NON-CONTRAST-ENHANCED RENAL AND ABDOMINAL MRA USING VELOCITY-SELECTIVE INVERSION PREPARATION

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Introduction: For non-contrast-enhanced (NCE) renal MRA, inflow-based slab-selective (SS) inversion-recovery (IR) 3D imaging has been used with the greatest popularity [1-3]. However, as this technique relies on the inflow of arterial blood into a volume-of-interest, it allows limited craniocaudal coverage and often requires a long inversion delay time (>1 second). We propose a new NCE renal and abdominal MRA method based on velocity-selective (VS) inversion preparation which has a potential for larger craniocaudal coverage due to preservation of arterial blood in the imaging volume during the preparation. The new VS IR method was demonstrated in healthy volunteers with a comparison to the SS IR method.

Methods: VS inversion pulse design: A VS excitation with a desired velocity profile can be designed using the excitation *k*-space formalism [4,5]. For non-spatial and velocity selectivity, RF sub-pulses are applied between a series of bipolar gradients with an envelope of the RF sub-pulses determined by the Shinnar-Le Roux transform [6]. Figure 1 shows the VS inversion pulse sequence used in this study (Fig. 1a), and Bloch simulation of the resultant magnetization (Fig. 1b). The VS pulse inverts spins with velocities of 0-40 cm/s in the superior direction (static tissues and venous blood) while leaving spins with velocities of 30-120 cm/s in the inferior direction intact (arterial blood in the abdominal aorta).

In-vivo experiments: Both SS IR and VS IR methods were used to acquire renal MRA and abdominal MRA in healthy volunteers on a GE 1.5 T scanner with an 8-channel cardiac coil. The pulse sequence was triggered by bellows and ECG signals sequentially, and consisted of a VS inversion pulse or an SS inversion pulse, an inversion delay time, a fat inversion pulse, and a balanced SSFP 3DFT readout with a linear view order (Fig. 2). The VS inversion pulse was played at the time of *peak* systolic flow determined by a scout PC flow MRI scan. The SS inversion pulse was played at the time of the *onset* of systolic flow to maximize inflow effects. The SS IR method without ECG gating was also performed. Imaging parameters for renal MRA were axial imaging slab, TI = 700 ms, spatial resolution = 1.4×1.4×2.0 mm^3, FOV = 28×20×10 cm^3, FA = 70°, TR = 4.5 ms, and two acquisition blocks per each k_z plane. Imaging parameters for abdominal MRA were coronal imaging slab, TI = 700 ms, spatial resolution = 1.4×1.4×2.0 mm^3, FOV = 34×30×12 cm^3, FA = 70°, TR = 4.6 ms, 2-fold SPIRiT acceleration [7], and two acquisition blocks per each k_z plane.

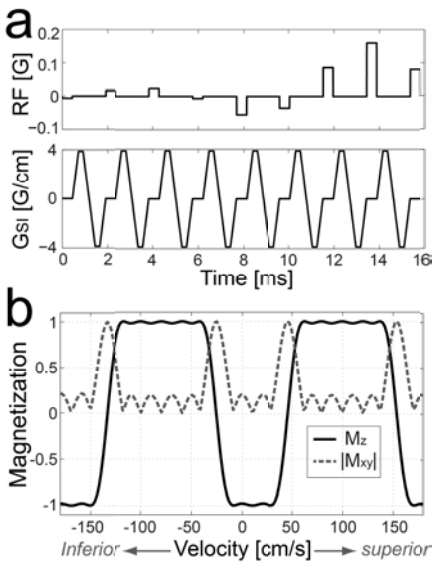

Figure 1. (a): VS inversion pulse sequence; (b): Bloch simulation of resultant normalized magnetization.

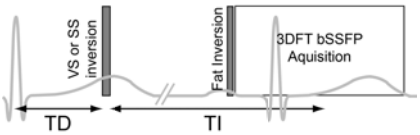

Figure 2. Timing diagram of VS or SS IR pulse sequence for NCE MRA.

Results: Figure 3 contains results of renal MRA which show excellent artery-background contrast using the proposed VS IR method (Fig. 3a). The SS IR method with optimized ECG gating shows comparable image quality except for a slight signal loss in the inferior segment of the abdominal aorta (arrow in Fig. 3c). Results of abdominal MRA demonstrate that the proposed VS IR method allows excellent visualization of arteries over large S/I FOV (Fig. 4a). The SS IR method with ECG gating visualizes a limited extent of the abdominal aorta due to insufficient arterial inflow into the imaging volume (Fig. 4b).

Discussion: We have demonstrated a new NCE renal and abdominal MRA method using a VS inversion preparation. This approach shares the benefit of the SS IR method by producing high artery-background contrast from a single acquisition without subtraction. Unlike the SS inversion, the VS inversion preserves arterial blood in the imaging volume during the preparation and thus enables visualization of various arteries over a large FOV. Another benefit of the enhanced artery tagging efficiency is the use of relatively short inversion delay times (~700 ms) that are favorable for suppression of background tissues.

References: [1] H Kanazawa et al., ISMRM 2002:140. [2] M Braendli et al., Am J Roentgenol 180: 725-728,2003. [3] M Katoh et al., Kidney international 66:1272-1278, 2004. [4] L de Rochefort et al., MRM 55: 171-176, 2006. [5] T Shin et al., MR Angio club 2011:12.8. [6] J Pauly et al., IEEE TMI 10:53-65, 1991. [7] M Lustig et al., MRM 64: 457-471, 2010.

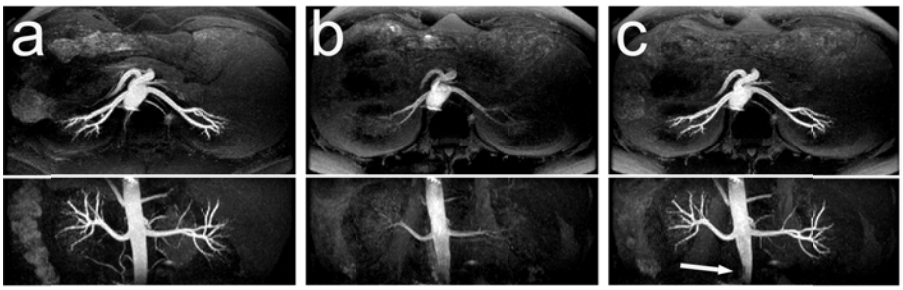

Figure 3. Axial and reformatted coronal maximum-intensity-projection (MIP) images of VS IR renal MRA (a), SS IR renal MRA without ECG gating (b), and SS IR renal MRA with ECG gating (c).

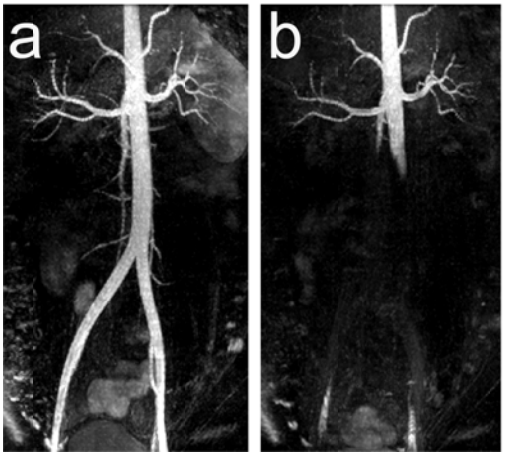

Figure 4. Coronal MIP images of abominal MRA using VS IR (a), and SS IR with ECG gating (b).