Test-Retest Reproducibility of perfusion measurements using PASL at 3 T

C. Preibisch[1], A. Förschler[1], A. Wohlschläger[1], C. Sorg[2], A. Kurz[2], C. Zimmer[1], P. Alexopoulos[2]

[1] Abteilung für Neuroradiologie, [2] Klinik und Poliklinik für Psychiatrie, Klinikum rechts der Isar der TU München

Introduction

Pulsed arterial spin labeling (PASL) perfusion imaging of cerebral blood flow (CBF) has already proven to be a useful instrument for the study of brain pathologies [1,2]. However, validated quantitative imaging methods are not available from the manufacturers. Therefore, the aim of the current study was to investigate the reproducibility of a PASL imaging sequence based on the previously presented PULSAR technique [3] combined with thin slice periodic saturation pulses (Q2TIPS) [4] to control for the length of the tagged bolus and facilitate CBF quantification with a single inversion time.

Subjects and Methods

Resting CBF maps were obtained from 20 subjects (10 male, 10 female, 30.7±9.1a) on two different days (time lag 8.4 ± 9.3 days).

Instrumentation: 3 T whole body scanner: body coil for transmit; 8-channel head coil for receive

Pulses Arterial Spin Labeling:

• PULSAR sequence [3] using a STAR tagging scheme [5] for labeling and a WET presaturation of the imaging volume [6].

• Thin slice periodic saturation pulses (Q2TIPS) [4] control for the length of the tagged blood bolus and facilitate calculation of CBF.

• Imaging parameters: single-shot EPI readout; TR/TE/α = 2500ms/17ms/90°; TI1/TI1S/TI2 = 700ms/ 1200ms/1500ms; 11 slices (aligned to Hippocampus, comprising parietal lobe); matrix 64x63; voxel size 3.75x3.75x6 mm³; gap 0.6 mm; 80 pairs of labeled-control; scan time 7 min 18 sec.

• Whole brain single shot EPI (voxel size 3.75x3.75x3 mm³; 40 slices) and T1-weighted TFE volume (voxel size 1x1x1 mm³; 170 slices) for spatial coregistration and normalization.

Postprocessing:

• Spatial preprocessing, coregistration, calculation of CBF-maps [7] (including correction for partial volume effects [8]) and statistical analysis were performed with custom programs written in MATLAB and SPM8 (http://www.fil.ion.ucl.ac.uk/spm). ROI evaluation used WFU Pickatlas (http://www.nitrc.org/projects/wfu_pickatlas).

• The within-subject standard deviation

$$SD_w = \sqrt{\sum (CBF_{i1} - CBF_{i2})^2 / 2n}$$

and repeatability (95% confidence limit) $CL = \sqrt{2} \cdot 1.96 \cdot SD_w$ [9, 10] were estimated for GM, WM and different brain regions.

Results

Fig. 1 shows a typical perfusion map. Mean CBF values (± SD), within-subject standard deviation SD_w and repeatability CL are summarized in Table 1. A 2×2 ANOVA with factors measurement and gender did not yield a significant main effect of measurement at $p < 0.001$ uncorrected. Significant effects of gender were only detected at the inferior and superior borders of the imaging volume, and are most probably due to different brain sizes.

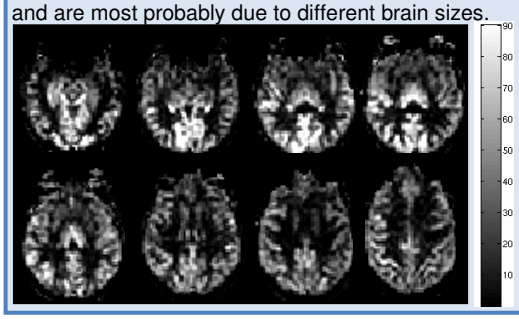

Fig 1: Typical CBF map of a female subject (age 22 a).

Table1: CBF (mean ± SD across all subjects), SD_w and CL in different anatomical brain regions:

	ROI size	CBF_1	CBF_2	SDw	CL
Frontal Lobe	[nvoxel]	[ml/100g/min]	[ml/100g/min]	[ml/100g/min]	
Inf. Frontal, Orbital	1447	33.0 ± 8.4	36.6 ± 7.7	5.5	15.4
Rolandic Operculum	2192	47.8 ± 9.1	48.9 ± 10.2	5.5	15.2
Olfactory Cortex	126	20.6 ± 5.9	20.6 ± 5.3	2.7	7.6
Insula	3442	37.9 ± 7.0	38.9 ± 7.6	5.2	14.3
Cingulum					
Mid. Cingulum	2273	47.6 ± 10.5	47.8 ± 12.0	5.2	14.5
Post. Cingulum	660	46.2 ± 11.6	47.8 ± 8.3	7.0	19.3
Limbic System					
Hippocampus	1453	32.2 ± 6.1	33.8 ± 5.0	3.5	9.8
Parahippocampus	671	37.4 ± 9.4	38.3 ± 7.2	5.4	14.9
Amygdala	141	17.9 ± 5.4	18.9 ± 6.1	4.9	13.6
Parietal Lobe					
Sup. Parietal	3301	38.7 ± 7.7	37.4 ± 9.5	4.9	13.5
Inf. Parietal	3682	47.2 ± 8.8	48.6 ± 7.5	4.6	12.6
Supramarginal	3076	45.1 ± 9.4	45.6 ± 8.2	4.8	13.2
Angular Gyrus	2806	43.4 ± 10.0	44.3 ± 9.5	4.3	12.0
Precuneus	5972	52.3 ± 10.4	52.1 ± 7.4	4.5	12.5
Deep Gray Matter					
Caudate	1762	21.2 ± 6.6	21.2 ± 4.1	3.8	10.4
Putamen	1864	24.0 ± 4.2	24.2 ± 3.4	3.0	8.3
Pallidum	235	17.1 ± 5.3	16.5 ± 5.3	3.4	9.3
Thalamus	1400	46.4 ± 11.6	47.0 ± 9.2	4.7	13.1
Temporal Lobe					
Heschls Gyrus	442	54.7 ± 12.9	54.0 ± 11.2	7.5	20.8
Sup. Temporal	4941	45.8 ± 11.9	45.5 ± 9.6	5.9	16.4
Sup. Temporal, Pole	703	35.9 ± 9.5	36.2 ± 10.2	7.0	19.4
Global CBF values					
GM	63112	39.5 ± 6.6	40.0 ± 4.5	3.3	9.0
WM	89384	9.9 ± 2.0	10.2 ± 2.6	1.9	5.3

Conclusion

Perfusion measurements based on PULSAR show good reproducibility lying in the range detected for other ASL methods [10-13]. Absolute CBF values are generally rather low especially in WM. In GM low perfusion values may in part arise from a high proportion of deep grey matter where lower CBF values were reported previously [14]. Another possible cause might be a relatively a low labeling efficiency of the STAR tagging scheme [3] as well as prolonged transit times to the distal slices of the relatively thick imaging slab. However, for imaging studies in patient populations good reproducibility, high volume coverage and limited measurement times are more important than the accuracy of absolute CBF values.

References: [1] Golay & Petersen. Neuroimaging Clin N Am 16:259-268 (2006). [2] Wintermark et al. J Neuroradiol 32:294-314 (2005). [3] Golay et al. MRM 53:15-21 (2005). [4] Luh et al. MRM 41:1246-1254. [5] Edelman & Chen. MRM 40:800-805 (1998). [6] Ogg et al. J Magn Reson B 104:1-10 (1994). [7] Nöth et al. JMRI 24:1229-1235 (2006). [8] Johnson et al. Radiology 234:851-859 (2005). [9] Bland & Altmann BMJ 313:744 (1996). [10] Parkes et al. MRM 51:736-743 (2004). [11] Yen et al. MRM 47:921-928 (2002). [12] Jahng et al. Radiology 234:909-916 (2005). [13] Hermes et al. MAGMA 20:103-115 (2007). [14] Grossmann et al. JMRI 29:1425-1431 (2009).