Arterial Spin Labeled Myocardium Perfusion Imaging with Background Suppression

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Introduction
Arterial spin labeling (ASL) is widely used for assessing cerebral blood flow (CBF). However, its application to myocardial blood flow (MBF) has been limited [1-2]. Current methods may suffer from artifacts due to high LV blood signal, and from lack of measurement consistency. In this work, we investigate ASL cardiac perfusion imaging using flow-sensitive alternating inversion recovery (FAIR) [3] with background suppression (BGS) [4-5]. We demonstrate that the ASL signal follows a non-central chi distribution, and determine the number of averages needed for reliable MBF quantification. Studies performed in healthy volunteers yield perfusion rates comparable to published literature values.

Methods
Pulse Sequence: The FAIR-BGS pulse sequence is illustrated in Figure 1. BGS is expected to reduce the effects of mis-registration and ringing from high LV blood signal [6]. It is achieved using a saturation – inversion – inversion preparation scheme that is designed to suppress a broad range of T1s including myocardium (1000-1200ms) and blood (1400-1600ms) at 3 T [7]. Adiabatic saturation and inversion pulses (BIR4 and hyperbolic secant) were used to reduce sensitivity to B0 and B1 inhomogeneity. The first inversion pulse alternated between being non-selective or slab-selective to generate control and tagged images respectively. A snapshot SSFP acquisition is used for its high SNR efficiency.

Experiments were performed in four healthy volunteers on a GE Sigma 3.0T EXCITE scanner with an 8-channel cardiac coil. Imaging parameters were flip angle = 40°, TR = 3.2ms, FOV = 20cm, matrix size = 96x96, and slice thickness = 10mm. The first inversion and the center of the imaging acquisitions occur at the same cardiac phase (mid-diastole) to ensure that the inversion slab contains the imaging slice, and the calculated perfusion rate reflects average perfusion over one heartbeat.

Results
Figure 2 contains FAIR-BGS images from one representative volunteer. We acquired 4 control and 4 tagged images per breath-hold, and performed 20-50 breath-holds per volunteer. To achieve \( N_{avg} > 10000 \), pixels were averaged over all myocardium as well as over multiple breath-holds. Figure 3 illustrates the agreement between the measured distribution and predicted non-central chi distribution. The measured distribution is broader, which satisfies the same confidence interval as a function of \( N_{avg} \) for MBF measurement of 0.76 ml/ml/min for \( N_{avg}=10000 \).

Discussion
This study demonstrates initial feasibility of assessing MBF using ASL at 3 T. Confident quantification of MBF continues to be limited by SNR, even at 3 T. Possible improvements could come from more efficient tagging schemes, more SNR-efficient acquisition, or the incorporation of respiratory navigation (rather than multiple breath-holds). BGS reduces the ASL signal by roughly 50%, but also reduces potential for artifacts from the LV blood pool. It may even potentially allow for non-subtractive ASL, which would increase SNR efficiency.

References