# ALPHA-CORRECTED PSEUDO-CONTINUOUS ARTERIAL SPIN LABELING FOR ROBUST QUANTIFICATION OF CEREBRAL BLOOD FLOW

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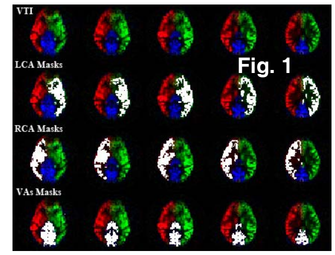
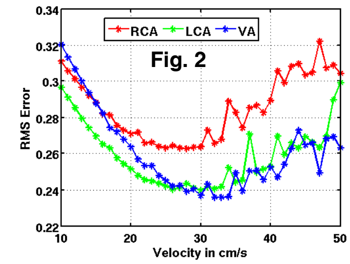
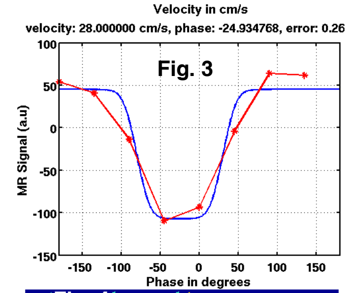
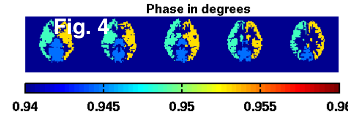


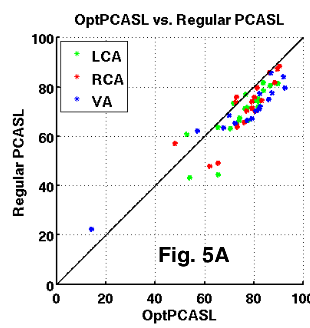



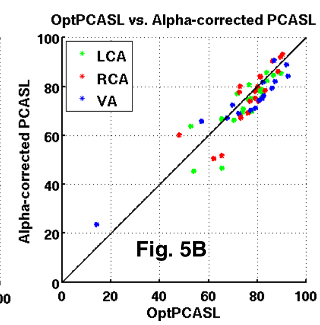




**Introduction**: Pseudo-continuous arterial spin labeling (PCASL) is gaining popularity and is expected to become the recommended ASL protocol by the ISMRM Perfusion Study Group for clinical applications. One main drawback of PCASL is that its tagging efficiency is highly sensitive to off-resonance effects and gradient imperfections. Optimized PCASL (OptPCASL) [1] has been proposed as a way to restore tagging efficiency, which empirically measures phase tracking errors, then applies an additional compensation RF phase and in-plane gradients to the PCASL pulse train to correct them. A similar approach titled tagging efficiency corrected PCASL [2] employs the conventional PCASL but uses the acquired phase errors to retrospectively correct for tagging efficiency loss during post processing. Unlike OptPCASL, this technique does not require user intervention and additional calibration scans. In this abstract, we present a refined version of the same technique and demonstrate its feasibility as a time-efficient approach to account for underestimation of cerebral blood flow (CBF) resulting from compromised tagging efficiency with the conventional PCASL tagging.

**Methods**: In the original implementation, alpha-corrected PCASL measures the phase tracking error for each voxel with an 8-phase MPPCASL [3] prescan and determines its tagging efficiency using the *assumed* velocity for blood passing through the main feeding arteries. In the new approach, we use a 30-sec vascular territory imaging (VTI) scan [4] to define the vascular territory maps corresponding to right carotid artery (RCA), left carotid artery (LCA), and vertebral arteries (VAs) and average the 8-phase MPPCASL time series within each territory. Averaging provides two notable advantages, i.e. 1) a significant SNR boost in the ASL signal, thereby improving the accuracy of the phase tracking error estimation; 2) an opportunity to estimate blood velocity specific to each feeding artery by comparing the shape of the averaged ASL signal with the Bloch-simulated inversion curves for a wide range of velocities. *Imaging:* A healthy 28-year old female subject was scanned on a 3T GE MR750 scanner using an 8-channel head coil. The scan protocol consisted of a 30-sec VTI prescan followed by the alpha-corrected PCASL scan, which ran first 32 reps under the 8-phase MPPCASL mode and the next 60 reps under the regular PCASL mode (tag/control signal modulation). Additionally, a separate OptPCASL scan was run with 60 reps to compare quantified gray matter CBFs between OptPCASL vs. alpha-corrected PCASL and OptPCASL vs. regular PCASL. The sequence parameters were: TR=4200ms, TE=3.3ms (2D spiral readout), tag duration=2000ms, post labeling delay=1600ms, 220mm FOV, 20 slices (5mm thick, skip 1mm). For the PCASL tagging, the balanced gradient scheme was used with Hanning-shaped RF pulses of 375us duration, $B1_{max}$=0.1G, $G_{max}$=1.6G/cm, $G_{mean}$=0.09G/cm, and a RF-to-RF spacing of 998us. *Post Processing:* The territory masks were used to generate the averaged 8-phase ASL time series for RCA, LCA, and VAs. Each signal was then iteratively fitted to Bloch-simulated inversion response curves corresponding to velocities ranging from 10cm/s to 50cm/s (1cm/s increment). Goodness of fit was assessed with normalized root mean square error and the velocity that yielded the least error was individually selected for RCA, LCA, and VAs. Additionally, a non-linear curve fitting procedure was used to estimate the phase tracking error for each feeding artery [3].




**Results:** Fig. 1 shows the processed images from the VTI scan and defined territory masks for 5 of the 20 slices. Fig. 2 shows the RMS error from fitting the territory-averaged ASL signal to the Bloch simulated inversion curves at different velocities. Fig. 3 shows the averaged ASL time series for the RCA and the inversion curve corresponding to 28 cm/s flow, which gave the best fit to the averaged ASL signal. The figure also shows the estimated phase tracking error (-24.93°). The velocities and phase tracking errors for RCA, LCA and VAs were determined to be 28cm/s, 30cm/s, 32cm/s and -24.93°, -23°, -26.27°, respectively. Velocity and phase tracking errors were then used to estimate the tagging efficiencies for RCA, LCA, and VAs using the Bloch-simulated efficiency map. Fig. 4 shows the tagging efficiency of three territory masks for the same 5 slices as shown in Fig. 1. These values were used to calculate mean gray matter CBF for each feeding artery at each slice, which were compared between OptPCASL vs. regular PCASL (Fig. 5A), and OptPCASL vs. alpha-corrected PCASL (Fig. 5B). Note that different colors denote CBFs in different territories.

**Discussion & Conclusion:** As can be seen from Fig. 5, the new alpha-corrected PCASL technique restores the lost tagging efficiency and corrects for underestimated CBFs associated with regular PCASL, producing values that are comparable to those obtained using OptPCASL. The presented results demonstrate the feasibility of this technique as a fast approach to correct for tagging efficiency loss in PCASL. **References:** [1] Shin et al, Magn Reson Med. 68:1135-44, 2012. [2] Shin et al, Abstract #2099, ISMRM, 2011. [3] Jung et al, Magn Reson Med. 64:799-810. [4] Wong et al, Magn Reson Med. 58:1086-91.