Comparison of pulsed arterial spin labeling sequences using different absolute quantification methods

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.Introduction

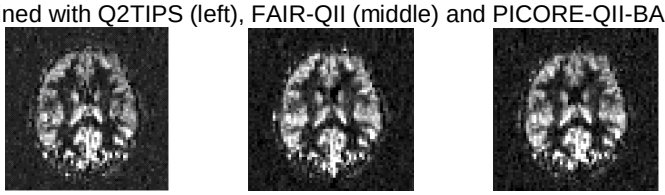
Arterial Spin Labeling (ASL) techniques are capable of providing quantitative information about local tissue perfusion (cerebral blood flow, CBF) by assessing the inflow of magnetically tagged arterial water into an imaging slice. Different ASL sequences have been proposed to tag the arterial water and to acquire the appropriate control image minimizing magnetization transfer effects and transit delay artifacts. Furthermore, to quantify absolute cerebral blood flow (CBF), it is necessary to know equilibrium magnetization of blood M0b. In this study, signal-to-noise ratios (SNR) of 3 different pulse sequences were compared: a) Q2TIPS [1] b) FAIR-QUIPSS II [2] c) PICORE-QUIPSS II with asymmetric BASSI pulses [3]. Because the equilibrium magnetization of blood cannot be easily determined in vivo, three different methods have been proposed to substitute this value with: a) estimating M0b from M0 of saggital sinus and white matter [4], or b) the average magnetization of CSF, or c) local M0 of tissue scaled by the water partition coefficient [5],[6]. We were able to show that for identical sequence parameters: a) FAIR-QUIPSS II has the highest SNR, b) FAIR-QUIPSS II gives slightly higher difference magnetization signal (i.e. higher CBF), c) the equilibrium magnetization of CSF is lower while the other two methods give similar values resulting in lower absolute CBF values if M0 of CSF was used.

Methods

8 normal human subjects on a 3T Siemens/Trio whole body scanner were measured. Identical sequence parameters for all 3 ASL schemes [TE=13ms; TR=2500ms; TI1=700ms; TI1s=900ms; TI2=1400ms; voxel size=3.5x3.5x3mm^3; 4 slice; 155 repetitions] were used with a 10cm tagged region positioned at a 1cm gap relative to the proximal edge of the imaging slice. Data were motion corrected, registered and control and tag difference images were calculated. To obtain only gray matter voxels, the difference images were thresholded. Only voxels passing the threshold in all 3 different ASL sequences were included in the subsequent analysis. The middle two slices were used for all experiments. The average SNR of ASL difference images of all gray matter voxels are computed. In order to evaluate the correlation of difference signals, the magnetization differences were plotted against each other and a linear curve was fitted by using iteratively reweighted least squares method. The slope is a measure of the correlation of the magnetization differences. For the determination of the equilibrium magnetization, the same sequence parameters as above were used except the TR and TI2 were chosen to be 10.000ms and 4.000ms, respectively.

Results

The average difference images obtained with Q2TIPS (left), FAIR-QII (middle) and PICORE-QII-BASSI (right) are shown below.



The average SNR (N = 8) of ASL difference signals for the 3 pulse sequences are shown in the left table. FAIR-QUIPSS II has the highest SNR, BASSI the second highest and Q2TIPS the lowest. The slopes of the fitted curves reflecting the relative magnetization difference are shown in the middle table. FAIR-QUIPSS II has the highest magnetization signal difference (proportional to CBF), 4-7% higher then BASSI and Q2TIPS. We also evaluated the noise level for control and tag images separately and found that the noise is lower in FAIR-QUIPSS II both in tag and control experiments (data not shown).

	Q2TIPS	FAIR-QII	BASSI
SNR	1.60 ± 0.12	1.97 ± 0.24	1.79 ± 0.24

	slope
F-Q	1.04±0.10
B-**F**	0.93±0.08
Q-**B**	0.95±0.05

Scheme	WM/CSF	avg(Mob)/CSF
Q2TIPS	1.3390	1.2873
FQII	1.2315	1.1803
BASSI	1.3269	1.2762
Avg rate	1.2975	1.2463

The ratios of the estimated M0 of blood are shown in the right table. The CSF equilibrium magnetization is lower while the other two methods give similar values, i.e. using M0 of CSF yields ~30% lower absolute CBF values. The computed absolute CBF values are in physiologically plausible range: 53.96-130.38 ml/gr-min (data not shown).

Discussion

In principle, all quantitative ASL sequences should yield the same absolute CBF values. In this study, we could show, however, that FAIR-QUIPSII yields higher magnetization difference between tagged and control images (proportional to CBF) and also a higher SNR than the two other ASL schemes. We are currently investigating what the cause for these differences are (e.g. higher tagging efficiency or lower physiological noise contamination). In addition, substituting M0 of blood with other values easier measurable can give rise to different absolute CBF values.

References

[1] Luh et al., MRM (1999), [2] Wang et al., JMRI (2003), [3] Warnking et al., MRM (2006), [4] Wong et al., MRM (1998), [5] Frank et al., MRM (1999), [6] Buxton et al., MRM (1998)