Comparison between pseudo-continuous and separate labeling coil in continuous arterial spin labeling

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Introduction: Perfusion based functional MRI through Arterial Spin Labeling (ASL) has remarkable potential as a tool to study brain function because of its quantifiable nature and close relation to neuronal activity. Many techniques have been developed to increase the sensitivity of ASL perfusion MRI. Continuous labeling techniques (CASL) offer SNR advantages over pulsed labeling techniques (PASL). In this study, we compare two continuous labeling schemes in terms of their success in improving the SNR and their activation detection efficiency in vivo: flow driven adiabatin inversion using a separate labeling coil (Double coil CASL) [1] and pseudo-continuous inversion (pCASL) [2].

Materials and Methods: A 27 year old female subject was scanned using a 3.0 T Signa Excite scanner (General Electric, Waukesha, WI) in accordance to the University of Michigan's IRB regulations. The pCASL experiment was conducted using the method described in [2]. The inversion plane was located at the carotid arteries (approximately 3 cm below the circle of Willlis). Images were collected using a gradient echo spiral imaging sequence (flip angle = 80 deg, TR= 3000 ms, TE = 12 ms, N. slices = 9, sl. thickness = 7 mm, FOV = 24 cm, tagging duration = 1400, post inversion delay = 1200 ms, N. frames = 40). The two coil CASL experiment was conducted using a separate labeling coil placed on the subject's neck. Acquisition parameters were kept as close as possible to the pCASL acquisition (flip angle = 80 deg, TR= 3000 ms, TE = 12 ms, N. slices = 9, sl. thickness = 7 mm, FOV = 24 cm, tagging duration =1300 ms, post inversion delay = 1500 ms, N. frames = 40). The post inversion delay and tagging time were adjusted to account for the extra distance from the tagging plane to the tissue. For each technique, using the above mentioned parameters, the same experiment was performed twice: 1) while the subject was at rest 2) while performing a sequential finger-opposition task. A high resolution (256x256) T1-weighted anatomical image was also acquired using the same prescription used for ASL data for grey matter segmentation.

Images were realigned using mcflirt (http://www.fmrib.ox.ac.uk/fsl/) to account for subject movement between scans. A Grey matter mask was created by segmentation of the T1 anatomical image after co-registration to the functional images. The data were reconstructed and pairwise subtracted. The methods were compared in terms of SNR and CNR. Signal was defined as the mean value inside the Grey matter mask over the 20 pairs of images. Contrast was calculated as the difference in signal between the active and resting state experiments. Noise was defined as the standard deviation of mean signal in the Grey matter mask over the 20 subtraction images. SNR was calculated using the resting state data. CNR was calculated over a 12 mm sphere in the motor cortex and included only those voxels whose signal (both pCASL and Double coil CASL) increased more than 10% in the active condition. CNR of each technique was estimated using the mean signal change at motor cortex ROI for active state subtraction images. In addition, perfusion was quantified from the double-coil and pCASL acquisitions during rest using the model proposed by Alsop [3] and modified by Wang [4] assuming grey mater T1 of 1300 ms, inversion efficiency of 0.8 and arterial blood T1 of 1600 ms.

Table 1. Comparison of SNR and CNR

	pCASL	Two-coil CASL
SNR	4.93	4.97
CNR	3.96	3.46

Table 2. Summary of Perfusion images (ml/min/100g)

	pCASL	Double-coil CASL
Mean	38.8	47.9
Std. Deviation	47.9	42.1
Median	38	48

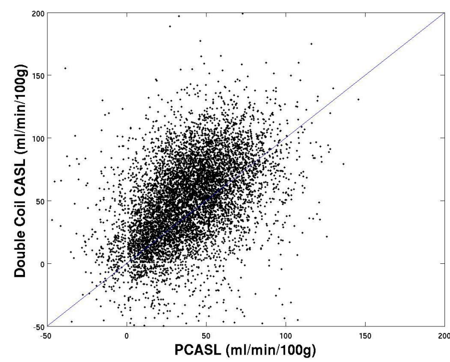

Fig. 1. Scatter plot comparing the quantitative perfusion images collected using pCASL and the Double-coil CASL techniques.

Results: Estimated SNR and CNR for both techniques are shown in table 1. Table 2 shows the mean gray mater perfusion values for each subject, A scatter plot comparing the obtained perfusion maps of the first subject is shown in figure 1. The plot indicates larger perfusion values measured with the double coil technique than with the single coil technique, but there is a clear correlation (r = 0.78) between the two techniques. The mean, median, and std. deviation over the image are shown in table2.

Discussion: Our preliminary results suggest that the performance of pCASL is comparable to that of the Double-coil approach. The Double-coil system offers the advantage of not causing magnetization transfer effects in the tissue. Its drawbacks are that longer distance from the tissue of interest means greater signal loss from T1 decay during transit (an additional 200 to 300 ms), and that it requires additional hardware. pCASL on the other hand has lower transient time but causes magnetization transfer. The combination of these two effects leads to a similar SNR and CNR both methods. The perfusion values calculated for both methods are highly correlated and well within the expected physiological range and also appear to have a normal spatial distribution.

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References: [1] Hernandez-Garcia *et al* , MRM, 51(3):577-585, 2004. [2] Garcia D *et al*, ISMRM, 2005. [3] Alsop D and Detre, JCBFM, 16(6):1236-49, 1996. [4] Wang J *et al* MRM, 48(2):242-54, 2002.