography in Carotid Endarterectomy: The Impact on Indication for Immediate Revision and Intermediate-Term Outcome

C. Ott, et. al
VASA
May 2008; 37: 151-156
Kantonsspital Graübunden, Chur, Switzerland.

Objectives
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.

Methods
We have observed 70 patients with 74 CEA. Indications for surgery were asymptomatic high grade stenosis (70-99%) or symptomatic stenosis of > 50%. The transducer was placed in a gel-filled sleeve which allowed a direct contact to the artery. IODS findings were related as “relevant”, “minor”, or “normal”. Relevant findings were immediately repaired. Perioperative 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).

Conclusion
IODS is a sensitive method to immediately detect 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 a Medistim VeriQ C™ which is a more convenient method than the one used in this study.

Cost-effectiveness of Intraoperative Imaging in Carotid Endarterectomy

Burnett MG, et. al
Neurosurgery
Sept 2005; 57(3): 478-485
University of Pennsylvania, Philadelphia, PA.

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, it must be considered to be more cost effective than not doing quality assessments.

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