A Novel Sequence to Simultaneously Measure R2, R2* and Perfusion

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Target Audience: Clinicians and researchers who wish to quantify muscle perfusion and tissue oxygenation.

Purpose: The severity and treatment success of peripheral arterial disease (PAD) has been correlated with the integrity of peripheral vasculature. Muscle perfusion and tissue oxygenation are indicators of microvascular function and can be non-invasively measured using blood-oxygen-level dependent (BOLD) and pulsed arterial spin labeling (PASL) techniques. However, there is compelling evidence that quantification of multiple parameters may improve diagnosis and treatment response of PAD. In particular, muscle spin lattice relaxation (R2) can be used to more accurately quantify perfusion and tissue oxygenation in conjunction with BOLD and PASL data. BOLD and PASL data can be acquired simultaneously to capture dynamic sequences of muscle in response to an induced period of ischemia. However, R2 data is often acquired using a slow spin echo based technique making it difficult to combine with current BOLD-PASL hybrid sequences. We propose an adaptation of a current BOLD-PASL sequence which combines R2, BOLD and ASL techniques (RBASL) to simultaneously measure R2, R2* and perfusion.

Methods: The sequence is similar to the SATIR sequence in that slice selective (SS) and nonselective inversion (NS) pulses are alternately applied to prepare each image (M0 and M0′ respectively). The images M0 and M0′ are acquired at multiple echo times using a multi-contrast echo planar imaging (EPI) based technique (single excitation followed by multiple image readouts). A final EPI contrast (no new excitation) is acquired after the next inversion pulse to be used in the calculation of R2 data.

Results: A schematic diagram of the RBASL sequence is shown in Figure 1. Figure 2 depicts a R2 map obtained with a conventional spin echo sequence compared to the R2 map obtained with the RBASL sequence (Fig. 2b). Regions were selected in each compartment of the phantom and R2 values were correlated between spin echo and RBASL based maps (Fig. 2c).

Discussion: The ability of this BOLD-ASL hybrid sequence to obtain perfusion and R2* data has been previously shown. Due to limited space we instead focus on the novel part of the sequence and show the ability to obtain R2 maps with the RBASL technique. There is a good correlation between the R2 values calculated using the spin echo data and the RBASL sequence as indicated by the blue points in Fig. 2c. One of the vials contained pure water (red points in Fig. 2c) which did not correlate well. One possible reason is that the echo time difference between the two RBASL images was relatively short (~80ms) which may not be long enough to adequately quantify the short R2 of pure water.

Conclusions: A previously published BOLD-PASL sequence was successfully modified to acquire simultaneous R2 data.

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References: