Journal of Cardiovascular Magnetic Resonance

Poster presentation

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Non-selective double inversion recovery pre-pulse for flow-independent black blood myocardial viability imaging

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from 13th Annual SCMR Scientific Sessions
Phoenix, AZ, USA. 21-24 January 2010

Published: 21 January 2010

Journal of Cardiovascular Magnetic Resonance 2010, **12**(Suppl 1):P104 doi:10.1186/1532-429X-12-S1-P104

This abstract is available from: http://jcmr-online.com/content/12/S1/P104

Introduction

MRI late gadolinium enhancement (LGE) using the inversion-recovery (IR) sequence is the current gold standard for assessing myocardial viability. Although it achieves high contrast between infarct and normal myocardium, there is often poor infarct-to-blood contrast. Flow-dependent and diffusion-prepared black-blood LGE techniques have previously been described.[12][1,2] Recently a quadruple-inversion recovery pre-pulse was introduced for T_1-independent flow suppression in carotid plaque imaging[3][3]. We introduced a modification to this pre-pulse aiming to achieve flow-independent signal suppression over a wide user-defined T_1-range and to improve sub-endocardial infarct detection in LGE myocardial viability imaging.

Methods

NS-DIR pre-pulse

A non-selective double-inversion recovery (NS-DIR) sequence with two time delays, TI_1 and TI_2, was implemented on a 3 T Philips Achieva MR-scanner (Philips-Healthcare, Best, NL). TI_1 and TI_2 were optimized in MATLAB simulations by minimizing $M_Z^{NS\text{-}DIR}$ over several user-defined T_1-ranges for a given heart rate.

Phantom experiments

A T_1-phantom containing 11 T_1-samples (T_1-range = 120 ms-1730 ms) was imaged with the NS-DIR pre-pulse using optimized TI_1 and TI_2 times. The signal-to-noise ratio (SNR) was calculated for each sample.

Patient Study

A 78-year-old man with previous myocardial infarctions was imaged with a 32-channel coil ~15 minutes after injection of 0.12 mmol/kg Gd-DOTA (Gadovist). Firstly a breath-hold 2D IR segmented gradient-echo (TFE) sequence was acquired in standard views. Imaging parameters included: spatial-resolution = 1.54 × 1.75 × 8 mm, TR/TE = 3.8 ms/2 ms, FA = 25°, TFE-factor = 25 and TI = 350 ms(chosen using LookLocker sequence).

Subsequently, identical planes were repeated with the IR replaced by the NS-DIR pre-pulse with imaging parameters maintained. TI_1 = 411 ms and TI_2 = 156 ms were used (optimized to minimize $M_Z^{NS\text{-}DIR}$ for T_1-range = 300-1400 ms, heart rate = 70 bpm).

Results

Simulations & Phantom experiments

$M_Z^{NS\text{-}DIR}$ simulations (Fig. 1a) indicate excellent signal suppression over the desired T_1-range for all heart rates with corresponding phantom studies in good agreement (Fig. 1b).

Patient Study

NS-DIR images demonstrate excellent signal suppression of blood and normal myocardium (Fig. 2a) while conventional IR-TFE images (Fig. 2b) display similar infarct and blood signal. Whilst both techniques demonstrate transmural anterior and inferior wall infarcts, the NS-DIR image depicts an apical, non-transmural sub-endocardial

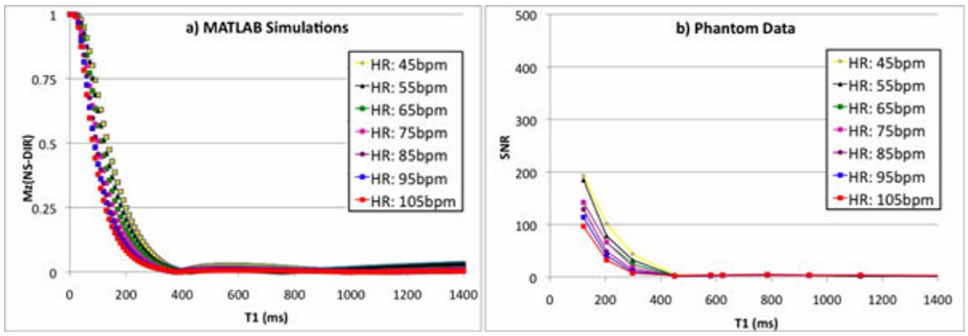

Figure 1
a) Simulated $M_z^{NS\text{-}DIR}$ curves for TI_1 and TI_2 values optimized to minime $M_z^{NS\text{-}DIR}$ for T_1 values between 300 and 1400 ms for difference heart rates. Figure 1b) The corresponding SNR values measured in phantom images using the same TI_1 and TI_2 settings and heart-rates are in good agreement with the simulations.

defect, which is difficult to distinguish from blood in the IR image.

Conclusion

We have developed a new flow-independent LGE sequence for improved contrast visualization. Simulations and phantom studies demonstrate excellent tissue suppression over a wide T_1-range. Preliminary patient data suggests improved visualization of small sub-endocardial defects. Further studies are warranted to investigate the clinical usefulness of this novel approach.

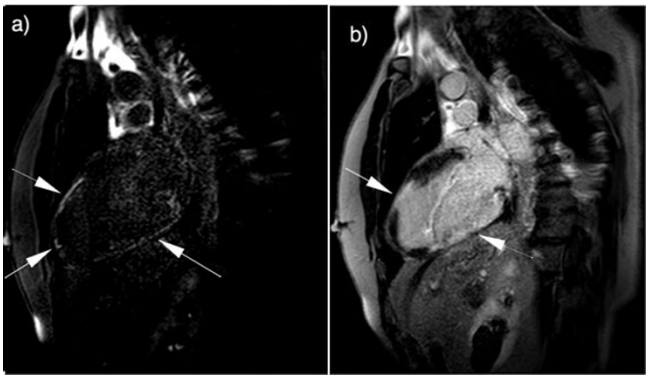

Figure 2
A 78-year-old man with previous myocardial infarctions was imaged using a) the NS-DIR pre-pulse and b) the standard IR sequence. Arrows indicate transmural infarcts in the anterior and inferior walls and a non-transmural apical infarct which is better visualized with the NS-DIR pre-pulse.

References

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