Time Efficient Triple Contrast Acquisition in Double Inversion Fast Spin Echo

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INTRODUCTION: Recent publications show that the multiple contrast images of carotid artery obtained by black blood FSE techniques are helpful for plaque component identification(1-3). Due to the nonselective inversion pulse in double inversion techniques, black blood images are usually acquired sequentially, resulting in long imaging times. To improve the time efficiency Song et al (4) and Parker et al (5) proposed multiple slice approaches, in which two or more consecutive spatially selective 180° pulses were applied allowing one or more data acquisition per TR. However, even these two efficient techniques utilize only a small fraction (typically about 10%) of the whole scan time for data acquisition. In this paper, we present a triple contrast technique with double inversion FSE. In this implementation images with two different T1 weightings are acquired during the double inversion acquisition dead time, resulting in images with three different contrasts from each slice without increasing scan time.

METHODS: The triple contrast sequence was implemented based on the double inversion preparation FSE technique. As shown in Figure 1 the modified version of double inversion consists of a hard inversion pulse of 1024 µs duration followed by one spatially selective (slice C) -90° Sinc pulse (3.2ms) and two spatially selective (slice A, slice B) -180° adiabatic hyperbolic secant pulses of duration 8640 µs and. The longitudinal magnetization of spins located in the slice (slice C) selected by the saturation pulse are flipped into the transverse plane and dephased resulting in T1 contrast at the time of FSE imaging of slice C. After 400ms of TI, PD-T2 images (slice A) are obtained by double contrast FSE with 16 ETL readouts followed by the FSE readouts for T1 acquisition (slice C). The time (*T1I*) between inversion and FSE readouts for T1 imaging was selected as 550ms. Each sequence of inversion pulses is triggered by ECG gating. During the next heart cycle the same preparation pulses are applied with saturation being applied to the alternate T1 imaged slice (slice D) and FSE data is acquired from the alternate slices (slice B, slice D). In this case, four separated slices (A,B,C,D) are interleaved during every other heart cycle (2RR). Therefore, the effective TR for the PD, T2, and T1 images is 2 RR, but the effective TR for each inversion is RR. The longitudinal magnetization of T1 imaging is given by

$$Mz(T1I) = Mo[1 - e^{-(\frac{T1I}{T1})}]$$

Carotid arteries of a normal volunteer that were centered at the bifurcation apex were scanned with the triple contrast sequence and a chemical fat saturation pulse. Other scan parameters included: 256 x256 matrix, ± 32 kHz receiver bandwidth, 16 ETL, 5264 µs echo spacing, 14 cm FOV and 2 mm slice thickness. The total scan time of triple contrast images for 16 slices was approximately 6.5 min.

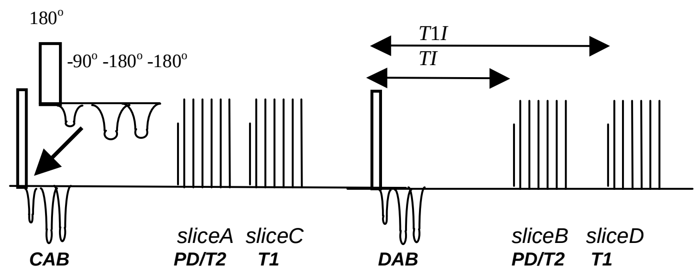

Figure 1 Pulse diagram of the triple contrast imaging sequence.

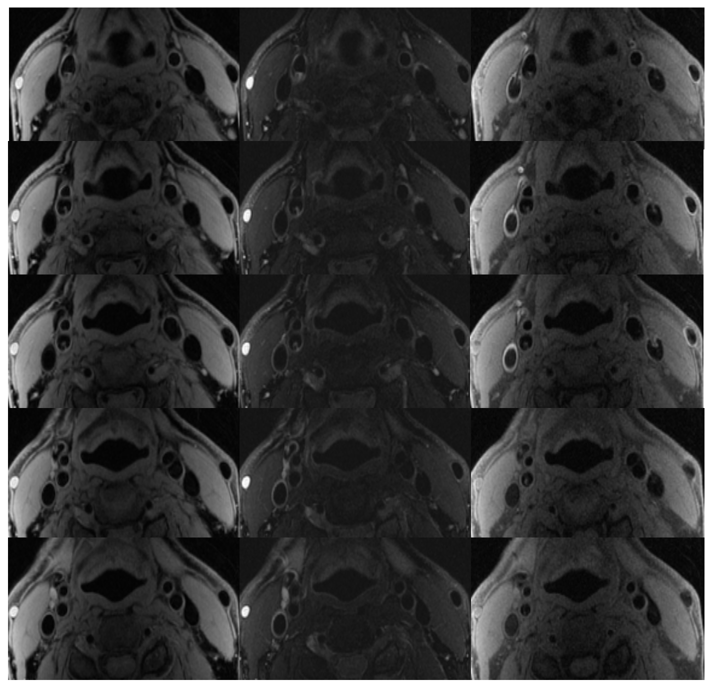

Figure2 Triple contrast images of human carotid arteries. (A) proton-density (B) T2 weighted images (C) corresponding T1 weighted images

RESULTS: Figure 2 demonstrates triple contrast carotid artery images on a human volunteer. Each of the three differently weighted images provides different contrast between blood and vessel wall with decent SNR. Column (A), (B) show the proton density and T2 weighted images from identical locations. Corresponding T1 images from the same location are shown in Column (C). Some proton density images in column (A) have bright signal near the wall area which remained relatively bright in the T2 weighted images of column (B). This bright signal is due to blood recirculation secondary to a small carotid plaque lesion. The lipid signal in the T1 weighted images in Column (C) is larger because of the longer time between fat saturation and signal acquisition.

DISCUSSION: The aim of the present study was to obtain multiple contrast images using double inversion magnetization preparation within one scan. Compared with previous approaches at increasing the efficiency of double inversion FSE techniques, the technique presented here allows improved imaging efficiency with the additional acquisition of T1 contrast images. The extra T1 contrast images, which are acquired with no increase in scan time, may provide improved information for evaluation of size and morphology of plaque in the carotid artery.

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REFERENCES:

1. Edelman RR, Chien D, Kim D, et al. Fast selective black blood MR imaging. Radiology 1991; **181**:655.
2.. Luo Y, et al. Accuracy and uniqueness of three in vivo measurements of atherosclerotic carotid plaque morphology with black blood MRI. MRM 2003; **50**:75.
3. Cai J, et.al. Classification of human carotid atherosclerotic lesions in vivo multi-contrast magnetic resonance imaging. Circulation 2002; **106**:1368.
4. Song HK, Wright AC, Wolf RL, Wehrli FW. Multi-slice double inversion pulse sequence for efficient black-blood MRI. MRM 2002; **47**:616.
5. Parker D, Goodrich K, Masiker M, Tsuruda J, et.al. Improved efficiency in double-inversion fast spin-echo imaging. MRM 2002; **47**:1017.