BOLD fMRI Response in the Motor Cortex is Strongly Linked with CO2 Reactivity in Patients with Carotid Artery Disease.

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Introduction

Blood oxygenated level-dependent (BOLD) functional MRI (fMRI) has become a widely used technique to investigate brain activation. fMRI is an imaging technique whereby the physiological changes accompanying brain activation are assessed, by providing information on increases in blood flow accompanying neuronal activation. The method is based on haemdynamic changes and any alteration in neurovascular coupling, baseline blood flow or blood volume is likely to affect results. It has been shown that stroke and carotid artery disease reduce cerebrovascular reactivity (CVR) and this factor influences the response to motor tasks[1,2]. Patients with carotid artery disease can have a reduced CO_2 reactivity indicating a decreased or exhausted cerebrovascular reserve (CVR). We further investigated the relationship between the motor task induced signal change and the CVR in patients with carotid artery disease.

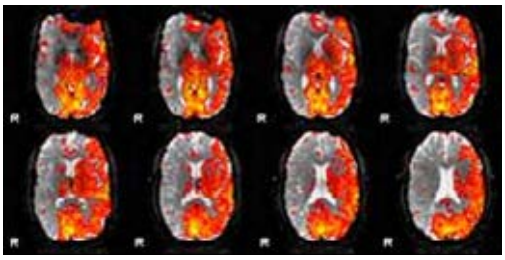
Methods

Eight patients (age 55-80) with moderate to high grade internal carotid artery stenosis or occlusion were investigated with motor task and CO_2 stimulation in the same session. The motor paradigm consisted of 5 alternating blocks of rest and activation with fist opening and closing. The rate of the task was regulated. During the 9 minute long CO_2 paradigm all the subjects had two periods of hypercapnia and 3 periods of normcapnia (Figure 2). Approximately 8% CO_2 level was provided during periods of hypercapnia. We analysed the data using FSL software (Figure 1). The mean percentage of signal intensity change during the motor task and CO_2 challenge was calculated separately for both motor cortices.

Results

There was a significant correlation between the BOLD responses to the motor task and CO_2 stimulation (Spearmans rho 0.809, $p<0.0005$) (Figure 3). No significant differences were found in motor BOLD responses between the side of the maximum stenosis and the contralateral hemisphere.

Figure 1 - *an example of CO_2 reactivity map from a patient with right sided carotid occlusion. The differences in signal change between the hemispheres are noted.*



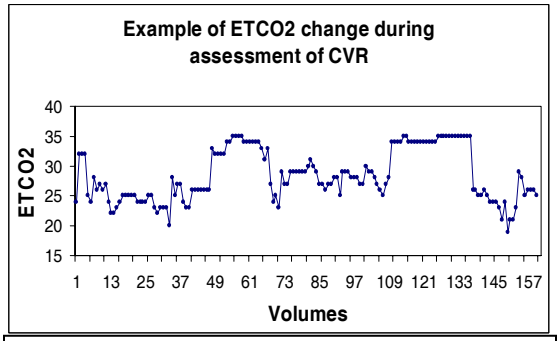


Figure 2 - *CO_2 Paradigm*

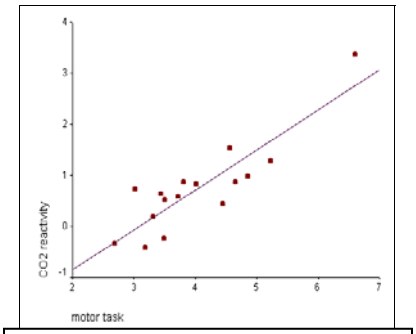


Figure 3 - *the percentage signal change in CO_2 and motor paradigm in all the hemispheres.*
Note - Spearmans rho of 0 .809, $p<0.0005$

Conclusions

These results confirm the effect of CO_2 reactivity on BOLD response in patients with carotid artery disease, and show that neurovascular coupling is linearly and strongly correlated with CVR. In the small sample no difference emerged between hemispheres suggesting that the degree of stenosis may be less relevant for the motor BOLD response than patients CVR. The observed relationship is important for designing clinical fMRI studies to avoid confounding effects from altered CO_2 reactivity. These results also highlight the need to fully investigate the haemodynamic situation of patients when interpreting BOLD fMRI data.

References

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2. Hamzei, F et al, The influence of extra- intracranial artery disease on the BOLD signal in fMRI. NeuroImage,20 (2003) 1393-1399