Comparing 3D Velocity-Selective Arterial Spin Labeling to 3D Pseudocontinuous Arterial Spin Labeling

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PURPOSE

In principle, velocity-selective arterial spin labeling (VSASL)[1] eliminates transit delay by tagging arterial blood based on its velocity. This method has the potential to improve ASL signal-to-noise ratio (SNR) in patients with slow or delayed flow as it avoids the use of a long post-labeling delay, yet is expected to show lower SNR in the general patient population due to saturation-based tagging rather than inversion. 3D pseudocontinuous ASL (PCASL)[2] is known to provide the largest SNR among all ASL tagging schemes, and may serve as a reference for SNR estimation of VSASL. However, no previous work has reported on the comparison of VSASL and PCASL, both with 3D imaging and with the same quantification method. In this study, we have combined VS tagging with whole brain 3D image acquisition[3], and have performed a comparison with 3D PCASL.

METHODS

Unlike single-shot imaging, we have found that 3D segmented imaging requires extremely good background suppression (BGS) to avoid artifacts in ASL images (swirling artifacts in our case with spiral acquisition) possibly due to different phase errors for different segments. Ideally, the TR that maximizes the SNR efficiency in VSASL is around 5 s; however, we used a TR of 3 s to achieve good BGS afforded by a shorter interval between pre-saturation and VS tagging. We used one pre-saturation and four inversion pulses for BGS, and the timing was optimized considering different T1 recovery as well as different T2 decay during VS tagging for various tissues in the brain. We performed VSASL and PCASL scans four times in two normal volunteers with slightly different BGS timing for each scan.

Image acquisitions were identical for VSASL and PCASL; fast-spin-echo 3D stack of spiral with 8 interleaves, TE = 11 ms, matrix size = 128x128, FOV = 220 mm, and slice thickness = 4 mm with 36 slices. Imaging parameters for VSASL were TI = 1600 ms, cutoff velocity = 2 cm/s, TR = 3 s, number of control/tag pairs = 5, and total scan time = 4:29. Dual sech pulse was used for VS tagging. PCASL parameters were labeling duration = 1450 ms, post-labeling delay = 2025 ms, TR = 4832 ms, number of control/tag pairs = 3, total scan time = 4:38. All imaging was performed on a GE MR750 3.0 T scanner.

RESULTS

Swirling artifacts in the ASL images were minimized when we achieved the lowest BGS residue particularly in vitreous humors using the pre-saturation and four inversion pulses at 2468 ms, 1584 ms, 741 ms, 279 ms, and 76 ms prior to imaging RF respectively. The corresponding BGS residue was approximately 2% of the equilibrium values, which is still higher than BGS residue of 0.2% with PCASL. BGS optimization was more challenging in VSASL because of shorter inversion recovery time and additional T2 decay during VS tagging. Figure 1 shows the ASL images of selected slices from 3D volume acquired using VSASL and PCASL. Both tagging schemes showed very similar flow patterns except VSASL images showed bright signals in regions containing cerebrospinal fluid (CSF) in the inferior slices, and exhibited lower SNR in general. With the parameters we used, the simulated SNR efficiency of VSASL was 72% of that of PCASL. In the four scans excluding the slices with bright CSF signals and swirling artifacts, the measured SNR of VSASL images was 71 ± 5% of that of PCASL, which showed good agreement with simulation. Measured cerebral blood flow (CBF) was 56 ± 3 ml/100 g/min with VSASL and 51 ± 3 ml/100 g/min with PCASL, showing only 7% discrepancy.

DISCUSSION AND CONCLUSION

3D VSASL achieved images that were consistent with 3D PCASL in normal volunteers. SNR with VSASL was about 30% lower than that of PCASL, but was adequate to provide clinically meaningful image quality. Apparent bright signal in CSF regions in the VSASL images may be due to CSF tagged by VS tagging pulse and remains to be suppressed in future work.

REFERENCES [1] Wong *et al*, MRM 55: 1334, 2006. [2] Dai *et al*, MRM 60: 1488, 2008. [3] Wong et al, 14th ISMRM p3427, 2006.
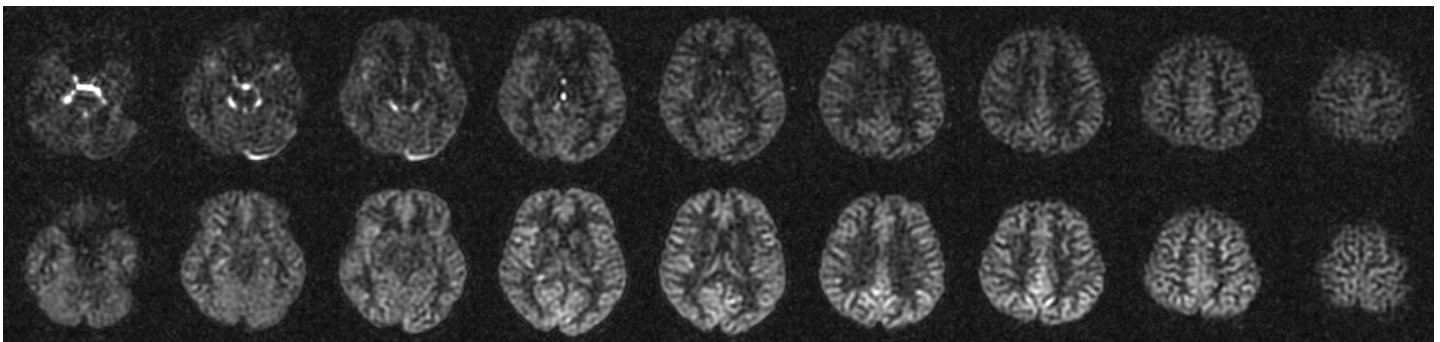
Figure 1. ASL images of selected slices acquired in a volunteer using 3D VSASL (top) and 3D PCASL (bottom). Images are windowed so that the images from both methods have the same noise level. Difference in blood flow signal between two methods reflects the SNR efficiency difference. Measured SNR with VSASL was 71% of that of PCASL averaged across four volunteer scans, which is in agreement with the value from simulation, 72%. Average CBF was 56 ml/100 g/min with VSASL and 51 ml/100 g/min with PCASL.