MEASUREMENT OF HEMODYNAMIC PARAMETERS IN CAROTID OCCLUSIVE DISEASE USING PARTIAL VOLUME CORRECTED PCASL fMRI

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INTRODUCTION: One of the main advantages of arterial spin labeling (ASL) fMRI vs. BOLD is that ASL yields an absolute measurement of CBF – a key physiological parameter of brain function and metabolism. Therefore, ASL can be used to simultaneously measure both baseline and activation changes in CBF under various conditions. This is especially important in clinical applications where separating the changes in baseline from changes in activation patterns could prove crucial in understanding how the disease affects the brain. In this study, we used pseudo-continuous ASL (PCASL)1 to measure changes in baseline CBF (ΔCBFb) and changes in CBF due to motor activation (ΔCBFA) in patients with carotid occlusive disease. These changes in CBF are being regressed against cognitive measures acquired on the same patients. The overall goal of the study is to determine the hemodynamic factors that correlate with the severity of the symptoms in this patient population.

METHODS: This is an ongoing study with a recruitment target of 63 patients with ≥80% stenosis. To-date, we have imaged 6 patients (age = 76 ± 5 y, 4 females). For each patient, ΔCBFA is defined as the change in CBF per hemisphere using a bilateral finger-tapping paradigm2. The reported CBF values correspond to the BA4 motor-ROI obtained from pickatlas and conjoined with each patient’s gray matter (GM) mask2. The motor activation paradigm consists of 4 ON-OFF blocks, 4 minutes each as previously described2. Briefly, each ON-OFF block consists of 30 ASL time-points (15 per condition) and is repeated 8 times (i.e., 120 ASL time-points per condition). Average baseline CBF is computed from the ASL images obtained during the OFF blocks.

Image Acquisition: The following images are acquired on a Philips 3T scanner: (1) Structural MPRAge, used to obtain tissue information3; (2) PCASL as per Osch et al.4, using labeling duration of 1.9s and post-labeling delay (PLD) = 1s; (3) FLAIR used to measure white matter hyper-intensities (4) T2*-weighted image for measuring the presence of microbleeds. Furthermore, we obtained arterial transit time (ATT maps) on 7 subjects prior to the start of the study. This map is used for computation of CBF on all patients as detailed in Borogovac et al.2.

Image Analysis: ASL images were analyzed using a method described in detail in Asllani et al.1. We use partial volume correction (PVEc) analysis of ASL data4 to account for hemispheric changes in brain atrophy. Each patient’s MPRAge is used to obtain voxelwise tissue information as posterior probability maps3.

Data Analysis: For each patient, the unaffected hemisphere is used as the control. A paired t-test is run on both (ΔCBFb) and (ΔCBFA) to investigate the effect of occlusion on the BA4 motor-ROI. To account for the smoothing effect of the PVEc method, we modified the activation kernel based to the shape of the BA4 motor ROI as schematically shown in Fig.1.

RESULTS: Baseline CBF randomly selected patient are shown in Fig.1. NOTE that the PVEc ASL method yields flow density images (panels 1-3, left to right), which represent the amount of flow per unit GM tissue, and therefore do not contain structure information4,5 (i.e., GM/WM contrast). We use these images to account for brain atrophy, which can be substantial in this population. All patients showed hemispheric asymmetry in baseline CBF.

The hemispheric asymmetry defined as the difference in avg. CBF between the two hemispheres was 16 ± 4 (t=2.6, p<0.005). We report % change data rather than absolute values to account for variability in baseline CBF across patients. Interestingly, the ΔCBFa did not correlate with ΔCBFA, i.e., not all patients showed asymmetry in ΔCBFA. For example, for one of the patients, while the difference in ΔCBFa between the two hemispheres was significantly different (avg ΔCBFa 18 mL/100g*min, p>0.005), the change in CBF due to activation was statistically the same [(ΔCBFA) Right - (ΔCBFA) Left ~ 7 mL/100g*min, p>0.005].

DISCUSSION: Use of an fMRI platform to investigate cerebral hemodynamics is justified by the wide availability of MRI at stroke centers throughout the country. Should our methods prove to be useful as a clinically relevant diagnostic tool, there would be much wider application than what currently available. Importantly, the results shown here provide further evidence for the inadequacy of BOLD fMRI for studying activity in neurovascular disease6.

REFERENCES: 1Dai W. et al., MRM 60(6), (2008); 2Borogovac A. et al., JCBFM 30 (2010); 3Gevers S. et al., JCBFM 31(8), (2011); 4Asllani I. et al., MRM 60(6), (2008); 5Chappel M.A. et al., MRM 65 (2011); 6Blicher J.U. et al., JCBFM 32(11), (2011).