Performance of Pseudo-continuous Arterial Spin Labeling in the Estimation of Fractional Changes in CBF with Activation: Comparison with QUIPSS II

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Introduction

Arterial spin labeling (ASL) techniques have been applied to functional studies to estimate cerebral blood flow (CBF) changes during brain activation and in turn to estimate the cerebral metabolic rate of oxygen. Due to shortening of the transit delay during activation, ASL techniques insensitive to changes in transit delay are required such as QUIPSS II (1) and continuous ASL (CASL) with a post-tagging delay (2). QUIPSS II is more widely used in functional studies due to better temporal resolution and lower SAR. The temporal resolution is governed by tagging duration and transit delay, i.e. the closeness of tagging location to imaging slices. With pseudo-CASL (PCASL), it is possible to place the tagging location as close as pulsed ASL and to match tagging duration and post-labeling delay (PLD). With tagging efficiency about 0.8 (3), the SNR per unit time is similar to QUIPSS II with the same temporal resolution. Here we applied PCASL and QUIPSS II with matching parameters to measure fractional CBF changes with motor and visual activation.

Methods

Labeling tag widths (τ, TI_1) of {400, 550, 700} ms were used with PCASL and PICORE QUIPSS II with PLD or $DTI=TI_2-TI_1$ of 800 ms and a TR of 2 sec. Parameters for PCASL include 800 µs RF with 0.05 G amplitude and 0.8/0.06 G/cm maximum/mean gradient strength. 10 cm tagging area for QUIPSS II tagging with 1 cm gap between tagging area and imaging slices. PCASL tagging area is about 2cm and is also placed with 1 cm gap, thus matching the transit delay. 5 oblique slices of 5mm/1mm gap covering both motor and visual cortex were acquired using EPI with SENSE 2 and TE=17.9 ms. Experiments were conducted on a GE 3T Excite scanner with a 16 channel receiver coil on 6 healthy subjects under approved protocols. Volunteers performed right-hand finger-tapping at the same time watching a 8 Hz flashing checkerboard with 20/40 sec on/off periods repeated 4 times with 30 sec in the beginning and 2 min at the end served as baseline measurement. A total of 6 runs were carried out for each subject. In 4 of the 6 subjects, additional three runs were acquired using PCASL with two consecutive in-plane pre-saturation before the tagging pulses as in QUIPSS II. Raw images were registered for bulk motion correction, and CBF time series were obtained by subtracting each image from the average of the previous and the next images. An ideal trapezoid reference waveform was cross-correlated with the CBF time series derived from both PCASL and QUIPSS II with 700ms tag. Activated voxels were identified from the primary motor and visual cortex area with a cross-correlation coefficient threshold of 0.4 from either PCASL or QUIPSS II runs and with at least ten activated voxels. The fractional changes in the ASL signal were calculated for each run with the same group of voxels. Temporal SNR (tSNR) were also calculated for the last two minutes resting scan.

Results

Fig. 1 shows a typical activation map overlapped on top of average PCASL perfusion images with left motor cortex and bilateral visual activation. **Fig. 2** shows the percent CBF changes in motor (top) and visual (bottom) area with QUIPSS II (TI_1=700, 550, 400ms, left 1-3), PCASL with in-plane pre-saturation (τ=700, 550, 400ms, middle 4-6), and PCASL without in-plane pre-saturation (τ=700, 550, 400ms, right 7-9), respectively. The mean CBF changes are 73%, 68%, and 64% in motor, and 83%, 81%, and 73% in visual with QUIPSS II, PCASL with and without in-plane pre-saturation, respectively. The averaged tSNR are shown in **Fig. 3** with 400ms tag lowest and 700ms tag highest consistent with theoretical calculation. With in-plane pre-saturation, tSNR in PCASL is about the same as QUIPSS II. However, PCASL tSNR is about 14% lower without in-plane pre-saturation.

Discussion and Conclusion

With in-plane pre-saturation, as in typical QUIPSS II application, the measured fractional CBF changes and tSNR of PCASL is the same as QUIPSS II. It is expected that with shorter tag duration with PCASL, variation due to cardiac pulsation should become larger. Previous observation of lower measured CBF with CASL compared to QUIPSS II (4) is most likely due to early exchange of tag and not due to sensitivity to blood velocity. As with QUIPSS II, it is expected that techniques such as RETROICOR (5) should further reduce variation in PCASL time series. In conclusion, we have demonstrated the application of PCASL to match the timing parameters for pulsed ASL resulting in similar performance.
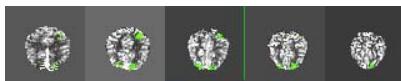

**Fig. 1** Typical activation map overlapped on top of average PCASL perfusion images.

References

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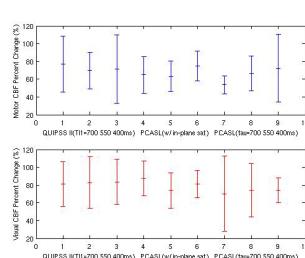
Fig. 2. Percent CBF changes in motor (top) and visual (bottom).
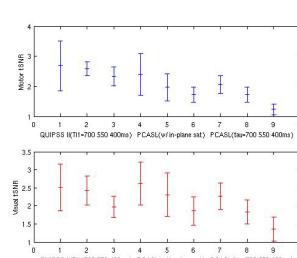
Fig. 3. Averaged tSNR in motor (top) and visual (bottom).