Feasibility of Arterial Spin Labeling on a 1T open bore scanner

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Introduction

In the last few years the interest in Arterial Spin Labeling (ASL) as a non-invasive diagnostic tool for the determination of cerebral blood flow, has increased substantially. Currently, the majority of ASL research is performed on MRI scanners with a magnetic field strength of 3 Tesla or higher. With the increasing obese population and the difficulty to measure children in cylindrical MRI scanners, open bore scanners were developed to accommodate these patient populations, although the lower field strength (max 1T) of these scanners is a major drawback. To support scientific research and clinical diagnosis in these patient populations it is essential to translate important functional MR techniques, like ASL, to these lower field strengths. Therefore, the purpose of this study was to implement and investigate the performance of different available ASL sequences on a 1T open bore scanner.

Materials & Methods

Seven healthy volunteers were scanned on a Philips 1T open bore MRI system using a 4 channel SENSE receive coil and body coil transmission. The scanning protocol consisted of a 3D T1w FFE scan for anatomical reference and brain segmentation, followed by 4 different ASL sequences (4x4x8 mm³ resolution, 80x49x7 matrix (AP/RL/FH), delay=1200 ms, 10 min acq. time). The studied ASL sequences were: a Multi-slice (Ms) single-shot EPI pCASL with and without background suppression (BS) (labeling duration=1300 ms, TE=17 ms, TR=2952 ms, NSA=99 BS=1540/2275 ms) [1], a Ms PASL no BS (PULSAR, TE=17 ms, TR=2200 ms, NSA=133) [2], and a Multi-shot (Msh) 3D GraSe pCASL BS (TE=23ms, TR=2747 ms, NSA=56 , ETL=145ms, Shots=2, Partial Fourier (z-direction)=5/8, oversampling=1.8, BS=1540/2275 ms) [3]. The anatomical data was segmented and registered to the ASL data with SPM, after which a Grey Matter (GM) ROI analysis was performed on the central 3 slices. Assuming convergence after 10 minutes, all ASL data was scaled to a mean 10 min CBF of 60 ml/100g/min followed by a comparison of the convergence rate (delta CBF), mean CBF, SNR and percentage of pixels significance (t-test) as function of time.

Results

Figure 1 depicts the 4 different ASL sequences (at 1, 5 and 10 min) and the GM probability mask combined for a single volunteer. With the exception of PASL, the perfusion is nicely confined to the GM in the ASL images. Although the GraSe images depict the cortical GM quite well, a considerable signal loss is observed in the basal ganglia (as depicted by the green arrows). After 1 minute a small difference between the Ms-pCASL with and without BS is noted (the anatomical detail with BS is slightly better, visible in slice 4 and 6), although after 5 minutes no difference between both sequences is observed. Figure 2 shows the results of the mean CBF, SNR, convergence and percentage of pixel significance as function of acquisition time (all restricted to GM). With the exception of the SNR, stable values are reached after 5 to 6 minutes for all sequences. The PASL sequence shows the fastest convergence and highest SNR. Both Ms-pCASL sequences show similar behaviour in terms of convergence and SNR, yet with a lower convergence rate and SNR than the PASL sequence. The SNR of the 3D GraSe sequence is in the same range as Ms-pCASL, however its convergence rate is the lowest of all sequences.

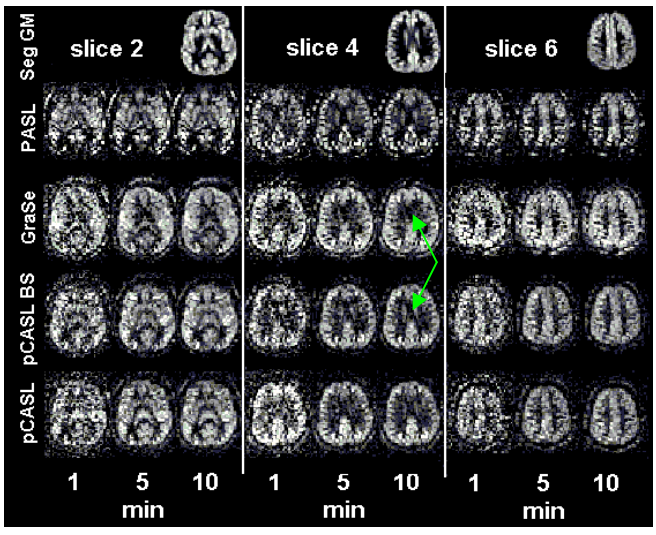

***Figure 1**: Segmented GM probability mask, PASL, 3D GraSe, pCASL with BS and pCASL without BS (after 1, 5 and 10 minutes). Green arrow depicts the signal loss in the 3D GraSe images.*

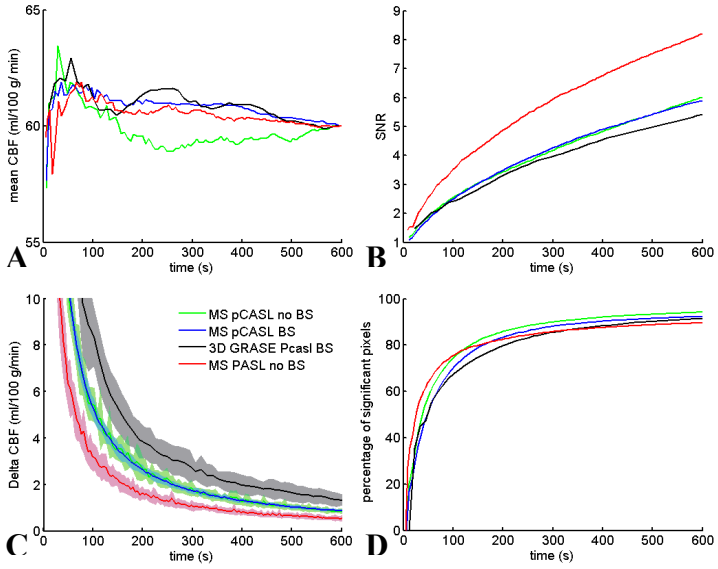

***Figure 2**: Mean CBF (**A**), SNR (**B**), Delta CBF (coloured shading is the standard deviation over the volunteers) (**C**) and percentage of significant pixels (**D**) as function of time, for each sequence.*

Discussion

We have demonstrated that ASL on a 1 Tesla open bore scanner is possible with a reasonable resolution and within a scanning period of approximately 5-6 min. Ms-pCASL proved to produce the most detailed images combined with acceptable SNR and convergence. Background suppression appeared to have minor influence on image quality and the analyzed CBF parameters. 3D GraSe has shown to produce detailed images, yet the quality of the images was not optimal for all volunteers, especially showing apparent hypo-perfusion in the basal ganglia. The PASL images showed poor image quality, although quality assessment in the GM showed that the pixels which do coincide with the GM show superior convergence and SNR. Poor image quality of PASL might be attributed to vascular signal, which could be improved by vascular crushing or a smaller labeling slab.

References

[1] Garcia et al., Proc. ISMRM 2005;#37, [2] Golay et al., MRM 2005;53:15-21; [3] Günther et al., MRM 2005; 54:491-498