Measurement of Deep Gray Matter Perfusion Using a Segmented True FISP ASL Method at 3T

E. Grossman[1], K. Zhang[1], J. An[2], A. Voorhees[3], M. M. Inglese[1], Y. Ge[1], J. Xu[3], and Q. Chen[1]
[1]NYU School of Medicine, New York, NY, United States, [2]Siemens Medical Solutions, Beijing, China, [3]Siemens Medical Solutions, Malvern, PA, United States

Introduction: Most pulsed arterial spin labeling (ASL) methods are based on echo planar imaging (EPI), which is prone to image distortion caused by local magnetic field inhomogeneity, especially at higher field. For example, imaging at the basal ganglia level with EPI can be particularly challenging. In our current work, we investigated the use of a true FISP based ASL sequence (1-3) for the measurement and quantification of local perfusion in deep gray matter. Our preliminary results show that this sequence is capable of measuring local tissue perfusion with high spatial resolution, and without any distortion commonly associated with EPI imaging.

Methods: All studies were performed on 3-T Siemens Trio scanners. Eleven normal human subjects (6 male, 5 female, age = 35.5 ± 9.9) were studied. A segmented true FISP sequence was combined with a FAIR (4, 5) ASL technique for our current work. A FOCI inversion pulse was applied every 5 s to allow for recovery of longitudinal magnetization. The FOCI pulse has a slice thickness of 2.5 times the thickness of the imaging slice to compensate for imperfect slice profile. Imaging parameters were: TR/TE = 3.2ms/1.6ms, FA = 50 deg, section thickness = 6-8 mm, matrix size = 192-256 x 192-256, and field of view = 25 - 30 cm. For all subjects, TI of 1200 ms was used for perfusion measurement. A separate scan with the IR pulses absent was also performed for M0 estimate. In addition, a pair of images were also acquired at TI_0 = 100 ms to correct for the off-resonance effects using an approach described by Figueiredo et al. (6). For one subject, additional pairs of label and control image were also acquired at inversion time TI of 85, 250, 750, 1000, 1250, 1500 and 2000 ms to obtain a "typical" transit delay time associated with the sequence. A general kinetic model described by Buxton et al. (7) was used for the calculation of local perfusion in deep gray matter and in frontal white matter. Figure 1A and B show outlines of the eight ROIs (red circles) that were selected for absolute quantification of perfusion in each subject, which included the left and right thalamus, putamen, caudate and frontal white matter.

Results: An example of control and labelled (slice selective and non-selective inversion) images obtained with the current technique is shown in Figure 1A and 1B. Note the signal intensity in the control image is higher due to un-inverted blood flow entering the tissue space. A qualitative blood flow map, shown as the difference between control and labelled images, is displayed in Fig. 1C. Using the Buxton model (7) and T1 values obtained in published works (8, 9), absolute perfusion was obtained from the 8 selected regions of interest (left and right thalamus, putamen, caudate, and frontal white matter) in all 11 subjects. Figure 2 is a bar graph displaying the perfusion values measured in these subjects with the mean and standard deviations indicated by the error bars.

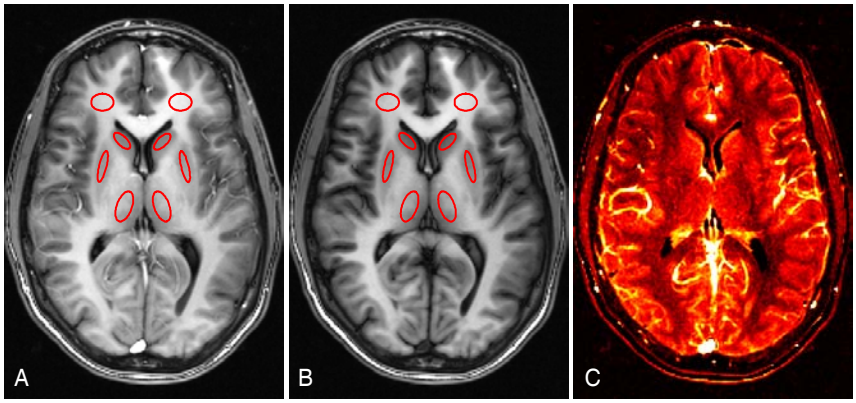

Figure 1. Images acquired with slice selective IR (A, control) and slice non-selective IR (B, label). The difference image (C) gives qualitative measure of local perfusion. Eight ROIs were selected for perfusion quantification (circles).

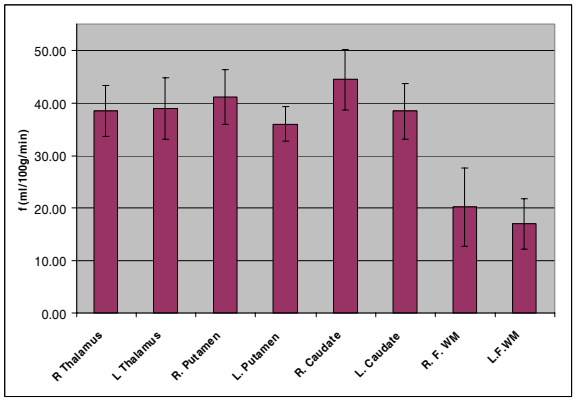

Figure 2. Absolute perfusion (ml/100g/min) obtained from the 8 regions identified in Figure 1A and 1B.

Conclusions: We have shown that it is possible to use a segmented true FISP sequence to routinely measure local tissue perfusion in deep gray matter. The benefits of such a sequence include high spatial resolution and no distortion artefacts. Issues which need to be further investigated include the over-estimation of perfusion caused by intravascular signal contamination and the imperfect slice profile of the imaging pulses.

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