SHORT- AND LONG-TERM REPRODUCIBILITY OF PCASL BRAIN PERFUSION IMAGING AT 3T

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Introduction

Arterial spin labeling (ASL) imaging is widely utilized in both neuroimaging research studies and clinical applications.[1] Among ASL methods, pseudo-continuous arterial spin labeling (pCASL) has better labeling efficiency than CASL, and can provide high signal to noise ratio for perfusion imaging.[2-3] Before applying pCASL imaging in clinical research, e.g. to monitor short-term (<hours) brain perfusion response to controlled interventions or to investigate long term (~weeks) therapeutic effects, the test-retest reproducibility of this method has to be evaluated.

While many studies assessed the reproducibility of ASL,[4-9] very few studies investigated pCASL reproducibility.[8-9] More importantly, pCASL reproducibility has not been reported in specific sub-cortical brain regions such as the thalamus and the cerebellum. These regions-of-interest are of particular interest for applications in diabetes[9] and neurodegenerative diseases[10]. Here we obtained test-retest data on healthy human subjects to evaluate data variability within and across sessions using a whole-brain pCASL protocol at 3T.

Methods

Brain perfusion imaging studies were performed on a TIM Trio 3T scanner (Siemens Healthcare, Erlangen, Germany) by using a 12-channel head coil as the receiver and the body coil for RF transmission. Five healthy males were enrolled for the study. Subjects were instructed to avoid any movements of arms or legs, keep eyes closed but remain awake. The positioning of each subject across sessions was kept consistent by using both position markers and comparing positions on high resolution anatomic images. To evaluate long-term reproducibility subjects were scanned twice one month apart. For each of the two sessions, subjects were asked to be exposed to similar exercise levels, food and alcohol intake within the 24 hours prior to the study. To evaluate within-session reproducibility, three determinations were obtained about every 20 minutes with each measurement lasting about 10 minutes. All studies were performed at the same time in the afternoon.

Whole-brain pCASL[2-3] data were acquired with in-plane resolution 3 x 3 mm^2 and 3 mm slice thickness with 20% slice gap, 1.5 s labeling time and 1.5 s and 1.4 s post-labeling delay time. Image processing was performed with Matlab (The MathWorks Inc., Natick, MA) and SPM (http://www.fil.ion.ucl.ac.uk/spm/). The maps of cerebral blood flow (CBF) were reconstructed by using the single blood-compartment model.[12] ROIs used for reproducibility evaluations were defined in the brain regions shown in Figure 1. The reproducibility was evaluated by using coefficients of variation (CV = SD/mean) and expressed in percentage relative to mean CBF. The within-person within-session reproducibility was calculated from N=5 volunteers, 2 sessions, CV computed per session across 3 determinations. The within-person across-session reproducibility was determined from N=5 volunteers, 3 determinations, CV computed per determination across 2 sessions.

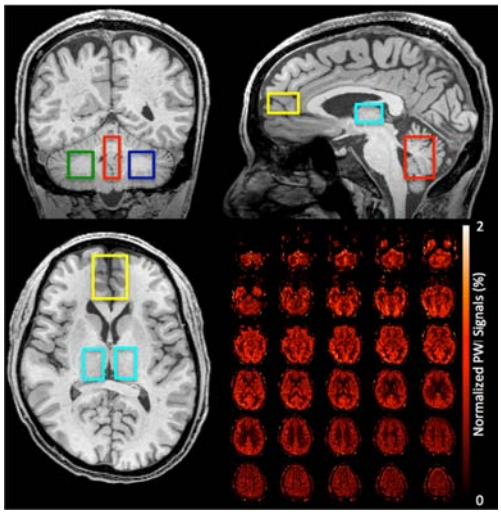

Figure 1 Regions of interest and representative CBF maps acquired with our pCASL protocol.

Results and Discussions

CBF maps of one representative subject are shown in Figure 1. The CBF values measured by our pCASL protocol were highly reproducible within and across sessions (Table 1), with average values of within- and across-session CVs generally lower than 5% in most of the investigated regions. Notably, across-session CVs were lower than within-session CVs, as reported in previous studies.[9] In addition, the between-session reproducibility of the first measurement in each session was in general better than the later measurements, likely due to subject motion.

Table 1. Between- and within- session reproducibility evaluated as coeffiecients of variation (C.V., %) for pCASL perfusion imaging with five healthy volunteers.*

	Thalamus		Frontal Cortex	Cerebellum		Cerebellar Vermis
	Right	Left		Right	Left	
Measurement No.	**Across-Session**					
1	2.11 ± 1.61	3.16 ± 1.66	2.42 ± 1.22	4.72 ± 2.25	4.55 ± 1.80	2.15 ± 2.29
2	4.02 ± 2.19	3.14 ± 0.55	5.60 ± 2.75	3.07 ± 1.35	5.87 ± 2.17	3.29 ± 1.27
3	5.77 ± 3.31	4.00 ± 3.76	4.12 ± 2.14	4.68 ± 2.81	5.20 ± 2.23	4.89 ± 1.47
Mean	3.47 ± 2.34	3.43 ± 0.93	3.95 ± 1.61	3.65 ± 1.75	3.61 ± 1.95	1.91 ± 1.76
Session No.	**Within-Session**					
1	2.65 ± 1.07	3.23 ± 0.79	2.23 ± 0.36	2.47 ± 0.90	5.14 ± 1.25	3.16 ± 0.98
2	3.11 ± 0.52	3.06 ± 0.39	2.41 ± 0.30	2.28 ± 1.32	5.50 ± 1.24	3.54 ± 0.81

* Mean denote the between-session coefficients of variation between mean CBF values of three measurements from each session.

Conclusions: Brain perfusion imaging using pCASL provides reproducible CBF measurements at 3T with a short (10 min), whole brain acquisition protocol, particularly suited for multi-modal clinical research studies. These data provide a valuable reference for neuroimaging applications using pCASL and are expected to assist experimental design in terms of power analysis and population size.

References

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