Title: Multi-slice Delayed Hyperenhancement Imaging of Myocardial Infarction using SENSE Accelerated Phase Sensitive Inversion Recovery True-FISP

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Introduction:

Following administration of Gd-DTPA, infarcted myocardium exhibits delayed hyperenhancement and can be imaged using an inversion-recovery sequence [1]. Using a conventional segmented acquisition requires a number of breath-holds to image the heart. Single-shot phase-sensitive inversion-recovery (PSIR) true-FISP may be combined with parallel imaging using SENSE to achieve multi-slice full heart coverage with high spatial resolution [2,3]. PSIR techniques have demonstrated a number of benefits [4] including consistent contrast and appearance over a relatively wide range of inversion recovery times (TI), improved contrast-to-noise ratio, and consistent size of the hyperenhanced region.

Purpose:

To demonstrate imaging myocardial infarction with multi-slice coverage of the entire heart in a single breath-hold.

Methods:

Infarct imaging was compared using 1) segmented IR-turboFLASH, and 2) multi-slice IR-true-FISP implemented on a Siemens Sonata 1.5T scanner. For both methods, the same spatial resolution ($1.4 \times 2.3 mm^2$), FOV ($370 \times 300 mm^2$), and TI (280ms) were used. A stack of 8 short-axis slices was acquired with 6mm slice thickness and 3.6mm gap. The IR-turboFLASH required 16 heart-beat breath-hold per slice, whereas the IR-true-FISP required a single 16 HB acquisition. Imaging was performed in diastasis with approximately the same acquisition window for both methods.

Typical parameters for the IR-true-FISP sequence were: BW 977 Hz/pixel, TE/TR 1.2/2.7 ms, 50° readout flip angle (5° reference), 256x128 image matrix. Rate=2 SENSE acceleration was used to obtain the full 128 line resolution using 64 phase encodes acquired in a single heartbeat (172 ms window) with 2 R-R intervals between inversions.

Typical parameters for the IR-turboFLASH sequence were: BW 140 Hz/pixel, TE/TR 3.9/8.5 ms, 30° readout flip angle (5° reference), 256x136 image matrix. The phase-encode dimension was slightly oversampled, yielding an effective resolution of 128 lines in this specific example. The 136 phase encodes were acquired in 16 heartbeats collecting 17 lines per heartbeat with 2 R-R intervals between inversions. The segment duration was 145 ms per R-R interval, acquired during diastasis.

A custom 8-element cardiac phased-array (Nova Medical, Inc) was used. A B_1-weighted phased-array combined phase-sensitive reconstruction method was used [4] for all sequences. This previously described approach acquires a reference image at the same cardiac phase, during the same breath-hold during alternate heart beats to estimate both the background phase and surface coil B_1-maps. Images were acquired approximately 20 minutes after administering a double dose (0.2 mmol/kg) of contrast agent (Gd-DTPA, Berlex Magnevist).

CNR between MI and normal myocardium was calculated using measured signal intensities and pre-scan noise measurement. Measured CNR was compared with values predicted based on simulation of the magnetization during inversion-recovery for both methods.

Results:

A stack of short-axis images of the heart for a patient with anterior MI is shown in Figures 1 and 2 acquired using both methods, respectively. The measured CNR for the segmented turbo-FLASH method was approximately 2.2 times that of the true-FISP with SENSE which was close to predicted.

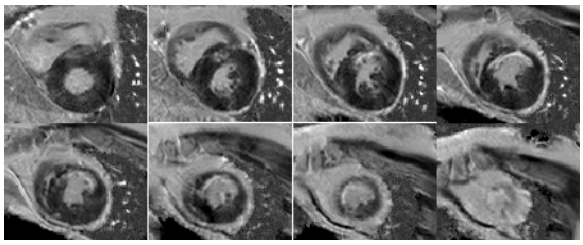

Figure 1. Short-axis stack acquired in 8 separate breath-holds using segmented IR-turboFLASH with single-slice-per-breath-hold.

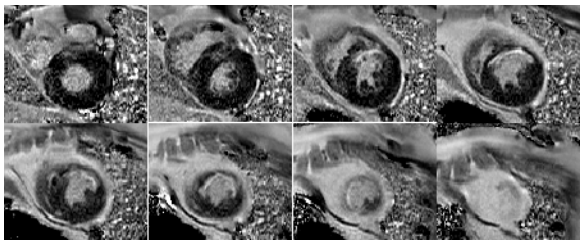

Figure 2. Short-axis stack acquired in a single breath-hold using multi-slice IR-true-FISP.

Conclusions:

Multi-slice coverage of the entire heart in a single breath-hold acquisition is possible using SENSE accelerated phase-sensitive inversion-recovery true-FISP. Using SENSE acceleration, it is possible to use single-shot true-FISP without compromising spatial resolution. Since the single-shot method is insensitive to breathing, the multi-slice acquisition, achieved by catenating several single-shot acquisitions, may be either breath-held for better slice registration, or free-breathing in cases where patients have difficulty holding their breath.

References:

1. Simonetti OP, et al. Radiology. 2001; 218:215-23.
2. Chung, YC, et al. JCMR 2003; 5(1) ; 40-1.
3. Pruessmann KP, et al. MRM 1999; 42:952-62.
4. Kellman P, et al. MRM. 2002; 47:372-83.