Investigating Different Arterial Spin Labeling Strategies For Measuring Gray Matter Perfusion and Arterial Transit Time

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Introduction

ASL is a non-invasive technique for CBF measurement using labeled blood water as an endogenous tracer. PCASL and PASL are the main ASL techniques differing in how the inflowing blood water is inverted. Although single-PLD PCASL has been recommended as the standard implementation, multi-PLD based techniques remain popular in neuroimaging studies, in particular, its high sensitivity to ATT [1]. Gray matter (GM) CBF is of primary interest due to its role in the central nervous system, however, its precise quantification is limited by partial volume effects. Whilst the sensitivity of the partial volume correction (PVEc) methods were investigated using PCASL [2], the preferred ASL strategy for GM CBF and ATT measurement remains unknown. In this work, we compare the GM CBF and ATT estimation between PCASL and PASL after PVEc. Simulated experiments were conducted to assess the impact of PVEc on GM CBF and ATT measurement from PCASL and PASL data.

Methods

One hundred T_1-weighted structural images and the corresponding PV estimates were randomly extracted from the UK biobank database [3], and they were transformed to the ASL space. Simulated multi-PLD PCASL data were generated using the parameters described in an optimization and reliability study [4]. Simulated multi-PLD PASL data were created using the parameters in the QUASAR Reproducibility study [5]. For all simulated data, GM and WM ATT were chosen to be 0.7s and 1.1s respectively. GM CBF was set to 60 ml/100g/min with and without spatial variations (implemented by the flat and fast sinusoidal GM CBF variations) as in [2]. WM CBF was set to 20 ml/100g/min for all simulated data. ASL difference signal was simulated using the tissue kinetic model. White noise was added to the signal using SNR = 5 and INF. GM CBF and ATT were estimated by fitting the tissue kinetic model and PVEc using the linear regression (LR) and spatially regularized methods [6][7]. RMSE was computed to assess the error between simulated and estimated GM CBF and ATT.

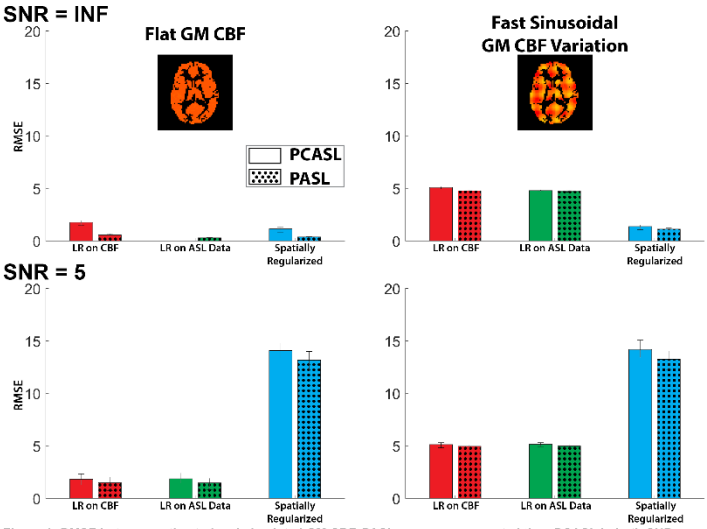

Figure 1: RMSE between estimated and simulated GM CBF. PASL was more accurated than PCASL in both SNRs.

Results

Figure 1 shows the RMSE between simulated and estimated GM CBF. Figure 2 shows the RMSE between simulated and estimated GM ATT.

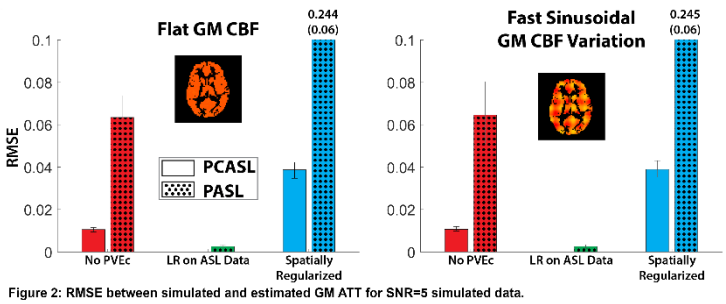

Figure 2: RMSE between simulated and estimated GM ATT for SNR=5 simulated data.

Discussion

Overall, PASL showed higher accuracy in GM CBF estimation in low SNR conditions (SNR = 5), which resembled the average SNR of the in vivo ASL data, whilst PCASL demonstrated higher accuracy in GM ATT measurement. The higher accuracy achieved by PASL was largely due to the higher number of PLDs in the simulated data (14 PLDs for PASL in comparison to 8 PLDs in PCASL).

[1] Alsop et al, MRM, 2014; [2] Zhao et al, NeuroImage, 2017; [3] Miller et al, Nat. Neurosci, 2016; [4] Mezue et al, JCBFM, 2014; [5] Petersen et al, NeuroImage, 2010; [6] Asllani et al, MRM, 2008; [7] Chappell et al, MRM, 2011