Effect of background suppression on CBF quantitation in pseudo continuous arterial spin labeling

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Introduction: Background suppression (BGS) of static tissue has been previously shown to be effective for reducing structural and physiological noise [1], thus improving the signal-to-noise ratio in arterial spin labeling (ASL) MRI [2]. However, BGS also causes a decrease in quantitative CBF estimates. It has been suggested that the decrease may be caused by slow magnetization transfer effects in blood, but a theoretical framework to accurately predict the experimentally observed decreases is lacking [3]. In practice, the effects of BGS on quantitative CBF estimates are typically compensated with the application of an empirically determined scaling factor. However, to the best of our knowledge, prior studies have not examined whether the scaling factor is indeed global throughout the brain and, perhaps more importantly, whether it is constant across subjects. In this preliminary study, we examined these factors using BGS in conjunction with pseudo continuous ASL (PCASL).

Methods: Three healthy subjects were scanned on a 3T GE MR750 scanner using an 8-channel head coil. Two experiments, with and without BGS, respectively, were performed on each subject using a PCASL method optimized to reduce phase tracking errors [4]. The balanced PCASL tagging scheme was implemented with: Hanning-shaped RF pulses of 375 us duration, $B1_{max}$ = 0.1 G, G_{max} = 1.6 G/cm, G_{mean} = 0.09G/cm, RF-to-RF spacing = 998 us, tagging duration = 2000ms and post labeling delay =1600ms. The images were acquired with a 2D spiral readout (TR/TE = 4300 ms/3.3 ms, reps = 60), for twenty 5 mm thick axial slices with 1 mm gap, achieving whole brain coverage. For the experiment with BGS, two hyperbolic secant pulses (mu = 40, beta = 400 s-1, B1max = 0.23 G, pulse width = 15 ms) were applied at 980 and 250 ms, respectively, before the excitation RF pulse. A 3D high resolution T1-weighted structural scan was acquired, which was used to define a gray matter (GM) mask. A tagging efficiency of 0.9 was assumed for the CBF quantification for both experiments. An empirical BGS scaling factor was determined for each subject by computing the least-squares fitted ratio of the per-slice mean CBF values obtained with and without BGS. To assess the performance of the BGS inversion pulses, we used phantom measurements to compute the ratio of the signal acquired with no BGS pulses to that obtained with two BGS pulses applied consecutively at 60 and 30ms prior to the excitation pulse.

Results & Conclusion: Experimentally determined inversion efficiency was 94% for the two BGS pulses and showed excellent B1 insensitivity on a per voxel basis. Reductions in ASL signals were observed in all subjects when BGS pulses were applied, consistent with the results from previous studies [2, 3]. An example from one subject is shown in Figure 1. Figures 2A, B, and C show the slice-by-slice comparisons for each subject of the GM CBF values obtained with (blue) and without (red) BGS, along with estimates corrected with a BGS scaling factor (green line). We found that the global scaling worked well in all subjects, which might be attributed to the fact that the BGS pulses were insensitive to both off-resonance and B1 variations at 3T. However, the BGS scaling factor was found to vary between subjects. Figure 3 is a scatter plot of the BGS scaling factor *vs.* whole-brain averaged baseline GM CBF (mean+/-std). The figure illustrates a reduction in scaling factor as baseline CBF increases. This trend can also be qualitatively observed from Fig. 2. Specifically, the spread between the red and blue curves tends to decrease as the baseline CBF decreases. The BGS scaling factor for the subject with the highest baseline GM CBF, 60.1 ml/100g/min, was 0.77 whereas that for the lowest baseline GM CBF, 40.0 ml/100g/min was 0.95, which represented a 21% difference in scaling factor. In summary, we found that the global scaling for BGS worked well in the PCASL experiment when applied within a given subject. However, there were considerable variations in the BGS scaling factor between subjects, indicating that the application of a global BGS scaling factor across subjects can lead to substantial CBF quantitation errors. Further work is needed to better understand the dependence of the BGS scaling factor on baseline CBF and to determine if BGS can be reliably used for studies that require quantitative CBF estimates.

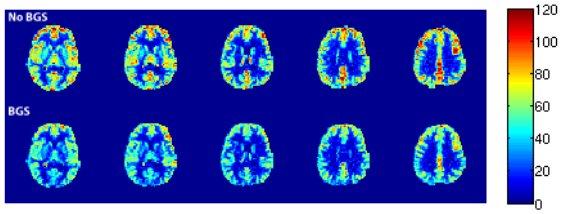

Fig. 1. *An example perfusion map (ml/100g-min) acquired without (top row) and with (bottom row) BGS.*

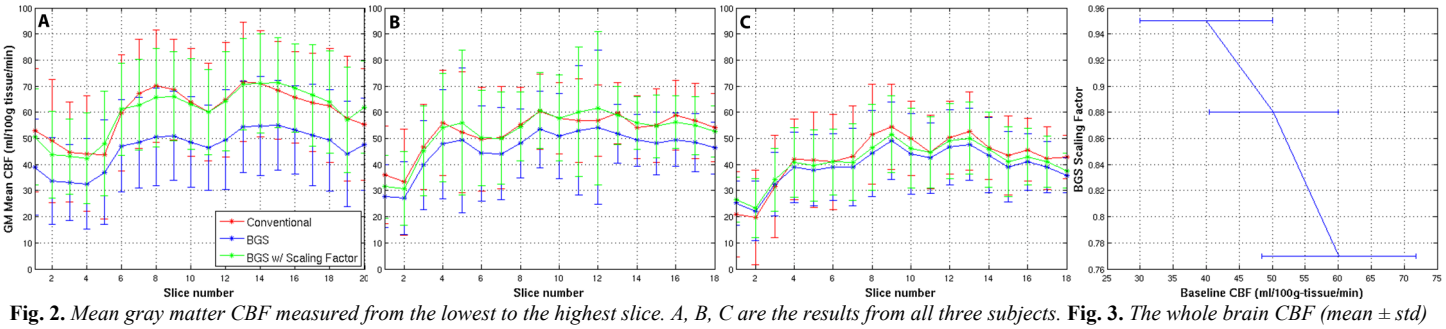

Fig. 2. *Mean gray matter CBF measured from the lowest to the highest slice. A, B, C are the results from all three subjects.* **Fig. 3.** *The whole brain CBF (mean ± std) plotted against the calculated scaling factors for three subjects.*

References: 1. Dixon WT et al., MRM 18:257-268 (1991). **2.** Ye FQ et al., MRM 44:92-100 (2000). **3.** Garcia DM et al., MRM 54:366-372 (2005). **4.** Shin D et al. 18th ISMRM (Abstract 1744).