Longitudinal Study of Cerebral Blood Flow Measurements in Normals Using Pseudocontinuous and Velocity-Selective Arterial Spin Labeling

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PURPOSE Arterial spin labeling (ASL) is a noninvasive method for measuring cerebral blood flow (CBF). This method allows for a quantitative measurement, enabling continuous monitoring of subjects over a long time period; however, little work has been reported on the longitudinal variation of the ASL CBF measurement in the same subject or the confidence level of such measurements. In this study, we have performed CBF measurements in five normal volunteers for six months using pseudocontinuous ASL (PCASL)[1] and velocity-selective ASL (VSASL)[2], and have analyzed global CBF changes.

METHODS Study design: We recruited five healthy volunteers (age 36 ± 6 years; 4 men, 1 woman). Each subject was scanned six times at the consistent time of the day at approximately one-month time intervals. For each scan, we performed high-resolution T1-weighted imaging, and CBF measurements using PCASL and VSASL. All subjects refrained from caffeine for 5 hours prior to scan. Experimental setup: T1-weighted imaging was performed using 3D SPGR with inversion recovery. Imaging parameters were TR = 9.2 ms, TE = 3.7 ms, TI = 400 ms, flip angle = 13°, and matrix size = 256 x 256 x 144 over FOV = 240 x 240 x 173. Parallel imaging was used with reduction factor of 2. PCASL images were acquired using fast-spin-echo 3D stack of spiral with 8 interleaves. Imaging parameters were labeling duration = 1450 ms, post-labeling delay = 2025 ms, TR = 4845 ms, TE = 11 ms, number of control/tag pairs = 3, matrix size = 128x128, FOV = 220 mm, and slice thickness = 4 mm with 36 slices. VSASL was performed using dual sech pulses for tagging with cutoff velocity = 2 cm/s, and 2D single-shot spin echo spiral imaging for an image acquisition. Imaging parameters were TR = 5 s, TE = 16 ms, TI = 1630 ms, number of control/tag pairs = 30, 64 x 64 matrix size, FOV = 220 cm, and 6-mm slice thickness/2-mm slice spacing with 10 slices. Scan times were 4:38 and 5:30 for PCASL and VSASL, respectively. Figure 1 illustrates how imaging slices were localized for the two methods. All imaging was performed on the same GE MR750 3.0 T scanner. Image analysis: Image analysis was performed using Matlab and SPM8. In CBF quantification, blood M0 was estimated from gray matter M0 with PCASL, and was estimated from cerebrospinal fluid (CSF) M0 with VSASL. All CBF images from PCASL and VSASL were registered to T1-weighted images. These images were then normalized to T1 template space, from which the gray matter was segmented. Only the intersectional imaging volumes from PCASL and VSASL were included in the analysis.

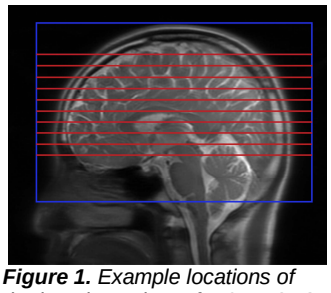

Figure 1. *Example locations of the imaging volume for 3D PCASL (blue) and slices for 2D VSASL (red).*

RESULTS Figure 2 shows global CBF measurement variation over six months and Table 1 summarizes statistical results for each subject. While CBF measurements with PCASL were always higher than the corresponding values from VSASL ($p<0.0001$ by paired Wilcoxon test), there was no significant difference in subject CVs between the two methods ($p=0.686$). Probability of measurement error being less than 10% of the true CBF was estimated based on assumption that physiological noise follows a Gaussian distribution with zero mean. There was no significant difference in the probability between the two (0.813). Variations in CBF with PCASL were almost always in the same direction as those with VSASL, suggesting that some of the variation is physiologic, and that the error of the measurement is even lower. Figure 3 shows representative CBF images from Subject 1.

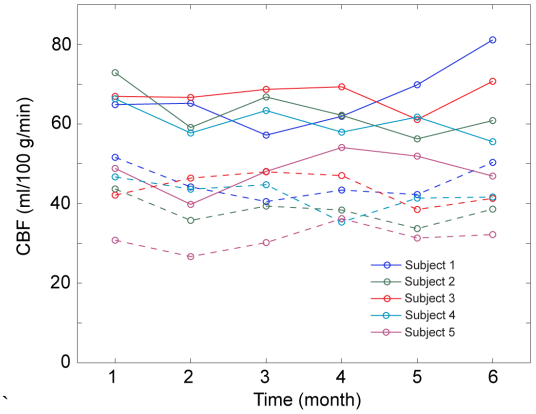

Figure 2. *Global CBF changes over six months measured in five healthy volunteers using PCASL (solid) and VSASL (dotted).*

DISCUSSION AND CONCLUSION While CBF from PCASL is in better agreement with literature values, both PCASL and VSASL demonstrated similar variation over time, with changes on the order of 10% or less over a 6 month period. Difference in quantitative CBF levels between PCASL and VSASL may be associated in part with different methods used for blood M0 estimation in CBF quantification.

REFERENCES [1] Dai *et al*, MRM 60: 1488, 2008. [2] Wong *et al*, MRM 55: 1334, 2006. **ACKNOWLEDGEMENT:** GE Healthcare, NIH P41 EB015891, NIH R01-NS066506-01, R01-NS047607-05.

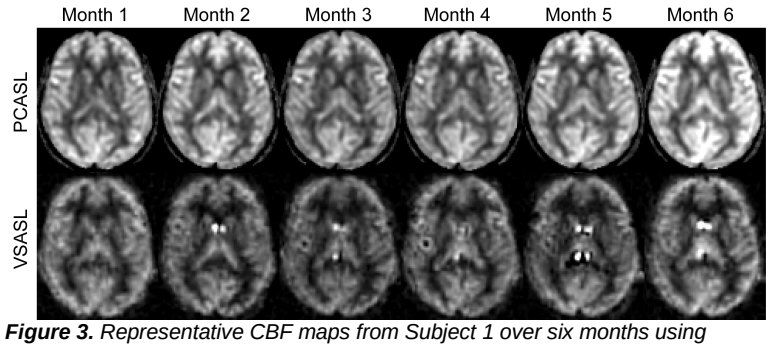

Figure 3. *Representative CBF maps from Subject 1 over six months using PCASL (top) and VSASL (bottom).*

Sub.	PCASL				VSASL				R
	Mean	SD	CV (%)	Pr (%)	Mean	SD	CV (%)	Pr (%)	
1	67	8	12	58	45	5	10	68	0.58
2	63	6	9	71	38	3	9	74	0.96
3	67	3	5	95	44	4	9	75	0.56
4	60	4	7	86	42	4	9	72	0.61
5	48	5	10	67	31	3	10	69	0.88
Avg.	61	5	9	76	40	4	9	72	0.72

Table 1. *Mean and standard deviation (SD) of CBF (ml/100 g/min) measured using PCASL and VSASL for each subject, and corresponding coefficient of variation (CV), probability (Pr) of measurement error being less than 10% of the true CBF, and correlation coefficient (R) between PCASL and VSASL.*