Variation in the Response to Breath-Hold BOLD fMRI in Patients with Impaired Cerebrovascular Reserve.

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Cerebrovascular reserve (CVR) is a measure of how well cerebral perfusion can increase when required. Decreased CVR is associated with a range of conditions including stroke and Moyamoya disease. Currently CVR is assessed prior to interior carotid – external carotid bypass surgery using single proton emission computed tomography (SPECT) and positron emission tomography (PET).

Breath-hold BOLD fMRI is an emerging technique for assessing CVR. The build-up of CO_2 which occurs when a subject holds their breath acts as a vasodilator, resulting in increased cerebral blood flow in normal subjects but less of a response in those with impaired CVR. The change in blood flow in response to CO_2 modulates the BOLD signal. In order to generate maps of CVR, fMRI uses general linear model analysis (GLM), comparing the time-series from each voxel to a regressor, related to the expected response. A number of groups have proposed ways to model this response, but few have studied patients known to have impaired CVR.

This study looks at the response to a 20s breath-hold in controls and a number of patients who are known to have impaired CVR. We defined the territories typically supplied by the cerebral arteries, producing six curves in total per subject. This allowed us to assess variation in response between different regions for our controls and the patient group.
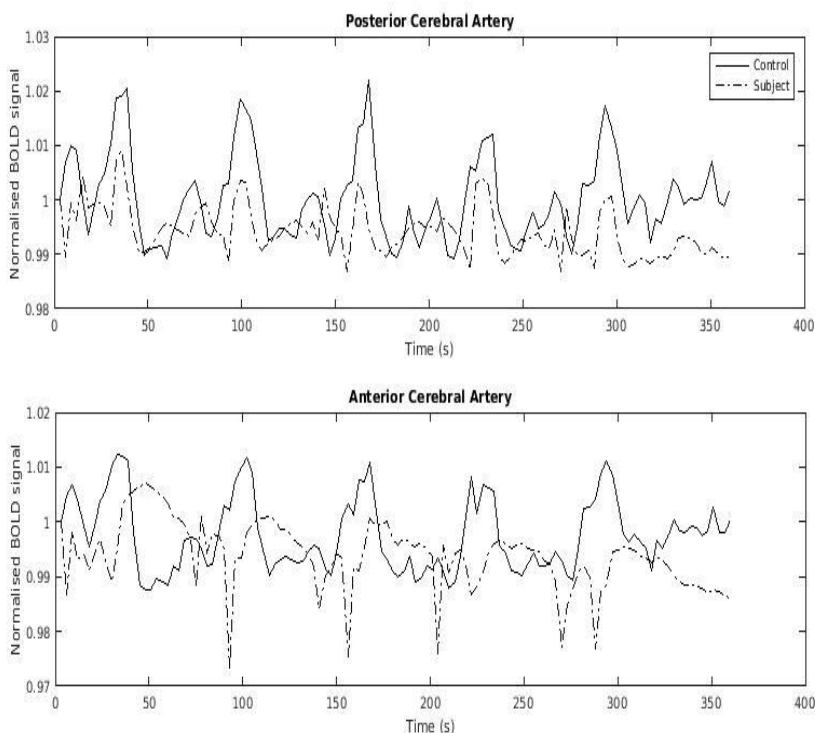
Figure 1: The response to a series of five breath-holds for a control and a subject with impaired CVR in the anterior region of the brain.

The top graph shows the responses in the territory of the posterior cerebral artery.

The bottom graph shows the responses in the territory of the anterior cerebral artery where CVR is impaired.

It was observed that in the patient population the shape of the response curve could differ markedly from that used typically as a regressor in the GLM; both the time delay and shape of the curve are different. If not accounted for, this variation has implications for the accuracy of CVR analysis with breath-hold BOLD fMRI in patients with impaired CVR.