Motion correction and image registration for human hepatic arterial spin labelling

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Motivation: Arterial Spin Labelling (ASL) is a non-invasive imaging technique which enables blood flow quantification. It is most commonly used in brain [1], however, there is a growing interest in its application in other parts of the body, such as liver [2]. Hepatic ASL is especially challenging due to respiratory motion. ASL acquisition consists of multiple repetitions of control-label pairs which are averaged after pair-wise subtraction, therefore any misalignment between individual volumes will deteriorate the final image quality as well as introduce incorrect values to the final hepatic blood flow map. Correction of this misalignment through image registration is, therefore, an essential part of post-processing. The aim of this study is to assess different post-processing frameworks and identify the best image registration approach to minimise the impact of hepatic motion during ASL acquisition.

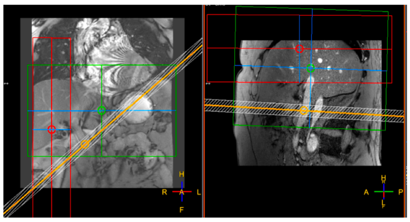

Figure 1. Illustrating information of image acquisition.

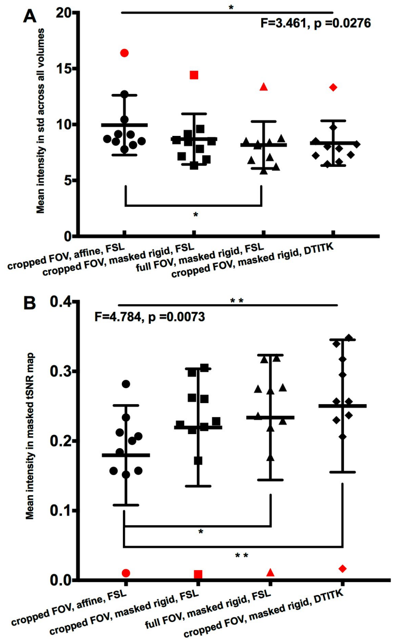

Figure 2. Evaluation of the final four registration approaches.

Methods: Subjects: 10 fasted healthy volunteers underwent two ASL studies 45 minutes apart. Scans from the second session were used for motion correction comparison. Acquisition: Pseudo-continuous ASL (pCASL,[3]) with 2s labelling and 2.5s post labelling delay were acquired with labelling plane placed across porta hepatis. Labelling strategy is shown with transverse and sagittal abdominal anatomical images overlaid with (red) acquisition FOV, (green) shim volume, (yellow) labelling planes (Figure 1). Spin-echo EPI read-out, TE/TR 15ms/8000ms, FA = 90°, 10 slices 6mm thick, FOV=400x400mm, matrix size 80x80, with fat and background suppression pulses. Proton density images were also acquired for calibration. Volunteers were instructed to synchronise their breathing with the sequence by using scanner acoustic sounds as an audio cue. Motion Correction: Four registration strategies were pre-selected based on initial tests: Full FOV data with masked rigid registration in FSL, cropped FOV to only include liver with masked rigid registration in both FSL and DTITK and cropped FOV data with affine registration in FSL. Images were all registered to an unbiased mean of control images. Statistical Analysis: Voxel-wise standard deviation (SD) of all volumes and tSNR defined as mean perfusion-weighted signal divided by SD of control-label subtractions across time was used to compare registration strategies. Both were calculated within a ROI and compared with one-way ANOVA excluding outliers (red). Graphs show mean ±SD. Significant differences were considered at *P < 0.05 and **P < 0.01.

Results: FSL affine registration on cropped/masked data performed worst with a significantly higher SD across all volumes than other methods (Figure 2A). DTITK rigid registration on cropped/masked data showed a significantly higher tSNR than other methods (Figure 2B).

Discussion and Conclusion: In this study, four image registration techniques were applied to hepatic ASL data from 10 healthy volunteers, each with 30 image pairs. Based on the two metrics of (A) lower SD of all volumes and (B) highest tSNR, rigid registration with DTITK on cropped and masked data performed best.

References: [1] Detre et al., JMRI (2012) [2] Bradley et al., J Hepatol (2018) [3] Pan et al., JMRI (2016)