Improvement in patients Cerebrovascular Reserve following Carotid Endarterectomy.

S. Goode[1,2], S. MacSweeney[3], and D. Auer[4]

[1]Academic Radiology, Queens Medical Centre, Nottingham, Nottinghamshire, United Kingdom, [2]Vascular Surgery, NUH, Nottingham, Nottinghamshire, United Kingdom, [3]Vascular Surgery, NUH, United Kingdom, [4]Academic Radiology, NUH, United Kingdom

Introduction

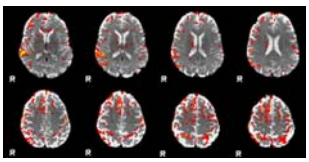
In patients with symptomatic carotid artery disease the predominant mechanism causing ischaemic injury is considered to be thromboembolic, however carotid stenosis and occlusion can also compromise cerebral haemodynamics. In particular stenotic disease can decrease CBF and Cerebrovascular Reserve (CVR) in the ipsilateral hemisphere, it has also been suggested that this reduced blood flow can result in impaired washout of emboli resulting in ischaemia in the territory distal to the stenosis[1]. Removal of the embolic source is accepted as the major benefit from Carotid Endarterectomy (CEA), however improvement in cerebral haemodynamics is also a key factor. Most of this data is from previous studies of patients' using Transcranial Doppler Ultrasound (TCD) to assess the reactivity of middle cerebral artery velocity following CO_2 stimulus[2-4]. Blood Oxygen Level Dependent (BOLD) hypercapnia fMRI can be used to produce high spatial resolution CVR maps and provide information on whole MCA territory reactivity as well as to identify small areas of impaired reactivity which are not detectable using TCD. Currently data concerning haemodynamic status prior to and after carotid endarterectomy (CEA) in patients is insufficient, and using this new methodology we are now able to gain more information on these changes. The aim of this study was to assess the haemodynamic effects of CEA on CVR in patients with carotid artery disease using hypercapnia fMRI.

Methods

12 patients with symptomatic internal carotid artery stenosis were scanned using a clinical 1.5T Intera (Philips, Best, Netherlands) MR scanner. These patients underwent a CEA and therefore were additionally scanned between 4-8 weeks postoperatively. Using a standard non-rebreathing anaesthetic circuit, 8 % carbon dioxide was administered to achieve transient episodes of hypercapnia; and the patients physiological parameters were continuously measured (blood pressure, pulse and arterial oxygen saturations). All patients underwent a 9 minute long paradigm consisting of 2 periods of hypercapnia (lasting 2 minutes 20 seconds) and 3 periods of normocapnia (air). The data was analyzed using FSL software. Before the time-series analyzes all the functional images were preprocessed using motion correction, high-pass filtering and smoothing. The individual activation maps of CO_2 for each patient were created by modeling the different conditions of normocapnia and hypercapnia on a voxel by voxel basis. To quantify the relative signal change for each patient the mean % signal change(%SC) following CO_2 stimulation was extracted from the grey matter of the MCA territory of each hemisphere, with the %SC being taken from the thresholded contrast maps and not normalised to CO_2. The degree of side-to-side asymmetry in the brain was calculated using the Hemispheric Asymmetry Index for all the patients pre and post CEA.

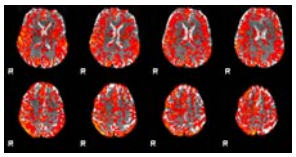
Results

We found a significant improvement in ipsilateral MCA territory CVR following CEA; Preop – Mean %SC 2.55 [SD 0.32] versus postop – Mean %SC 2.75 [SD 0.27], p=0.028 (Paired T-Test). There was no improvement in CVR in the contralateral MCA territory; Preop – mean %SC 2.62 [SD 0.46) versus postop – Mean %SC 2.68 [SD 0.25], p=0.699 (Paired T-Test). We also looked at the Hemispherical asymmetry index (HAI) and we found that there was a significant improvement in the mean HAI following CEA; Preop mean HAI 2.34 [SD 7.61] versus postop mean HAI -2.61 [SD 3.17], p=0.041 (Paired T-Test).

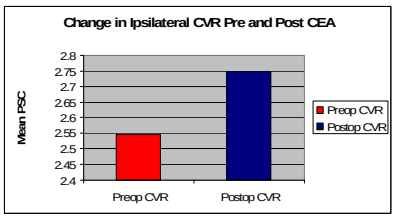


Pre Right CEA – CVR map of patient with Right sided 70-79% stenosis

Carotid Endarterectomy



Post Right CEA – CVR map showing improvement reactivity following CEA



Graph Showing Improvement in Mean % signal change in ipsilateral MCA territory following CEA

Conclusion

Our main finding is that in patients with carotid artery disease there is a significant improvement in the ipsilateral cerebrovascular reserve following CEA but no improvement in the contralateral territory. By looking at the AI in these patients before and after surgery we found that this asymmetry is actually reversed following intervention. These findings show that CEA benefits patients not only by removing embolic source, but also by improving their cerebrovascular reserve.

References

[1] Caplan LR et al. Cerebrovasc Dis, 2006. 21(3): p. 145-53. [2]D'Angelo V et al. Surgical Neurology, 1999. 51(3): p. 321-6. [3] Soinne L et al. Stroke, 2003. 34(7): p. 1655-61. [4] Telman G et al. Eur J Vasc Endovasc Surg, 2006. 32(4): p. 375-8.