Measurement of Arterial Blood Velocity Distribution in the Human Brain Using Velocity Selective ASL

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Introduction:

Quantitative imaging of cerebral blood flow using arterial spin labeling (ASL) is a promising tool for the diagnosis, monitoring and treatment of stroke, but the possibility of long transit delays due to collateral circulation makes conventional ASL problematic. Velocity selective ASL (VSASL) tags blood without spatial selectivity and thus is in principle immune to transit delay effects. Recently introduced velocity selective pulse trains for velocity selective inversion (1) may help to increase tagging efficiency in VSASL. However, these pulse trains invert relatively narrow bands of velocity, and knowledge of the distribution of arterial velocities would be useful for pulse optimization. Using VSASL, we report here direct measurements of the arterial blood velocity distribution in the human brain.

Methods:

Five healthy subjects with no known cerebral vascular disease were recruited and scanned at 3T for this study. The study was IRB approved and informed consent was obtained from all subjects. After a localizer scan, 5 slice 2D axial VSASL scans using the dual adiabatic spin echo pulse train (2) were performed with the following parameters: single shot spiral with matrix 64×64, TE 15ms, TR 3000ms, tag delay 1600ms, FOV 24cm, slice thickness 8mm, and spacing 4mm. 6 VSASL scans were performed, with the velocity cutoff of the tagging pulse set to: 2, 4, 8, 16, 32, and 64 cm/sec. The velocity cutoff in the image acquisition was 2 cm/sec for all scans. Data was analyzed using MATLAB. Thresholding was applied on the VSASL images to isolate the grey matter perfusion signal, which is then used to generate the relative arterial blood volume in each velocity bin.

Results:

The relative blood volume above each velocity cutoff is shown in Figure 1. The relative blood volume in each velocity bin is shown in Figure 2. The amount of blood flow at high velocities rapidly decreases. Approximately 60% of arterial blood is below 32 cm/sec, with only about 10% above 64 cm/sec.

Discussion/Conclusion:

Using the dual adiabatic spin echo VSASL pulse, an arterial blood velocity distribution was generated. The velocity distribution was relatively uniform across individuals, suggesting that the vascular myogenic response maintains a fairly constant velocity distribution profile. Due to the use of the dual adiabatic spin echo pulse, which has a symmetrical velocity response, positive and negative directions of blood flow could not be distinguished. Future experiments with the use of velocity selective pulses with asymmetrical response (1) may help to differentiate the positive and negative velocity distribution.

References

1. Wong et al, ISMRM p. 619, 2009. 2. Wong et al. MRM 55 p.1334, 2006.

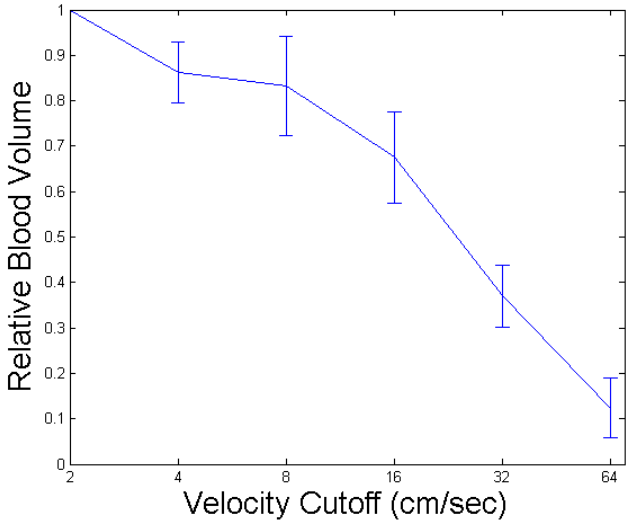

Figure 1: Relative Blood Volume vs. Velocity Cutoff Graph. The relative blood volume is normalized to the blood volume flowing above 2 cm/sec at the time of tag and decelerates to below 2 cm/sec at the time of imaging. The data points indicate the blood volume that is flowing faster than the velocity cut-off at the time of tag and decelerates to below 2 cm/sec at the time of imaging.

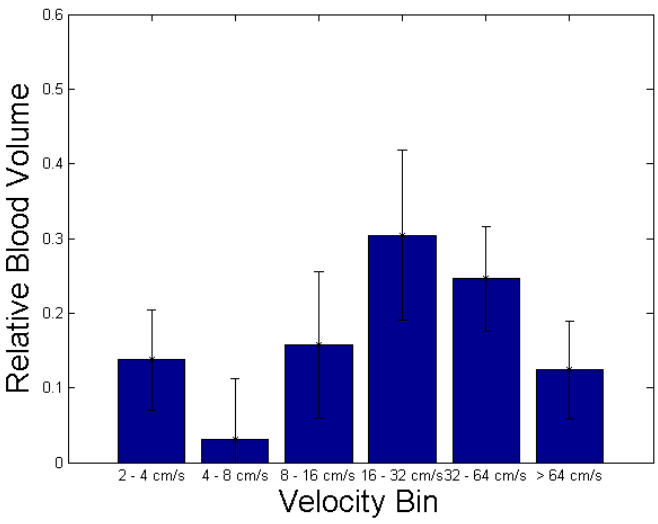

Figure 2: Relative Blood Volume vs. Velocity Bin Graph. The relative blood volume is normalized to the blood volume flowing above 2 cm/sec at the time of tag and decelerates to below 2 cm/sec at the time of imaging. The bins are generated using the data points in Figure 1.