Reproducibility and Convergence of CASL Perfusion MRI at 3.0 Tesla

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Purpose/introduction

Arterial Spin Labeling (ASL) is used to quantify cerebral blood flow of gray and white matter. Its non-invasiveness makes the methods very attractive compared to standard clinical methods, especially in the pediatric population. However the low signal effect of the labeled blood and consequently the reproducibility of ASL is an important concern when using this method in clinical practice for assessing perfusion abnormalities. Commonly the protocol consists of 40 to 60 paired acquisitions of labeled and controlled scans, inducing the possibility of decreased CASL quality due to head motion. The use of 3.0 Tesla is assumed to increase the perfusion contrast compared to 1.5 Tesla. Here we study the reproducibility and the convergence of cerebral blood flow (CBF) measurements using CASL at 3.0 Tesla in the brain when increasing the number of acquisitions.

Subjects and methods

For studying interscan reproducibility we obtained CASL data from 6 healthy volunteers that were scanned on three different occasions in a period of 3 weeks. To assess intrascan variability during each session two CASL scans were performed. CASL imaging was performed by using the amplitude modulated CASL approach originally described by Alsop and Detre (Radiology 206:410-416) using a post-labeling delay of 1.2 s. This method is implemented on a 3.0 Tesla MRI scanner without compromising clinical SAR levels. The position of the labeling plane was planned and carefully reproduced using a MRA scan each consecutive session perpendicular to the posterior ascending portion of the internal carotid artery. Single-shot spin-echo EPI images (TR/TE =4500/32 ms) were acquired of 11 slices of 7 mm with 1 mm slice gap (imaging matrix of 64 x 64). Acquisition of 50 pairs of labeled and control volumes takes approximately 8 min. The reproducibility was expressed in terms of the standard deviation of the difference in mean whole brain CBF between two repeated measurements (dSD), according to the method of Floyd et al. (JMRI 18:649-655) in a similar reproducibility study that was performed on a 1.5 Tesla.

Results

In Figure 1a the intersession dSD converges to ~6 ml/100g/min after 25 averages, whereas the intrasession dSD remains around 4.5 ml/100g/min after 25 averages. Interestingly the former value is much lower than the value reported by Floyd et al. for a 1.5 Tesla scanner with 45 perfusion acquisitions (9.6 ml/100g/min), whereas the latter value is comparable to the value reported for 1.5 Tesla (4.3 ml/100g/min). In addition we determined the convergence of CASL measurements by calculating the mean absolute difference between mean whole brain CBF values as a function of the number of averaged acquisitions. From Figure 1b it can be concluded that averaging more than 25 pairs of labeled and control volumes does not change the mean CBF value. This statement is visualised for one dataset in Figure 2: no clear differences are visible between 30,40 and 50 averages.

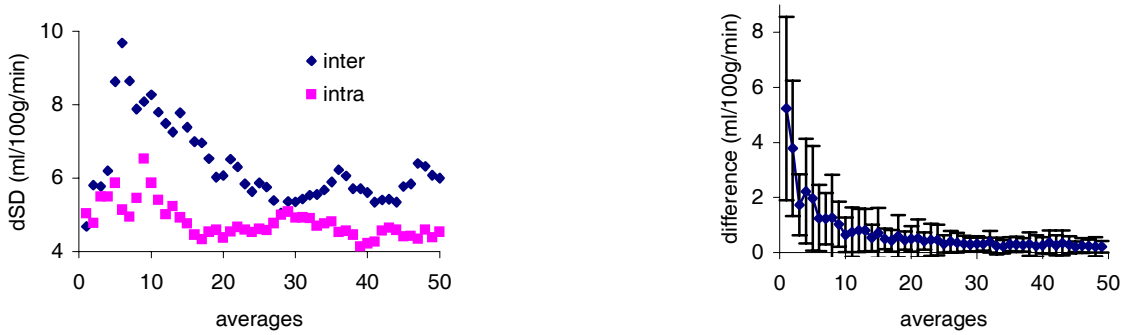

Figure 1: dSD (standard deviation of the difference in mean whole brain CBF between two repeated measurements) as a function of the number of averages used (a), convergence of CASL measurement expressed as mean absolute difference between mean whole brain CBF values when increasing the number of averages (b).

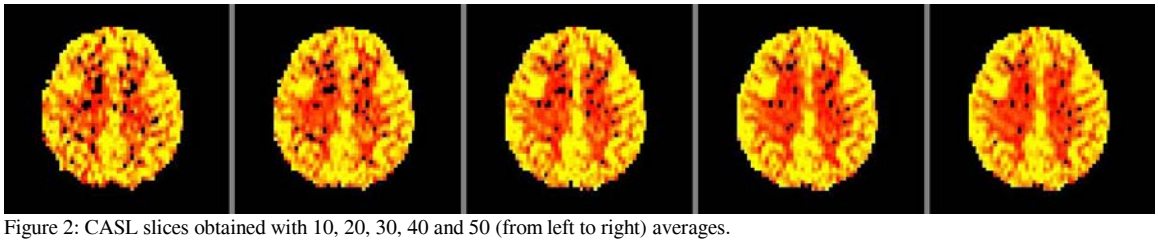

Figure 2: CASL slices obtained with 10, 20, 30, 40 and 50 (from left to right) averages.

Conclusions

From our study it can be concluded that the number of averages for CASL at 3.0 Tesla need not to be higher than 25. Both reproducibility and convergence do not improve further when acquiring more CASL pairs. As motion is a matter of concern when acquiring CASL data sets, we expect the limited number of acquisition to improve the CASL quality indirectly.