Comparison of Transit Delay Sensitivity between Pseudo-Continuous ASL, Pulsed ASL and Velocity-Selective ASL

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Target Audience: Researchers who are interested in Arterial Spin Labeling.

Purpose: Transit delay (TD) sensitivity remains the main source of error in local CBF quantification using Arterial Spin Labeling (ASL). In conventional ASL such as Pulsed ASL[1] (PASL), Pseudo-Continuous ASL[2] (PCASL), a gap between the tagging and imaging regions is required to minimize any undesired perturbation of the tissue magnetization. This gap, in combination with the complexity of the vasculature, can result in long and heterogeneous TDs, confounding the quantification with incomplete inflow if an insufficient post labeling delay (PLD) is used or reduced SNR if an unnecessarily long PLD is used[3]. Velocity-Selective ASL[4] (VSASL) labels spins on the basis of flow velocity rather than location, and in theory can eliminate this gap and associated heterogeneous TDs. However, this has not been verified by direct measurement of TDs in VSASL. In this study, the TDs in VSASL were directly measured via multi-TI experiments and compared with those in PASL and PCASL.

Methods: Four healthy subjects (3M, 1F) were scanned on a GE 3T MR750 scanner with an 8-channel head coil under an IRB approved protocol. The tagging parameters were: PCASL: 46.9±3.5mm gap between the tagging and imaging regions, tagging duration=0.6s, TIs=[0.65:0.6:3.05]s; PASL: PICORE, 20mm gap between the tagging and imaging regions, TIs=[0.6:0.6:3]s; VSASL: BIR-8 based saturation pulse[5] with a cutoff velocity (V_c)=2cm/s along the S/I direction, TIs=[0.6:0.6:3]s. Other imaging parameters included: flow-crushing gradients in the imaging with V_c=2cm/s along the S/I direction, FOV=220×220mm, 7 slices with 6mm slice thickness and 6mm gaps, fat saturation, spin echo, TR/TE=5s/14.7ms, spiral-out readout with a 48^2 matrix, 46ms delay between slices, 12 pairs of tag and control images after 2 dummy repetitions. The ASL signals in gray matter (GM) were fit to a kinetic ASL signal model[6] to give the TDs and bolus durations (BDs) per pixel for each tagging method (BDs equal to the tagging duration in PCASL).

Results: Examples of ASL images at different TIs are shown in **Fig. 1**. The results of fitting are summarized in **Fig. 2**: in each panel, the TD and BD maps for the 3rd and 5th slices are shown at the top; examples of data fitting are shown below, with corresponding (regions of interest) ROIs overlaid on the PCASL bolus duration maps; the mean and standard deviation (std) of the TDs and BDs in each slice are summarized on the right. Both PCASL and PASL showed highly heterogeneous TDs across the brain; in contrary, VSASL showed much more homogeneous TDs that were near zero in most pixels. Across slices and subjects, the averaged TDs of PCASL, PASL and VSASL were 1.28±0.28s (mean±std), 1.09±0.28s and 0.24±0.07s. PCASL had slightly longer TDs than PASL ($P<1\times10^{-8}$); both PCASL and PASL had significantly longer TDs than VSASL ($P<1\times10^{-16}$ and $P<1\times10^{-14}$ respectively). PCASL and PASL showed increased TDs as the imaging slice moved higher, while VSASL did not. The averaged BD of VSASL was 1.64±0.24s, longer than that of PASL (1.39±0.20s) (P<0.001) since VSASL tags arterial blood globally.

Discussion: The resemblance of the spatial distribution of TDs between PCASL and PASL, and the spatial distribution of BDs between PASL and VSASL, suggests that the fitting was valid. Compared to PASL, the longer TDs of PCASL were likely due to bigger gaps between the tagging and imaging regions. Finite BDs were detected for VSASL, likely due to limited transmit RF coverage. BDs shorter than the arterial T_1 in some brain regions explain the early peak time observed in VSASL inflow experiments[7].

Conclusion: TD measurements verified that VSASL is insensitive to TD, in contrast to PCASL and PASL.

References: 1. Kwong, PNAS, 1992; 2. Dai, MRM, 2008; 3. Alsop, JCBFM, 1996; 4. Wong, MRM 55:1334, 2006; 5. Guo. ASL Workshop, 2012; 6. Buxton. MRM 1998; 7. Guo, ISMRM 2012.

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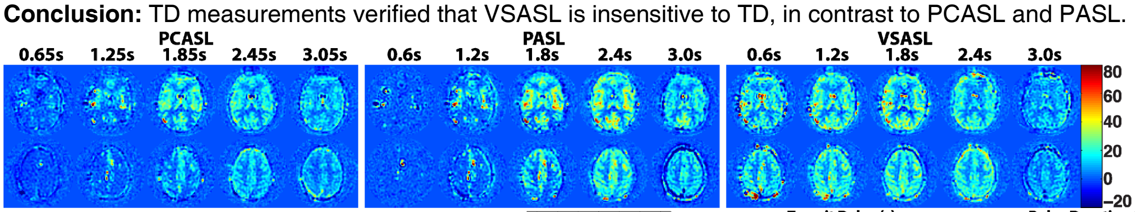

Fig. 1. ASL signals (a.u.) at different TIs, showing the 3rd and 5th slices from Sub. 4.

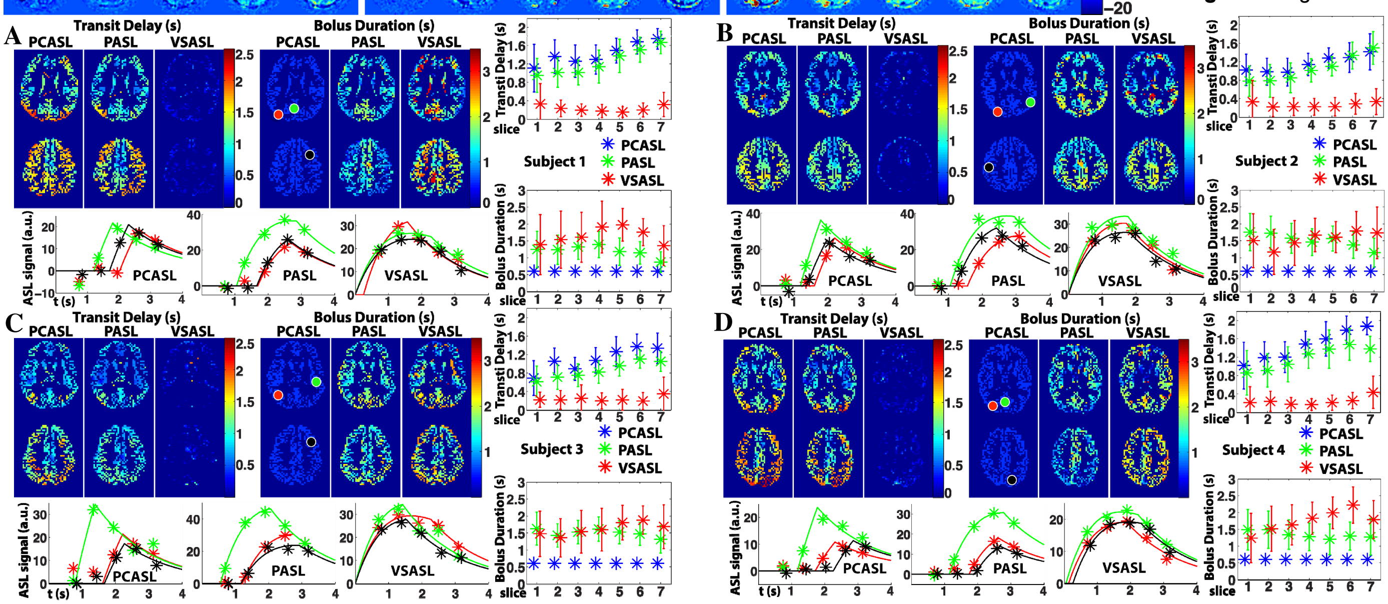

Fig. 2. Fitting results.