Volume Localization using Adiabatic Inversion Pulses in FAIR Imaging

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Introduction: Adiabatic full passage (AFP) inversion pulses have been extensively used in arterial spin labeling (ASL) for perfusion-weighted MRI [1, 2]. Spatial localizations using AFP inversion pulses have been focused on non-selective whole volume inversion and selective slice or slab inversion. Selective AFP refocusing pulses have been utilized in paired or unpaired means for volume selection in magnetic spectroscopy, spectroscopic imaging to compensate B_1 inhomogeneity [3, 4]. To date, no report has been published using selective AFP inversion pulses for volume selection in perfusion-weighted MRI. The motivation of this work is in two folds. First is to perform localized perfusion-weighted MRI that is sensitive to spin perfusions from three directions. Second is to apply the broad bandwidth and B_1 immunity property of AFP pulses for sharp volume definition and for signal sensitivity enhancement.

Method: Imaging experiments were performed on a 0.38T electro-magnet (Resonex-5000/Paradigm) equipped with shim coils (24 channels) and 3D gradient coils (Tesla Engineering). A home-made solenoid NMR coil (ID = 3.5 cm) in an EPRI/MRI co-imaging duel-resonator unit was used for MRI image acquisition on a MR Solutions console (software version 6000). An inversion-recovery (IR) spin-echo (SE) pulse sequence using volume-selection inversion AFP pulses (HS1, R-factor = 15, T_p = 4 ms, B_1(max) = 2 kHz) was developed (Fig.1), where 5 lobe sinc pulses (bandwidth = 3 kHz, pulse width = 2 ms) were used for 90º excitation and 180º spin refocusing. A non-selective IR-SE using a single AFP inversion pulse (HS1, R-factor = 15, T_p = 4 ms, B_1(max) = 2 kHz) was also developed to implement the flow-sensitive alternating inversion recovery (FAIR) technique [5]. A perfusion phantom was built from a plastic syringe tube (ID = 20 mm). Distilled water was circulated through the phantom using a variable-speed flow pump (Fisher Scientific) and TYGON tubing (ID = 4.8 mm) at a flow rate of 0 and 120 mL/min. A single slice axial image was collected from the localized volume in the phantom using the volume-selection IR-SE sequence (TE/TR = 18/1600 ms, matrix size = 64 x 64, FOV = 30 x 30 mm^2, slice thickness = 4 mm, voxel size = 5 x 5 x 5 mm^3, TI = 1200 ms, number of averages = 4, scan time = 25 min 37 sec). Perfusion imaging was also performed using conventional IR-SE pulse sequences on the phantom. FAIR images were post-processed using the formula in [5] and a self-written program in Matlab (V7.6, MathWorks).

Results: T_1-weighted and FAIR images collected on the phantom using the volume-selection and the conventional slice-selection IR-SE pulse sequences are shown in Figure 2. The perfusion rates measured in the regions-of-interests (ROI) using both kinds of sequences are very close (Figs. 2C and 2F). Positive and negative image contrasts were produced in the selected volume using the volume-selection IR-SE sequence at flow rate = 120 and 0 mL/min, respectively (Figs. 2A and 2B). In comparison to the conventional IR-SE sequence, greater T_1-contrast was generated at flow rate = 0 mL/min using the volume-selection IR-SE sequence (Figs. 2A and 2D). T_1-weighted images generated using volume-selection and slice-selection IR-SE pulse sequences are shown in Figs. 2B and 2E.

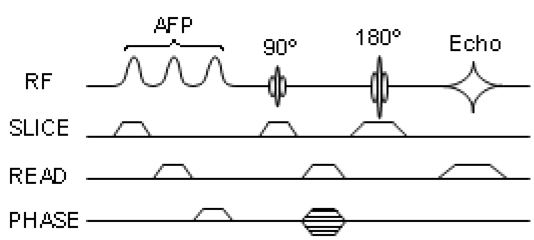

Figure1. IR-SE pulse sequence using selective AFP inversion pulses for localized volume selection and spin inversion.

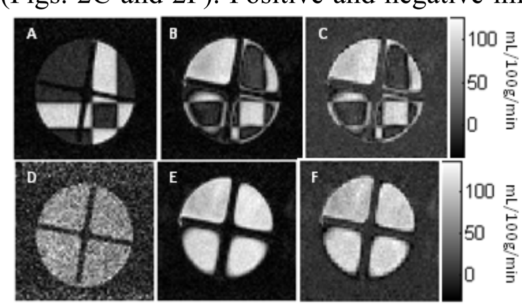

Figure 2. T_1-weighted images generated using volume-selection IR-SE sequence (A,B) and slice-selection IR-SE sequence (D,E) at flow rates of 0 and120 mL/min; FAIR images collected with volume- (C) and slice-selection (F) at the flow rate of 120 mL/min.

Discussion: Phantom experiments demonstrate that volume-selection inversion AFP pulses can be used to implement FAIR techniques with acceptable accuracy in perfusion rate measurements. T_1 contrast enhancement produced at the zero flow-rate using the volume-selection IR-SE sequence could result from more effective spin inversion using the volume-selection AFP pulses. Signal-to-noise ratio (SNR) and volume localization could be further improved using surface coils in future experiments.

References and Acknowledgments: [1] R.L. O'Gorman, et al, Magn. Reson. Med. 55:1291-1297 (2006). [2] J. Schepers, et al, Magn. Reson. Med. 47: 330-336 (2002). [3] M. Garwood, et al, J. Magn. Reson. 153: 155-177 (2001). [4] J. Valetter, et al, J. Magn. Reson. 189: 1-12 (2007). [5] P. Martirosian, et al, Magn. Reson. Med. 51: 353-361 (2004). Funding support: NIBIB (EB0890, EB4900).