3D Contrast-Enhanced Flow-Insensitive Peripheral Vessel Wall Imaging

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Introduction: Black blood imaging techniques are used in peripheral vessel wall imaging to provide distinct visualization of the vessel wall as well as to minimize flow associated imaging artifacts. Current methods for suppressing blood signal in vessel wall imaging included double inversion recovery (DIR) preparation [1], flow sensitive dephasing (FSD) preparation [2], etc. These preparation schemes are dependent on blood flow during magnetization preparation. Therefore, these techniques are less effective with slow flow, particularly in patients with severe stenosis. In this work, a 3D contrast-enhanced, flow-insensitive vessel wall imaging technique which exploits the T1 difference between blood and vessel wall was developed.

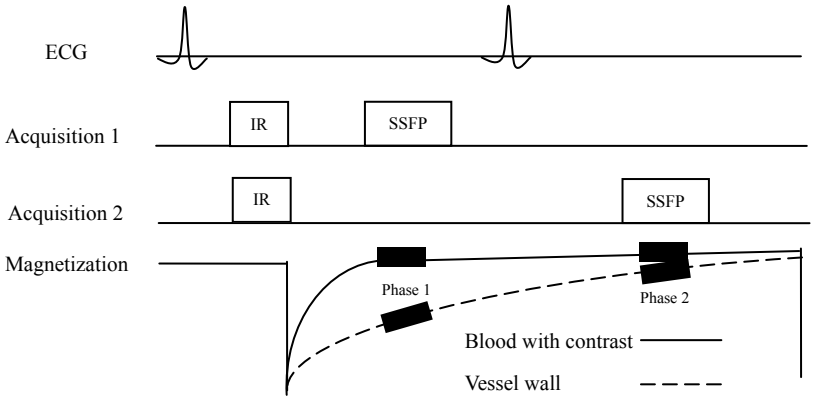

Fig. 1. Pulse sequence diagram and magnetization changes during one TR. 3D SSFP was played with TI = 350ms to acquire phase 1 image. Followed by another acquisition of SSFP with TI = 1600~1800 ms to acquire phase 2

Theory: Two images are acquired with different inversion time (TI) after a non-selective inversion recovery. After contrast injection, blood has a shorter T1 than the vessel wall and surrounding tissues and thus has the fastest recovery, as shown in the magnetization recovery curve in Fig. 1. Due to the fast recovery, blood signal at the two images (phases 1 and 2) is similar while the vessel wall signal difference between the two images is still considerably large. By subtracting the two images, the blood signal will be canceled out and the vessel wall will be depicted clearly. Because the inversion pulse is non-selective, this technique is not dependent on flow.

Methods: The peripheral arteries were imaged using this technique in three healthy subjects (2 Male, 1 Female) on 1.5T (Espree, Siemens) using a 12-channel body coil array and spine coils. An ECG-triggered, 3D segmented SSFP sequence was used for acquisition. In order to achieve a stable state in which blood maintains a relatively consistent contrast concentration and T1 value, Gd-BOPTA (0.2 mmol/kg body weight) was slowly injected from the antecubital fossa using a power injector at a rate of 0.2 ml/s. Infusion of the contrast agent was immediately followed by 20 ml of saline solution injected at the same rate [4]. Data acquisition started 40s after the initiation of contrast agent injection. Our initial experiments showed that an TI value of 350 ms allowed sufficient blood signal recovery and similar blood signal intensity (SI) compared to the fully recovered acquisition (phase 2). This TI value was used in phase 1 acquisition for all subjects. Immediately following the phase 1 acquisition came the phase 2 acquisition with TI of 1600~1800 ms which depends on the volunteers' heart rate. Other parameters included: TR/TE = 4.0/2.0 ms, flip angle = 90°, resolution = 0.74 x 0.74 x 3.0 mm^3, 14 slices, transversal view, 25 k-space lines per cardiac cycle, bandwidth = 560 Hz/pixel, GRAPPA acceleration factor = 2.

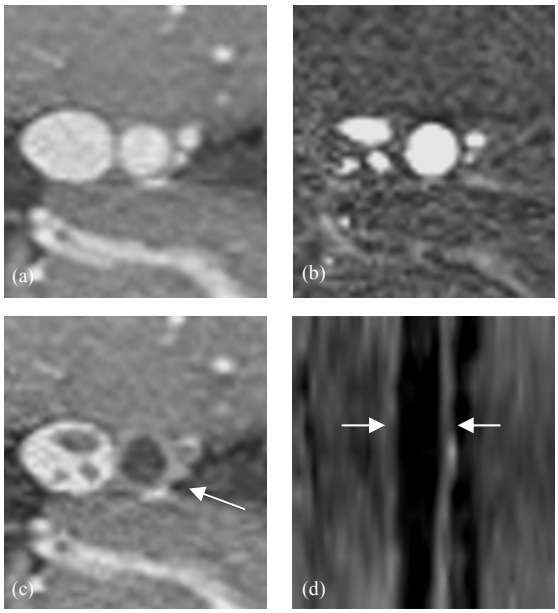

Fig. 2. Transverse images acquired at TI = 350 ms (a) and TI = 1800 ms (b). (c) is the subtraction of (a) and (b). (d) is the MPR from the 3D data.

Results: Fig. 2 shows example images using the method. Fig. 2 (a) and (b) are transverse images acquired at phase 1 (TI = 350 ms) and phase 2 (TI = 1800 ms), respectively. Fig. 2 (c) shows the subtraction (a) and (b). Blood signal is effectively suppressed while the vessel wall is clearly delineated in both the transversal view and MPR image (Fig. 2d). Fig 2 (d) is the MPR image that the whole 3D data formulates. Clear vessel wall depiction is achieved.

Discussion and Conclusions: We developed a new method for 3D flow-insensitive vessel wall imaging. This technique can substantially improve imaging efficiency than single slice DIR method. Further optimization and validation of the technique is required to demonstrate the effectiveness of the approach.

References: 1. Edelman RR, et al. Radiology 1991:181:655-660. 2. Koktzoglou I, et al. JCMR 2007; 9:33. 3. Kellman P, et al. JMRI 2005; 605-613. 4. Xiaoming B, et al. MRM 2007;58:1-7.