Pulsed arterial spin labeling with multi-band excitation

Tae Kim[1], Wanyong Shin[2], Erik Beall[2], Mark J Lowe[2], Tiejun Zhao[3], and Kyongtae Ty Bae[1]

[1]*Radiology, University of Pittsburgh, Pittsburgh, PA, United States,* [2]*Imaging Institute, Cleveland Clinic, Cleveland, OH, United States,* [3]*Siemens Medical Solution USA, INC., Siemens MediCare Healthcare USA, Pittsburgh, PA, United States*

Introduction

While multi-slice arterial spin labeling (ASL) has shown potential to measure whole brain perfusion [1], accurate whole brain perfusion quantification using ASL is still challenging. When the number of acquired slices in ASL is increased, the increased spread in acquisition time across the slice group results in a variability in labeling decay across slices. This is difficult to model and is typically corrected with empirical factors that do not produce robust results for a wide spread in acquisition times. Although echo planar imaging (EPI) enables to acquire data quickly, it still takes relatively long time compared to a lifetime of labeled spins when acquiring the multiple slices needed for covering the whole brain. This limits the spatial resolution of perfusion imaging to a limited number of slices. Recently, multi-band excitation (MB) imaging technique was developed to boost the speed of data acquisition [2,3]. In this study, we implemented MB acceleration to pulsed ASL (flow-sensitive alternating inversion recovery, FAIR), and compared our results with data acquired using the conventional ASL method.

Methods

Two male healthy volunteers were studied on a 3-T Siemens scanner using a 32-channel head coil. Perfusion quantification with MB accelerated EPI acquisition was compared with conventional FAIR method in order to test its robustness. Six slices with slice thickness of 5 mm and inter-slice gap of 1.5 mm were acquired by conventional FAIR method, and eighteen slices were obtained by MB acquisition with 3-fold acceleration after ASL spin preparation. Since the center of brain coverage of two scans was aligned each other, the 7^{th} to 12^{th} slices of MB ASL scans have the same in-plane location as the six slices of the conventional ASL scan. The same slice-selective inversion size and location (14 cm) was applied for the labeling condition in the same way for both conventional and MB acquisition. Interleaved control and tag images were acquired with single-shot gradient-echo, EPI with matrix size = 64×64 and FOV = 25.6×25.6 cm^2, TR/TE = 3 s/18 ms, and 40 averages. The labeled spins in adjacent bands excited by MB can be obtained with either ascending or descending order acquisition. In order to investigate this, two schemes of experiments were performed: (i) QUIPSS II was incorporated with FAIR labeling scheme for the perfusion [3], using TI_1 of 700 ms and TI_2 of 1000 ms; and (ii) FAIR technique with bipolar gradients was used (b = 70 s/mm^2). CBF was quantified with the single-compartment model. Six slices of perfusion maps from the conventional method were compared to those with MB in the same locations in terms of voxelwise correlation.

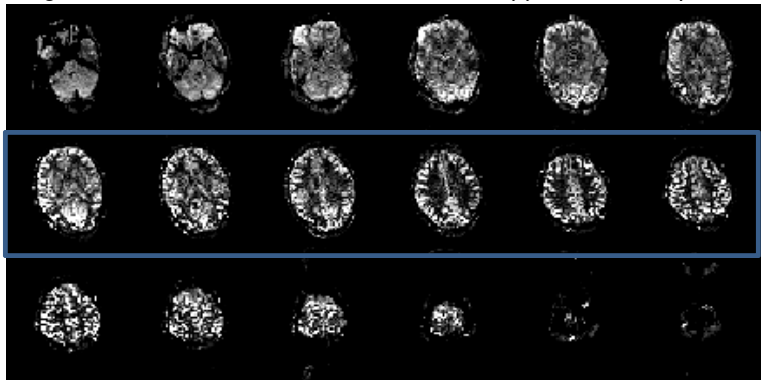

Fig. 1. The PASL signal differences (ΔM) acquired by MB excitation with 3-fold acceleration.

Results and Discussion

Fig. 1 demonstrates 18 slices of the PASL signal difference (ΔM) with MB excitation with 3-fold acceleration using QUIPSS II acquisition with ascending order. We found that MB accelerated ASL scan with flow crushing bipolar gradients increases noise in the upper slice of perfusion signal changes (data not shown). It may be explained by interference arising from the excited spins in the lower slab of the MB excitation. A voxelwise and slice-by-slice quantification comparison of MB accelerated and conventional ASL scans is shown in **Fig. 2**. Similar quality of perfusion maps were obtained as compared to the conventional excitation method. The voxelwise correlation of CBF quantification between MB and conventional scans was highly significant; from two subjects, correlation coefficient = 0.77 and 0.78, respectively. Reduction in contrast to noise of quantified perfusion maps with MB ASL scan is observed in white matter regions. It may be caused by the reduced MB de-aliasing efficiency, which can be improved by implementing CAIPIRINHA [3]. **Fig. 3** shows high resolution perfusion maps with 3-fold MB acceleration. When MB ASL is combined with in-plane parallel imaging, the data acquisition time per slice can be reduced, leading to the compensated SNR due to a shortened echo time.

References: 1. Wang et al., MRM 2002; 2**.** Moller et al ., MRM 2009; 3. Setsompop et al., MRM 2012.

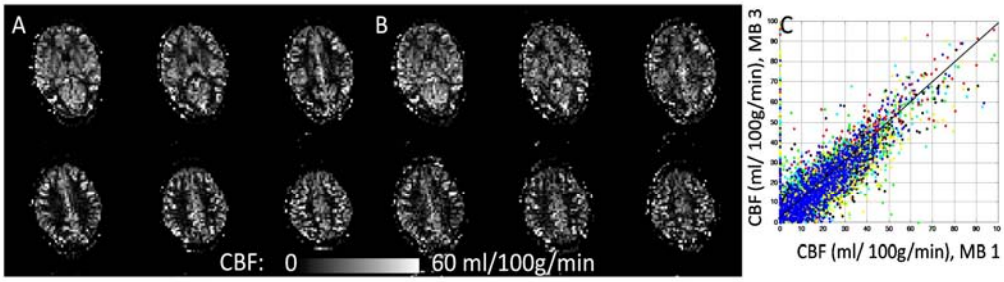

Fig. 2. Perfusion maps acquired with conventional (A) and MB technique (B). The quality of perfusion maps acquired by MB acquisition is highly comparable with that by the conventional method. Pixel-by-pixel comparison of each slice is highly correlated (C). MB1: conventional excitation, MB3: multi-band excitation with 3-fold acceleration.

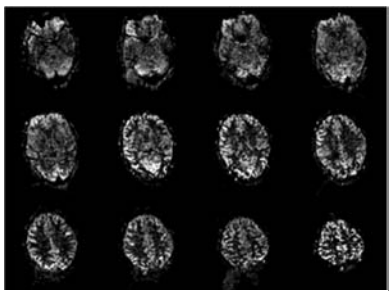

Fig. 3. The PASL signal difference (ΔM) at 128×128 resolution. 12 slices are selected for demonstration.