MEASURING LONGITUDINAL CHANGES IN CBF IN POST-STROKE RECOVERY USING PARTIAL VOLUME CORRECTED ASL PERFUSION MRI

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INTRODUCTION: The aim of this study is to use partial volume corrected (PVEc) arterial spin labeling (ASL) perfusion MRI to characterize diaschisis and determine its contribution to hemiparesis following subacute stroke. The factors that contribute to initial symptom severity and subsequent recovery remain largely unknown. Patients show considerable variability in the initial severity of hemiparesis from infarcts of similar size and location. Variability is also seen in recovery from hemiparesis; patients with large strokes and a severe initial deficit can make a good recovery while patients with small infarcts can make a poor recovery. A likely factor contributing to variability in stroke outcome is how the rest of the brain responds to the focal injury. It is known that stroke leads to a reduction in CBF in areas remote from the focal infarct, often in another arterial territory. This phenomenon is called *diaschisis*. Studies suggest that initial stroke deficits are due, in addition to the lesion itself, to a combination of mechanisms, including edema and metabolic disturbances, decreased neuronal function in the ischemic penumbra, and diaschisis[1]. Recovery is attributed to resolution of these processes and to reorganization. It is known that the degree of hemiparetic deficit at one month is more predictive of outcome at 6 months than the deficit at one week. Here, for each patient, PVEc ASL CBF images are compared across two time points: within-one-month and 6-months post-stroke. Furthermore, each patient is compared against an age-matched, stroke-free control group via a one-to-many statistical analysis.

METHODS: *Patients*: Baseline PVEc ASL CBF[1] images were obtained at two time-points: within 3-4 weeks of the subacute stroke, and 6 months post-stroke, from 28 patients (17 males, age 64±8 years). Only patients with clinically determined hemiparesis within 3 to 4 weeks of their first symptomatic ischemic stroke have been recruited. *Age-matched controls:* ($n_{controls}$ = 50) consist of neurologically intact adults, both male and female recruited from the NOMAS cohort[2]. *Imaging*: Images were acquired in a 1.5T scanner (Philips) using a standard transmit-receive coil. For CASL, single shot SE-EPI: TR/TE=4s/36ms, θ=90°, FOV=220x198 mm², acq. matrix=64x58, 13 slices (8mm/1mm-gap) were acquired. To induce the adiabatic inversion of water spins, a block-shaped RF pulse, 1.8s long, 35 mG amplitude, and a *z*-gradient, 0.25 G/cm, was applied prior to acquisition of each labeled image[r]. To correct for off-resonance effects, an amplitude modulated (250 Hz sine) RF pulse of the same power and gradient was applied before the acquisition of each control[3]. Labeling plane was positioned 100mm beneath the center of the imaging volume. 30 control/label pairs were acquired for 3 PLD values: 500ms, 800ms, and 1000ms. A high resolution, 3D T1 (SPGR): TE/TR=3 ms/34 ms, θ =45°, 100 slices (1.5mm/1mm-gap), FOV=240x240mm², acq. matrix=256x256, was also acquired. *Image Processing*: Gray matter (GM) flow density maps (CBFd) were obtained using the PVEc ASL method[4]. *Data analysis*: For each patient, the GM flow CBFd images were compared with the controls using a one-to-many statistical analysis, for each time point. In addition, a voxelwise paired t-test (α=0.05) was run for the two time points (6months apart) in each subject.

RESULTS: In Fig.1 GM CBFd images from a stroke patient (62 yo, male) are compared across two time-points: within-1-month (2nd row) and 6-months post stroke (3rd row); the difference is shown in the 4th row. SPGR images are shown in the 1st row with the lesion visible in the R posterior caudate-putamen (1st row, middle panel.) Fig.2A shows SPM{T} for the voxelwise (controls-patient) comparison for the within-1-month scan. Significant decreases ($p<0.01$, $\alpha_{uncorrected}=0.05$) in CBFd were found in the anterior cingulate, superior temporal gyrus, insula, middle frontal gyrus, superior frontal gyrus, caudate, and fusiform gyrus. Inspection of the voxelwise (controls-patient) contrast of the 6-month data (Fig.2B) indicates marked improvement in the contralateral (L) side in: anterior cingulate, superior gyrus, insula, superior, medial, and inferior frontal gyri, inferior parietal lobe, caudate, and superior temporal gyrus. No regions survived the statistical threshold for a control subject (bootstrap test). We also report on the correlation of the changes in CBF with changes in motor deficit over the same time period.

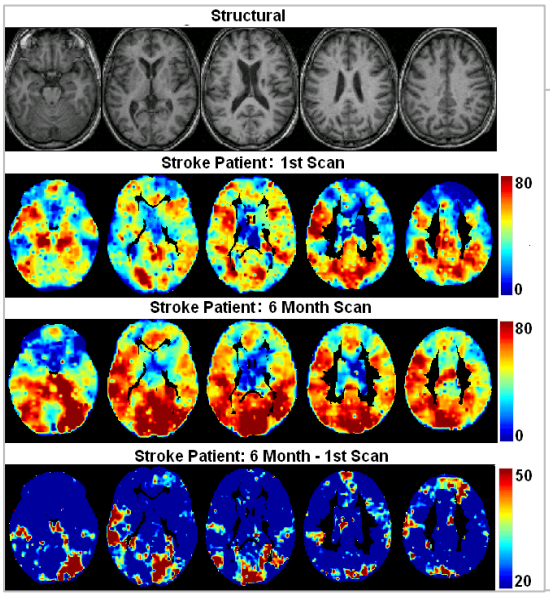

Fig.1 (left): Within patient comparison of PVEc ASL CBFd images from the within-one-month of the sub-acute stroke (2nd row) and 6-months post-stroke (3rd row). The difference between the two time-points (thresholded at 20mL/100g·min) is shown in the 3rd row. Structural images are shown in the 1st row. Note the lesion in the middle panel of the 1st

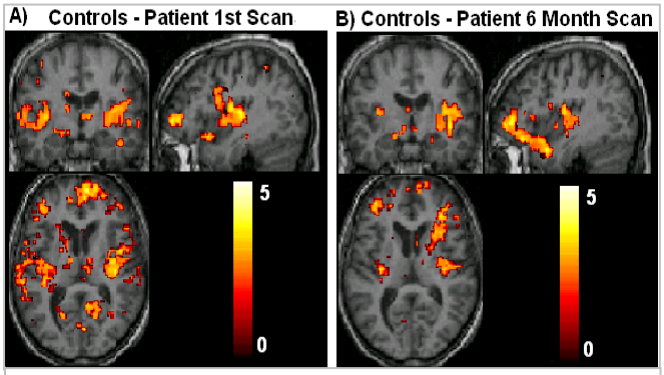

Fig2: SPM{T} maps of the controls-patient contrast for the within-one-month (A) and 6-months (B) post-stroke time-points. The patient was diagnosed with Right posterior caudate-putamen subacute stroke. Note marked improvements with time in the contralateral (L) side.

DISCUSSION: Absence of the 1/f noise makes ASL ideal for tracking slow-varying changes in the brain such as those due to recovery after stroke. Here, we have presented preliminary results that show feasibility of PVEc ASL for characterizing diaschisis. By using a partial volume corrected variant of ASL, we can measure flow density maps that are less sensitive to intersubject variability in brain structure and tissue content. **REFERENCES** [1]Sandson *et al.*, Neurology, 1996; [2]Asllani *et al.*, NeuroImage, 2008, [3]Alsop & Detre , JCBFM, 1996, [4]Asllani *et al.*, MRM, 2009.