Myocardial Perfusion Measurement with Arterial Spin Labeling at 3 T: A Comparison with 1.5 T

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INTRODUCTION

Relatively low signal noise ration (SNR) might be one of the major problems that limit the accuracy and reliability of the non-contrast agent myocardial perfusion measurement with arterial spin labeling (ASL) based on Look-Locker scheme. However, the quantitative improvement in the accuracy and reliability of the myocardial perfusion measured at higher field is not clear for ASL. In this study, the outcome of the higher SNR and longer intrinsic T_1 on the accuracy of the T_1 and myocardial perfusion measurement was investigated in a phantom and volunteer study at 3 T, in comparison with 1.5 T concurrently.

MATERIALS AND METHODS

Pulse Sequence Myocardial T_1 and perfusion were measured by a hyperbolic secant inversion (IR) prepared (non-selective (*NonS*) and selective (*Sel*) prepared separately and were combined into one scan) single-shot GRE acquisition (1). Based on the Look-Locker scheme, the sequence acquired multiple data points along the magnetization recovery time course after each IR pulse. There was a 3 s idle time between the two IR acquisitions.

Scan Procedure All the studies were performed on a 1.5 T (Sonata, Siemens) and a 3 T (Trio Tim, Siemens) system sequentially, with body coil as transmitter and a 12-channel phased array coil as receiver. First, the accuracy of T_1 was investigated in a serial of cylindrical phantoms (D = 2 cm) that were composed of different concentration of agarose, gadolinium-DTPA, NaCl, and distilled water to simulate human tissue characteristics (2). The T_1 of the phantom ranged from 750 to 1100 ms for a 1.5 T system. Then, 5 healthy volunteers underwent the myocardial perfusion measurement with ASL at 3 T and 3 of them at the 1.5 T systems as well. A single slice, short-axis view of the heart at the middle ventricular level was imaged. Major imaging parameters included the excitation flip angle $\alpha = 5^o$, TR = 2.2 ms, phase FOV = 160 ~ 280mm, slice thickness = 8mm, interpolated final image matrix = 256 × 160, k-space lines = 64 ~73, number of images N=12 after each IR pulse, two initial inversion time TI_1s = 91ms and 151 ms and an assumed perfect inversion of $\beta=180^0$, and were all kept the same between the two scanning systems. The data acquisition was trigged either by simulated ECG signal (RR interval = 700 ms) for phantom or by the ECG signal of the volunteer. Each group of data acquisition was repeated twice in order to evaluate the reliability of the ASL in perfusion measurement. Each pair of *Sel* and *NonS* IR prepared data acquisitions was completed within a breathhold (approximately 21 s).

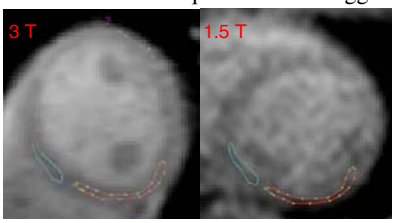

Fig. 1: ASL source images of the IR prepared GRE sequence from 1.5 T and 3 T.

Data Analysis ROI was drawn on the source images in both the phantom and volunteer studies for further data analysis. In the volunteer study, 3 or 4 regional ROIs (posterior, anterior, posterior lateral and posterior septal) were drawn and the position of the ROI was adjusted accordingly to account for bulk cardiac motion (Fig. 1). ROIs severely affected by the artifact were discarded from further analysis. A multi-variable T_1 regression algorithm adapted for the saturation effect and ECG triggered data acquisition was employed for the T_1 calculation in ROIs (1). Then, the MBF within these ROIs was calculated with *Sel* and *NonS* myocardial T_1s and the blood T_1 in the left ventricle cavity (3).

RESULTS

For the phantom study, which already had sufficiently high SNR at 1.5 T (SNR = 65.6 vs. SNR =162 at 3 T), no obvious improvement in the T_1 accuracy was observed (Table 1). For the volunteer studies, the SNR from a *NonS* IR preparation (along the TI time course) increased dramatically from 1.5 T to 3 T (Fig. 2), because of the combined interactions of higher magnetization and more severe saturation effect at higher field. The myocardial T_1 measured from the *NonS* IR prepared single-shot GRE sequence increased from 978 ± 50.2 ms at 1.5 T to 1291.2 ± 16.8 ms at 3 T; and so did the blood T_1 (1519 ± 59.6 ms at 1.5 T vs.1917 ± 47.3 ms at 3 T), which were all in accord with the literature values (4). The myocardial perfusion measured at 3 T had a relatively low variation among repeated studies and much closer to the literature values in humans, compared with those obtained from 1.5 T (Table 2).

Table 1: Summary of predicted T_1 in the 1.5 and 3 T system

True T_1 on 1.5 T (ms)	753.3	859.3	1071	1112
Error of the predicted T_1 from 1.5 T (%)	1.31	1.13	3.90	3.14
True T_1 on 3 T (ms)	797.0	895.5	1161	1183
Error of the predicted T_1 from 3 T (%)	1.22	2.13	3.73	2.61

CONCLUSION AND DISCUSSION

In this preliminary study, a single shot GRE based ASL sequence as proposed previously may provide more reasonable myocardial perfusion at 3 T compared with 1.5 T, because of the higher SNR and the enhancement of spin labeling due to the longer T_1 relaxation time. Cardiac motion and artifact caused by the rapid blood flow may destroy the myocardium signal and following perfusion analysis in some of the ROI areas.

Tissue diamagnetism may be a reason that the myocardial T_1 increased approximately 30% from 1.5 T to 3 T, in contrast with only a 4~9% increase in T_1 of the agarose phantoms. The large variation of the myocardial T_1 and myocardial perfusion obtained at 1.5 T may also be associated with difficulties in locating an appropriate ROI in the myocardial territory given the low SNR available. It should be noted that 3 T may also introduces some new factors that could affect the T_1 and thus perfusion measurement, which include the field inhomogeneity caused by the spatial non-uniformity of the transmitter and receiver and the dielectric properties of the subject imaged and need to be investigated in the future.

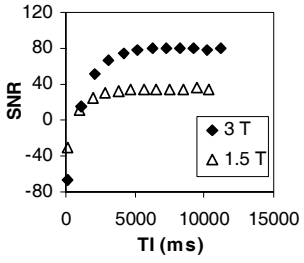

Fig. 2: SNR along the TI

Table 2: Myocardial perfusion of the volunteer measured on the 1.5 and 3 T system

Volunteer NO.	Perfusion in 3 T (ml/min/g)	Perfusion in 1.5 T (ml/min/g)
1	0.919 ± 0.09	0.75 ± 0.22
2	0.997 ± 0.18	-0.68 ± 1.42
3	0.987	3.86 ± 0.04
4	1.03 ± 0.19	-
5	2.31 ± 0.13	-

REFERENCES 1. Magn Reson Med 2005;53:1135-42. 2. Med Phys 2005;32:3199-208. 3. J Magn Reson Imaging 1998;8:1240-45. 4. Magn Reson Med 2005;54:507-12.