Background Suppression Does Not Reduce Physiological Noise in Myocardial ASL Perfusion Imaging

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Introduction

Myocardial blood flow (MBF) measurement in humans using arterial spin labeling (ASL) shows promise but has produced highly variable results [1-4]. One critical source of measurement errors is the physiological noise caused by static tissue mis-registration due to metabolic fluctuation, respiratory and cardiac motion, and other unknown variations over time [5]. Background suppression (BGS) [6-7] has been widely used in brain ASL as a means to reduce such physiological noise. We performed myocardial ASL scans with and without BGS, and investigated if the use of BGS reduces physiological noise. If the high physiological noise stems from mis-registration of myocardial tissue, it has to be reduced by the use of BGS. We determined that the change in physiological noise using BGS is not statistically significant, and that the source of physiological noise is unlikely to relate to mis-registration of myocardium.

Methods

Figure 1 illustrates the cardiac gated FAIR [8] sequences with and without BGS. Inversion and imaging are both centered at mid-diastole. One pair of control and tagged images was acquired 6 s apart during a single breath-hold with an identical inversion delay, and six breath-holds (10-12 s each) were used for signal averaging. Image acquisition was performed using a snapshot SSFP, and the inversions were achieved using adiabatic (hyperbolic secant) pulses. For BGS, extra saturation on the slab containing imaging slice and nonselective inversion were added with real-time adjusting timing to suppress myocardial signal on the imaging time in the presence of variable heart rate. Experiments were performed on a GE Signa 3.0 T EXCITE with an 8-channel cardiac array coil. Regions of septal myocardium on mid-short axis were manually segmented for each breath-hold. On the region of interest, we measured myocardial tissue signal on control and tagged images, estimated MBF measurements using Buxton's general kinetic model [9], and calculated the probability of MBF measurement error being < 0.1 ml/ml/min based on the standard deviation of measurements from six breath-holds with a Gaussian model of physiological noise [5].

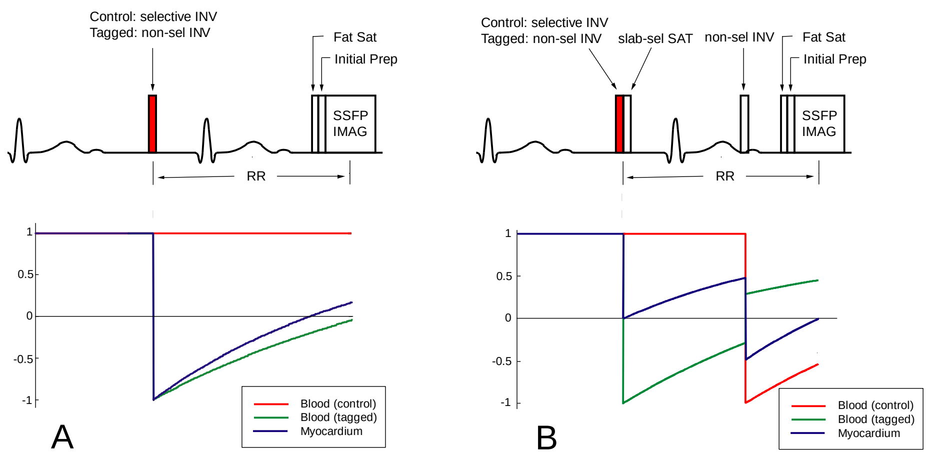

Fig. 1. Cardiac gated FAIR – SSFP pulse sequences **A:** without and **B:** with BGS

Scan	FAIR Myo. signal (%)	FAIR MBF	FAIR Conf. (%)	FAIR with BGS Myo. signal (%)	FAIR with BGS MBF	FAIR with BGS Conf. (%)	Myo. signal ratio (%)
1	27.1	0.88	26.8	2.5	0.83	25.6	9.2
2	31.0	1.02	48.9	6.2	0.64	26.1	20.0
3	51.8	0.71	93.4	12.1	0.27	43.1	23.4
4	42.9	0.89	64.0	4.7	0.35	38.1	11.0
5	41.1	1.03	40.0	6.1	0.31	99.1	14.8
6	31.7	0.69	91.7	4.1	0.15	70.1	12.9
7	33.9	0.82	46.0	4.6	0.35	30.2	13.6
8	23.2	0.70	52.4	4.4	0.71	55.6	19.0
9	37.7	1.07	72.4	8.5	0.73	68.2	22.6
10	21.7	1.09	51.5	5.0	0.68	61.3	23.0
Avg.	32.2	0.89 ± 0.16	58.7 ± 21.7	5.8	0.50 ± 0.24	51.7 ± 23.6	18.0

Table 1. Average myocardial signal on control and tagged images with respect to equilibrium signal, MBF estimate (in ml/ml/min), and measurement confidence (probabililty that error is < 0.1 ml/ml/min).

Results

Table 1 summarizes the results from all ten scans. Using BGS, the myocardial tissue signal was reduced by 82%, MBF estimates decreased by 44%, and measurement confidence decreased slightly. Using t-tests, the decrease in measured MBF was found to be statistically significant ($p=0.0004$) while the change in measurement confidence was found to be statistically insignificant ($p=0.47$).

Discussion

Cardiac-gated FAIR already has relatively low myocardial signal, and BGS pulses were able to reduce this further by 82%. Results from ten scans show that BGS produced no significant change in physiological noise, which suggests that static tissue mis-registration in the subtraction is not a significant source of physiological noise in human myocardial ASL. Measured MBF was lower with BGS, and may be due to the long saturation duration (20ms) or imperfect inversion.

References

[1] Poncelet BP *et al*, MRM 41:510, 1999.
[2] Wacker CM *et al*, JMRI 18:555, 2003.
[3] An J *et al*, 13th ISMRM p253, 2005.
[4] Zhang H *et al*, MRM 53:1135, 2005.
[5] Zun Z *et al*, MRM submitted, 2008.
[6] Ye FQ *et al*, MRM 44:92, 2000.
[7] Duyn JH *et al*, MRM 46:88, 2001.
[8] Kim SG, MRM 34:293, 1995.
[9] Buxton RB *et al*, MRM 40:383, 1998.