Fast CBF Estimation in Multi-Phase Pseudo-Continuous Arterial Spin Labeling (MP-PCASL) Using Signal Demodulation

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INTRODUCTION
The multi-phase pseudo-continuous arterial spin labeling (MP-PCASL) method [1] offers more robust cerebral blood flow (CBF) quantification than the conventional PCASL method [2] and higher SNR than Pulsed ASL. In addition, it provides phase tracking errors at the tagging locations, which gives additional opportunities for measuring and optimizing the tagging efficiency of conventional PCASL [3]. However, the MP-PCASL method requires a per-voxel fit to the nonlinear signal equation. This time required for this nonlinear fitting procedure (about 5 minutes) can be problematic for applications such as optimized PCASL for functional MRI studies [3]. Here we propose a signal demodulation processing method for MP-PCASL that reduces the required processing time by two orders of magnitude, while providing comparable estimates of CBF and phase errors.

THEORY
For MP-PCASL the phase increment between two successive RF pulses can be expressed by the equation: \Delta \theta = \gamma G d t \frac{2\pi n}{N}$, where \gamma is the gyromagnetic ratio, G is the average gradient strength, t is the interval between RF pulses, d is the distance from the gradient center to tagging location, n denotes the nth phase, and N is the number of phases. Here \gamma G d t is the phase tracking term and \frac{2\pi n}{N} is the phase offset which generates different amounts of inversion.

Fig. 1 shows a time series from a voxel obtained with 4-phase PCASL and its power spectrum (upper row). Because the power spectral density has a dominant component at the multi-phase frequency, the sinusoidal component at the multi-phase frequency (lower row of Fig. 1) contains different amounts of inversion.

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RESULTS AND DISCUSSION
We compared the mean gray matter CBF values obtained using 4-phase PCASL with the nonlinear fitting and the proposed demodulation methods over 5 subjects (3 men and 2 women). The experiment was executed on a 3T Sigma HDx scanner with an 8-channel head coil (GE Healthcare, Waukesha, WI). PCASL scan parameters were 1600 msec tag duration, 1000ms post labeling delay, TR 3.6 sec, 80 reps. Imaging parameters included 24cm FOV, 20 slices (5 mm thick, skip 1mm), single-shot spiral acquisition (TE = 3ms), and 5 min. scan time. Mean gray matter CBF values and mean phase tracking errors were obtained from the gray matter mask, which was defined with a high resolution anatomical scan.

REFERENCES