Whole Brain 3D Velocity Selective Arterial Spin Labeling using a Background Suppressed Flow Weighted Spiral Fast Spin Echo Acquisition

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Introduction

In velocity selective ASL (VSASL) (1,2), arterial spins are tagged based on their velocity, rather than their location. This spatially non-selective tagging method allows in principle for the elimination of transit delays in the delivery of tagged blood to the target tissues. For stroke and other vascular diseases in which flow can be slow and/or circuitous, VSASL is a promising approach for the quantitative imaging of CBF using ASL. Because of this transit delay insensitivity and spatial non-selectivity, VSASL is particularly amenable to volumetric image acquisition methods. We demonstrate here whole brain VSASL using a 3D stack-of-spiral fast spin echo (FSE) acquisition.

Methods

In VSASL, the tag is generated using a velocity selective pulse train that saturates flowing spins above a selected cutoff velocity V_c. In order to produce an ASL signal that is proportional to CBF, the image acquisition should also include a saturation of spins flowing faster than V_c. This allows for imaging only of spins that decellerated through V_c, and generates a signal that is proportional to CBF•T, where T is the time between tagging and image acquisition. A simple method for introducing flow dependent saturation into the imaging sequence is flow weighting gradients, and in this implementation we use such gradients placed around the first 180° pulse in an FSE pulse train. The first flow weighted echo is not collected, but all subsequent echos are collected using a spiral readout. The trajectory used was an interleaved stack-of-spirals, with different K_z steps encoded along the echo train, and different spiral interleaves encoded across TRs. Centric encoding along K_z was used to minimize T_2 decay at the center of K-space. The echo time for the first echo need not be equal to the echo spacing for subsequent echos, and these are minimized independently. Because the arterial blood may be tagged either inside or outside of the imaging region, it is important for quantification of CBF that the magnetization of arterial blood in those two locations are the same at the time of the tag. In order to achieve this, a global non-selective saturation was applied immediately after image acquisition.

Scanning and tagging parameters were: GE 3T scanner; commercial 8 channel head coil; V_c=2cm/s; velocity encoding in the S/I direction; T=1600ms; TR=3000ms; background suppression using 2 non-selective inversion pulses 1550ms and 450ms prior to image acquisition; FOV 24cm; 64x64 spiral matrix; 32-8mm partitions; 16 echos; hard 180° pulses; 8 spiral interleaves; 2 tag volumes and 2 control volumes for a total scan time of 3min 12s.

Results

An example data set from a normal volunteer is shown in **Figure 1**. As expected for an FSE acquisition, signal in areas of poor field homogeneity such as the inferior frontal lobes and medial temporal lobes is well preserved. While the image quality is generally good, there are residual ghosting artifacts most noticeable in the posterior third of the most superior slices. Calculate CBF values in gray matter are in the expected range of 70-100ml/100ml/min.

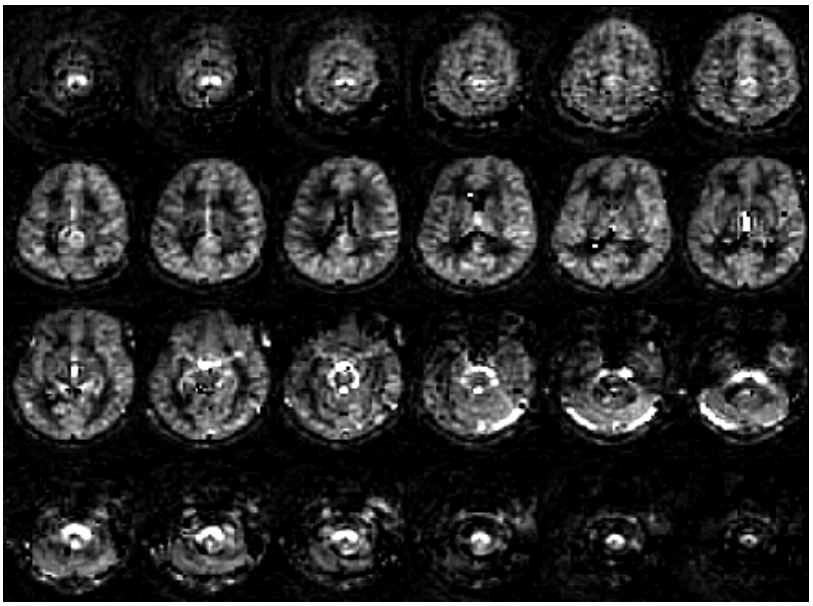

Figure 1: 3D spiral FSE VSASL image. Shown are 24 of 32 partitions collected in a scan time of 3:12

Discussion

A flow weighted 3D spiral FSE sequence has been developed that is suitable for use with VSASL. Residual ghosting artifacts are likely due to motion through the flow weighting gradients, and will be addressed in the future using variable density and self navigated spiral methods.

Acknowledgements

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References

1. Wong et al, ISMRM 2002, p 621.
2. Duhamel et al, Magn. Reson. Med. 2003;50:145-153.