Voxel based perfusion variability in ASL

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Introduction

For the use of arterial spin labeling (ASL) in clinical routine, knowledge on variability of ASL measurements is of great importance. Thus far, ASL variability studies have mainly focussed on intrasession and intracenter and multicenter variability of global perfusion and of perfusion in the flow territories of major brain feeding arteries [1,2]. As a part of the Dutch multicenter reproducibility study [2], we further analyzed variability patterns over different brain regions performing a voxel based analysis of variance (ANOVA).

Methods

Voxel based perfusion variability was assessed at three imaging centres in the Netherlands, all equipped with a Philips 3T MR scanner with the same implementation of continuous, pulsed and pseudo-continuous ASL with and without background suppression (CASL, PULSAR, P-CASL with and without background suppression). Local ethics committees approved this study and the six healthy participants (five male; age 25-50) gave written informed consent. Volunteers were scanned twice at each site with 1 to 3 weeks between sessions. The imaging protocol consisted of: an amplitude modulated CASL sequence [3] (combined with MR angiography for planning of the CASL labeling plane and acquired with a transmit/receive head coil), a PULSAR sequence [4], a P-CASL sequence [5] performed with and without background suppression, and a high resolution 3D T1- weighted anatomical scan for registration purposes (all acquired with a SENSE-8-channel head coil and body coil transmission). Scans were made in a randomized fashion. For imaging parameters of ASL sequences see *Table 1.* After quantification of whole brain perfusion, all data were scaled to a mean cerebral blood flow (CBF) of 30 ml/100g/min in order to remove global variability between scans. Perfusion images were transformed into standard space via registration on corresponding grey matter masks. The transformation matrices of perfusion weighted images were used to transform all 36 sets individual dynamics into standard space. Subsequently, voxel based variability was assessed by performing a one-way analysis of variance using ANOVA. The latter was used to assess within and between session variability. Results were depicted in brain maps reflecting the standard deviations (SDs) of measured signal intensities in all voxels in the brain. To assess perfusion variability within sessions the analysis was performed on the signal intensities in all voxels of 40 paired subtractions of labeled and control images (subtractions C-L). To assess perfusion variability between sessions the analysis was performed on the signal intensities in all voxels of 36 means of subtractions C-L.

Imaging Parameters	P-CASL	CASL	PULSAR
TR; TE	4000; 14 ms	4500; 32 ms	3000; 20 ms
FOV; Matrix	240x240; 80x79	210x210; 64x45	240x240; 80x79
Slices; Thickness	17; 7 mm	11; 7 mm	17; 7 mm
Sequence	GE EPI	SE EPI	GE EPI
Post Labeling Delay	1525 ms	1200 ms	1200 ms
Averages	40	40	40

Table 1: Imaging parameters

Results

The mean PULSAR perfusion maps show hyperperfusion of the posterior circulation. The within session SD maps, show that perfusion variability is smallest in P-CASL based sequences. Background suppression further reduces perfusion variability. In CASL, obtained with a transmit/receive head coil, variability is largest in the frontal area. For all ASL techniques variability is mostly seen in vascular regions. The PULSAR data show high SDs in the posterior circulation within and between sessions. The between session SD maps show non global perfusion variability since all data were scaled to mean CBF 30 ml/100g/min. Between session SDs are smaller than within session SDs. Again P-CASL based sequences show less variability than PULSAR and CASL data.

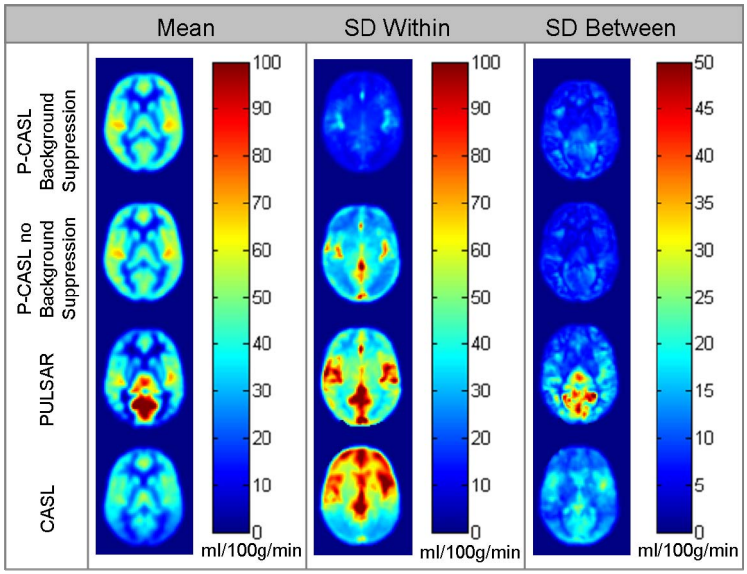

Figure 1: Brain maps of mean perfusion and corresponding standard deviations (SDs). The SD maps reflect per voxel variability of perfusion measurements within and between imaging sessions. Data were averaged over all subjects and sessions.

Discussion

P-CASL based sequences show least per voxel variability both within and between imaging sessions. In the CASL within SDs, largest variability is seen in the frontal zone. This finding could be due to the fact that images were obtained with the transmit/receive head coil with a varying magnetic B1-field within this head coil. Regarding the within session data, SDs are largest in the vascular regions. This can be explained by the relatively unstable signal from the large vessels due to blood pulsation. For PULSAR there is a relatively large SD between in the posterior circulation. This is in accordance with earlier findings for reproducibility in this region [2] and also reflected by the mean perfusion maps. Apparently, the large perfusion variation in this region is not sufficiently reduced by scaling all brains to a mean value of 30 ml/100g/min. Between session SDs are smaller than within session SDs since global variability is removed by scaling of the data and since convergence of the measured signal causes large variation in the within session data that can no longer be observed in the between session data. The results of our study show that P-CASL with background suppression is least variable over different brain regions whereas other ASL techniques show more variability, mainly in vascular regions. Most striking per voxel variances were found in the posterior circulation for PULSAR and in the frontal region for CASL.

References

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