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Operative Factors Associated with the Development of New Brain Lesions During Awake Carotid Endarterectomy

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WHAT THIS PAPER ADDS

This study is the largest reported analysing subclinical cerebral changes associated with CEA. The study demonstrates that awake patients who need a shunt are more prone to develop DWI lesions detected by MRI scans 5 days later, and the use of a shunt is an independent predictor. Moreover, in patients who do not require a shunt eversion CEA is associated with significantly fewer DWI changes than patients having longitudinal endarterectomy and vein patch.

Objectives: The aim was to analyse a prospective, consecutive series of awake carotid endarterectomy (CEA) patients undergoing, when possible, pre- and postoperative diffusion-weighted magnetic resonance imaging brain scans (DWI).

Methods: All CEA patients from June 23, 2006, to January 13, 2012, were prospectively entered in the study. CEA was performed under regional cervical block. Only patients demonstrating shunt dependence were shunted. Before August 7, 2008, all longitudinal endarterectomy had been performed with a vein patch. From that date all CEA were eversions without a patch, except shunted patients who were vein patched. DWI was performed 2 days before and 5 days after (3 Tesla). Scans were reported by MRI-trained radiologists. Logistic regression analysis (LRA) identified predictive variables for MRI changes using backward stepwise elimination of variables with $p > .05$.

Results: There was a total of 295 consecutive CEA. There were no deaths but four clinical strokes (1.4 %); 89 excluded from DWI leaving 206; of these 27 (13%) developed new DWI lesions including four of 57 (7%) in the asymptomatic group and 23 of 149 (15%) symptomatic patients. Nineteen of the 206 (9.2%) were shunted. LRA showed that shunt dependence was highly associated with new DWI lesions: odds ratio (OR) 6.43; 95% confidence interval (CI) 2.3—17.9; $p < .001$. Both the vein patched, non-shunted group (OR .25; CI 0.09—0.72; $p = .010$) and the eversion (all non-shunted and all non-patched) group (OR 0.05; CI 0.01—0.22; $p < .001$) were associated with a low risk of new lesions, with the eversion group a lower risk than the patched group.

Conclusions: One in every eight CEA patients developed new DWI lesions (rate doubled in symptomatic patients). Shunt dependence in conscious CEA patients is highly associated with the development of new DWI lesions compared with non-shunted patients. For non-shunted patients the new lesion risk is low, and in those patients the risk in the eversion group is lower than in the patched group.

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INTRODUCTION

Carotid endarterectomy (CEA) is a proven stroke preventative measure and has been thoroughly scrutinized.[1—3] However, CEA will continue to face challenges from alternatives such as carotid artery stenting (CAS)[4,5] and best medical therapy (BMT).[6,7] Sensitive means to assess therapeutic efficacy are required.

Cerebral ischaemia can occur from embolism or haemodynamic disturbance. Subclinical cerebral micro-embolism can occur from carotid plaques.[8,9] Such embolism can be potentiated by surgical manipulation and should be assessed in addition to the traditional gross endpoints of stroke and transient ischaemic attack. Diffusion-weighted magnetic resonance imaging (DWI) is a well-established accurate method to diagnose acute cerebral infarction

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facilitating the analysis of procedural variables which may cause such events.[8,10] Such subclinical ischemia may be a risk factor for both future cognitive decline and for future clinical stroke.[9,11,12] DWI is a more accurate method than clinical examination to assess the brain for ischaemic change especially in asymptomatic patients.[13,14] Flow reduction during clamping could also cause DWI-detected ischaemia and this may be most relevant in patients who are shunt dependent and likely to have little cerebral reserve during the clamp time required for shunt insertion and removal. By documenting new DWI ischaemia using previously published CEA methods,[15] procedural variables having statistically significant influences on the cerebral findings could also be demonstrated.

METHODS

Patients

With local ethics committee approval all patients undergoing CEA by the same surgeon (BMB) between June 23, 2006, and January 13, 2012, were prospectively entered into the study with outpatient DWI 2 days before and 5 days after the surgery. Saggital T1, axial T2, diffusion weighted, coronal fluid attenuated inversion recovery and three-dimension time-of-flight magnetic resonance angiography sequences were obtained with a single 3-Tesla scanner as per the study protocol.

When enrolment for the study commenced in 2006, many coronary stents and other implants had not been tested with 3 Tesla, so patients with coronary stents, prosthetic cardiac valves, defibrillators and pacemakers were contraindicated and therefore excluded. In addition because 3-Tesla DWI was only available on an outpatient basis, referred inpatients also had to be excluded. Symptomatic patients with greater than 50% internal carotid artery (ICA) stenosis on duplex scan and asymptomatic patients with a greater than 80% ICA stenosis and a life expectancy over 3 years were considered operative candidates. All symptomatic patients were operated within 4 weeks of symptoms, some the same day.

If patients were not already taking aspirin it was commenced (100 mg daily) for at least 1 week before the procedure. All received an infusion of Dextran 40 as previously reported.[15] We were able to access Dextran 40 via an arranged access scheme from the Australian Therapeutic Goods Administration. The infusion was commenced on admission to hospital for 2—4 hours prior to the surgery at 20 mL per hour until the skin incision. It was recommenced after wound closure and continued until the next morning. Except for in- patient referrals, admissions were on the day of surgery. All patients were examined postoperatively at 30 minutes, at 3—4 hours, the next morning, and by the attending medical team 3—4 hours after that and discharged on the first postoperative day.

The scans were reported by any one of a group of four specialist cerebral MRI-trained radiologists, blinded to the patients' neurological presentation, to the side of the surgery, and to the outcome. All preoperative scans were reviewed by the radiologist who was reporting the postoperative scan. That radiologist may or may not have been the same person but was chosen to report according to an independently devised work roster. Comparisons were then made between preoperative and postoperative scans, specifically assessing for new radiological signs of ischaemia. Findings were recorded in detail; for statistical analysis they were simply graded as positive or negative for acute ischaemia after visual assessment of the diffusion images as outlined by Burdette et al.[10]

Method of CEA

CEA was performed in conscious patients using cervical block anaesthesia with early clamp control of the distal ICA.[15,16] Javid (Bard, Murray Hill, New Jersey, USA) shunts were used when there was neurological deterioration after ICA clamping. Only patients demonstrating shunt dependence were shunted. For shunt-dependent cases the test clamp was immediately removed to allow neurological restoration. The carotid bifurcation was then carefully exposed without clamp protection, the external carotid artery (ECA) was controlled with a silicone vessel loop, the ICA reclamped, and the common carotid artery (CCA) clamped. A longitudinal arteriotomy was performed through the plaque to reach plaque-free lumen proximally and distally. The shunt was then inserted distal small end first, allowing free back flow out of the shunt while the larger end was inserted into the CCA with the surgeons free hand controlling and clamping the CCA so that the CCA clamp could be removed. Clamp times without a shunt ranged from 30 to 45 minutes. Vein harvest added 15—20 minutes but was performed before definitive clamping or shunting. All patients were anticoagulated with intravenous unfractionated heparin (90 units per kilogram of body weight) and reversed with protamine sulphate (10 mg per 1000 units of heparin given) after declamping. Eversion endarterectomy followed complete oblique transection of the ICA opposite the ECA origin. Just before anastomotic completion, the CCA clamp was released with the arteriotomy pinched closed allowing the endarterectomised ICA to be subject to full arterial pressure while the ICA remained clamped to allow any fragments to be dislodged and flushed out of the circulation by back flow from the declamped ICA following CCA clamp reapplication. The ICA clamp was removed just as the arteriotomy closure was being completed allowing further back bleeding and venting of air. The ICA clamp was then applied at the anastomosis and the CCA clamp removed. The ECA clamp or sling was then removed allowing selective antegrade filling of the ECA for 5—10 cardiac contractions before final ICA clamp release.

Before August 7, 2008, all endarterectomy performed had been longitudinal and vein patched (LEVP). From then all CEA were eversions without patch and without shunt, except shunted patients who were all LEVP. The change to eversion endarterectomy was for logistic reasons based on shorter operative times coinciding with the necessity to teach vascular surgical trainees who had replaced general trainees.