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[1]. 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[2,3]. However, there is compelling evidence that quantification of multiple parameters may improve diagnosis and treatment response of PAD[3,4]. In particular, muscle spin lattice relaxation (R_2) can be used to more accurately quantify perfusion and tissue oxygenation in conjunction with BOLD and PASL data[5-8]. BOLD and PASL data can be acquired simultaneously to capture dynamic changes of muscle in response to an induced period of ischemia. However, R_2 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[9] which combines R_2, BOLD and ASL techniques (RBASL) to simultaneously measure R_2, R_2* and perfusion.

Methods: The sequence is similar to the SATIR sequence[2] in that slice selective (SS) and nonselective inversion (NS) pulses are alternately applied to prepare each image (M_{SS} and M_{NS} respectively). The images M_{SS} and M_{NS} 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 R_2 data.

Results: A schematic diagram of the RBASL sequence is shown in Figure 1. Figure 2 depicts a R_2 map obtained with a conventional spin echo sequence compared to the R_2 map obtained with the RBASL sequence (Fig. 2b). Regions were selected in each compartment of the phantom and R_2 values were correlated between spin echo and RBASL based maps (Fig. 2c).

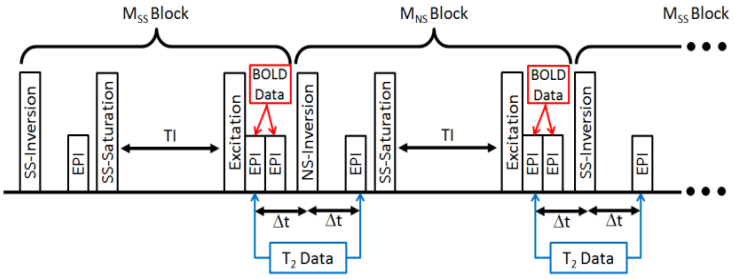

Figure 1: RBASL technique to simultaneously measure R_2, R_2* and perfusion.

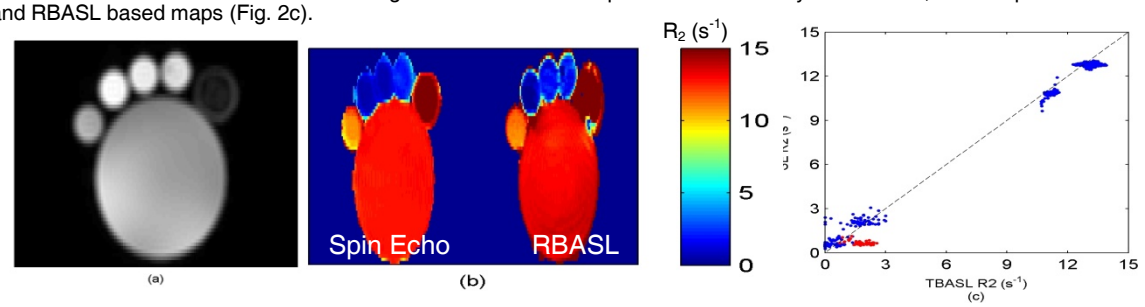

Figure2: Validation of R_2 in a phantom (a) containing liquids with various R_2 rates. The R_2 maps in (b) are from a spin echo sequence (left) and RBASL (right). Correlation of R_2 values from select regions are shown in (c).

Discussion: The ability of this BOLD-ASL hybrid sequence to obtain perfusion and R_2* data has been previously shown[9]. Due to limited space we instead focus on the novel part of the sequence and show the ability to obtain R_2 maps with the RBASL technique. There is a good correlation between the R_2 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 R_2 of pure water.

Conclusion: A previously published BOLD-PASL sequence[9] was successfully modified to acquire simultaneous R_2 data.

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