Comparison of Water Excitation versus Fat Saturation in Perfusion MRI - Effects on Lipid Signal, SNR and CBF

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Introduction

Frequency-selective fat saturation is a widely used technique of fat suppression to minimize chemical shift artifacts in EPI scans where low bandwidth in the phase encoding direction can significantly displace lipid signal in that direction. However, we have observed that fat saturation provides poor and inconsistent lipid suppression in spin-echo EPI pseudo-continuous arterial spin labeling (pCASL) data. Poor and non-uniform lipid signal suppression is particularly problematic in ASL data, since it can produce large residuals in control-label difference pairs, resulting in large and spurious estimations of cerebral blood flow (CBF). Consequently, we also acquired a water-only excitation version of the sequence. In this study, we compare fat-saturation and water-excitation SE-EPI pCASL for lipid suppression, signal to noise ratio (SNR), and estimation of (CBF).

Methods

Imaging protocol: Data was acquired in a subsample of 14 subjects from the Philadelphia Neurodevelopmental Cohort on a 3T MR scanner (Magnetom Trio, Siemens, Erlangen, Germany) using a 32-channel receive-only head coil. The pCASL sequence described in [1] was used with the following parameters: labeling was performed at 90mm inferior to the center of the imaging slab, post-labeling delay of 1.2s, resolution of 2.3 x 2.3 mm^2, 5mm slice thickness, 1mm slice gap, TE/TR=29ms/4000ms, 20 axial slices, 40 pairs of alternating control and tag images. Two pCASL data sets were acquired on each subject, once with frequency-selective fat saturation and once with water excitation. Both options were Siemens product methods [2]. To account for any potential order effects, the order of data collection was reversed in half of the sessions.

Statistical Analysis: Mean temporal SNR was calculated from the image time series; average CBF maps were generated for each subject following the methodology described in [3]. Paired t-test were used used to compare whole brain, gray matter (GM), white matter (WM) and gray matter/white matter difference in CBF between fat saturated and water-excited pCASL.

Results

Water excitation generally provided better fat signal suppression, Figure 1. Figure 2 shows the average CBF (n=14) from both water-excited and fat-saturated pCASL data. The CBF calculated from water-excited data was 12%, 14%, 10% and 24% higher than the CBF calculated from fat-saturated data in whole brain ($p<<0.01$, **), gray matter ($p<<0.01$, **), white matter ($p<<0.05$, *) and gray/white matter difference ($p<<0.01$, **), respectively. The average temporal SNR (tSNR) (n=13) from fat-saturated pCASL data was 12% higher than that of water-excited pCASL data ($p<<0.01$).

Conclusion

Lipid signal contamination in EPI based perfusion imaging is problematic due to the large chemical shift in the phase encoding direction. Moreover, the artifact in CBF imaging from inconsistent and fluctuating fat suppression is magnified by the calculation of difference image pairs. In this study, water excitation produced superior suppression of lipid signal when compared to fat saturation in a SE pCASL application at 3T. It also produced higher estimated values for CBF in both gray matter and white matter. A persuasive argument that water excitation is superior for perfusion imaging is that it produced a more significant contrast between GM and WM. However, overall temporal SNR was higher when using fat saturation, suggesting that water excitation may only partially excite all the water signal in a spin-echo pulse train [4]. These results suggest that water excitation may be preferable to fat saturation in EPI based pCASL imaging.

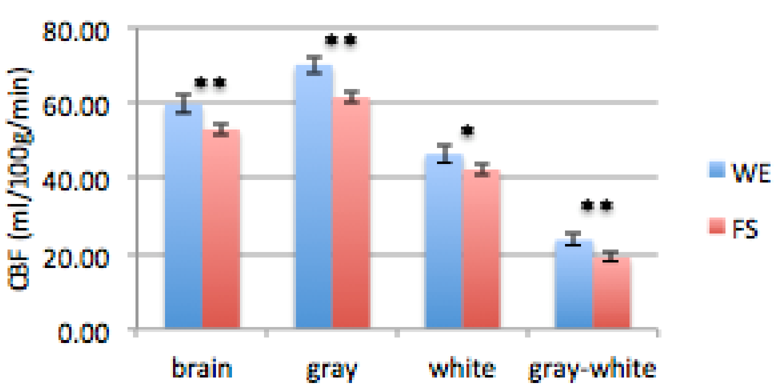

Fig. 2 Average brain, gray matter, white matter and gray/white difference CBF of the 14 subjects from water-excited (WE) and fat-saturated (FS) pCASL data.

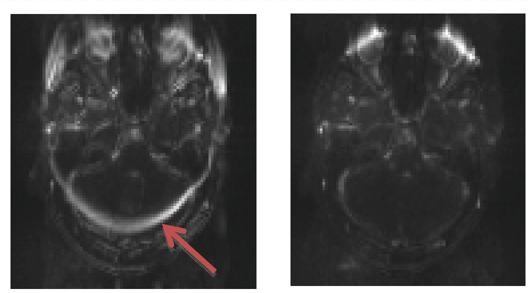

Fig. 1 Temporal Standard Deviation (SD) of the 80 fat-saturated pCASL images (left) and the 80 water-excited pCASL images (right) from a single subject for a single slice position. Chemical shift artifact (red arrow) in the fat-saturated pCASL SD image can be clearly seen.

References

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