Detection of Brain Activation Using High-Resolution Arterial Spin Labeling Perfusion fMRI at 3T

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INTRODUCTION: We face a pressing demand for development of fMRI methods that meet the needs of clinical applications. As a method that can directly and reliably measure cerebral blood flow (CBF), arterial spin labeling (ASL) is primed to rise to this challenge[1]. One drawback of ASL is its relatively low spatial resolution, a consequence of its inherently low SNR. Measuring and improving the SNR of high-resolution ASL is an important step toward increasing its utility. To this end, we tested the feasibility of high-resolution (1.15 x 1.15 x 3 m^3) ASL for detecting changes in CBF due to motor activation at 3T and compared its SNR to that of the more commonly employed low-resolution (3.4 x 3.4 x 3 mm^3) ASL. We also investigated how the CBF measurement is affected by correcting for partial volume effects (PVE).

METHODS: For each subject (n = 5, age = 46 ± 6 y, 3 men), the following images were acquired on a Philips 3T scanner: (1) MPRAGE, used to obtain tissue information[2]; (2) PCASL with labeling duration = 2 s, post-labeling delay = 1.5 s, effective TR = 8.8 s, 8 slices. All subjects signed informed consent and the study was approved by the IRB of LUMC. The activation paradigm consisted of two [rest(OFF)-activation(ON)] blocks. For the high-resolution ASL, each ON-OFF block contained 20 CBF images (10/condition); for the low-resolution each block contained 10 CBF images (5/condition). Motor activation was achieved via sequential finger tapping. In addition to using the conventional method[1], ASL CBF images were also processed using PVE correction (PVEc) method[3]. The activated motor-ROI was defined by the voxels that survived the statistical threshold $T \geq 2$ (paired t-test, α=0.5, corrected for multiple comparisons with a cluster size of 20 voxels.) One of the subjects was scanned 3 times, 24 hours and 44 days apart.

RESULTS: To give a sense of the quality of the high-resolution ASL imaging at the single-subject level, resting CBF images (20/subject) are shown in Fig.1. The statistical T-map for the activation contrast from one of the subjects is shown in Fig.2; the T-maps for the other subjects were similar. While the PVE-correction did not affect ($p>0.2$) the high-resolution images (Fig.3A), it had a significant effect ($p<0.005$) on the low-resolution ASL (Fig.3B). A summary of the CBF measurements averaged over all the subjects for each condition is given in Fig. 4. The coefficient of variation for the repeat measurement (24 hours and 44 days apart) was 0.11 and 0.19 for resting and activation CBF, respectively.

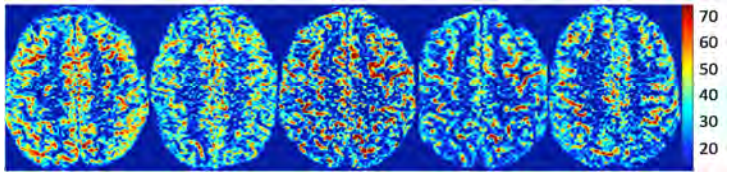

Fig. 1: High-resolution (1.15 x 1.15 x 3 mm^3) baseline ASL CBF images from the 5 subjects. (Units in are in mL/100g*min.)

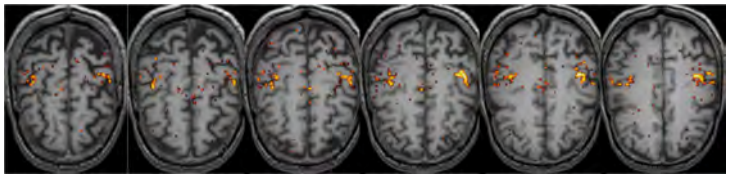

Fig.2: T-maps (ON-OFF contrast) from the high-resolution CBF images are overlaid on the subject's MRPAGE. (Only voxels with T>2 and that had > 4 neighbors with T>2 were included.)

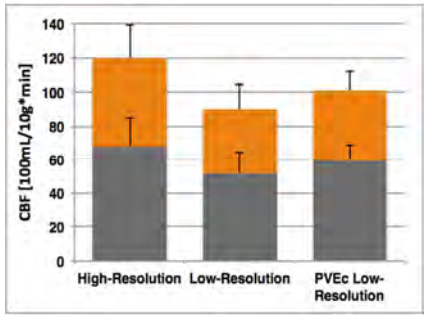

Fig. 4: Group-averaged CBF of the motor-ROI at rest (grey) and activation

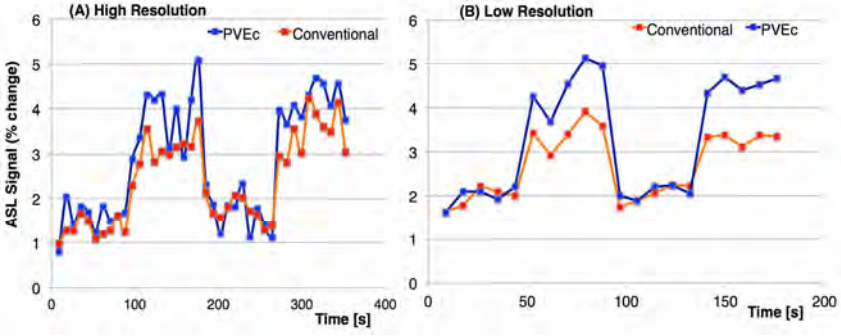

Fig.3: (A) High resolution ASL signal averaged over a representative subject's activated-ROI for each time-point. (B) Same as (A) but for low resolution data.

CONCLUSION: We have shown the feasibility of high-resolution ASL imaging at 3T, which could prove useful in applications where the region of interest is too small (e.g. hippocampus) to be adequately captured by the low-resolution ASL.

REFERENCES: [1]Alsop D.C. et al., *Magn Resn Med* in press, 2014; [2]Borogovac A. et al., *J Cereb Blood Flow Metab* 30(10) 2010; [3]Asllani I. et al., *Magn Resn Med*, 60(6) 2010.