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Highly-accelerated first-pass cardiac perfusion MRI using compressed sensing and parallel imaging

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Introduction

Robust implementation of first-pass cardiac perfusion MRI for clinical use can be particularly challenging due to competing constraints of spatial and temporal resolution, and spatial coverage [1]. k-t SENSE [2] can be used to achieve high accelerations, but dynamic training data are required which reduces the effective acceleration rate. An alternative acceleration technique is compressed sensing (CS) [3], where spatial and temporal correlations result in sparsity of image series content, which may in turn be exploited to achieve high levels of undersampling without losing image information. We have recently presented the combination of compressed sensing and parallel imaging (JOCS: JOint-CS [4]) to increase the acceleration rate of CS alone. In this work, we demonstrate first-pass cardiac perfusion MRI with whole-heart coverage and high spatial and temporal resolution using the JOCS technique.

Purpose

Evaluate the feasibility of highly-accelerated first-pass cardiac perfusion MRI with whole-heart coverage per heartbeat using JOCS.

Methods

First-pass cardiac perfusion MRI with 0.1 mmol/kg of Gd-DTPA (Magnevist) was performed in two healthy volunteers and one patient with coronary artery disease. A modified multi-slice TurboFLASH sequence was employed on a whole-body 3 T scanner (Siemens;Tim-Trio) using the 12-element body matrix coil array. The relevant imaging parameters include: FOV = 320 mm × 320 mm, image-resolution = 1.7 mm × 1.7 mm, slice-thickness = 8 mm, TE/TR = 1.3 ms/2.5 ms, repetitions = 40. Acceleration was accomplished using ky-t random undersampling to produce the required incoherence. Breath-hold measurements with acceleration factor of R = 8 (allowing 10 acquired slices per heartbeat, temporal-resolution = 60 ms/slice) were performed. In the patient, delayed-enhancement images were obtained using a phase-sensitive inversion recovery (PSIR) [6] pulse sequence, 15 min-

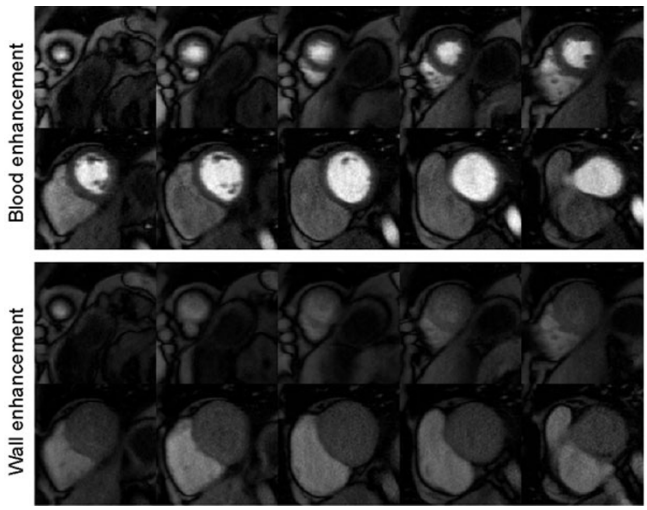

Figure 1
8-fold accelerated perfusion images with whole-hearet coverage at peak blook and peak myocardial all enhancement for one volunteer study.

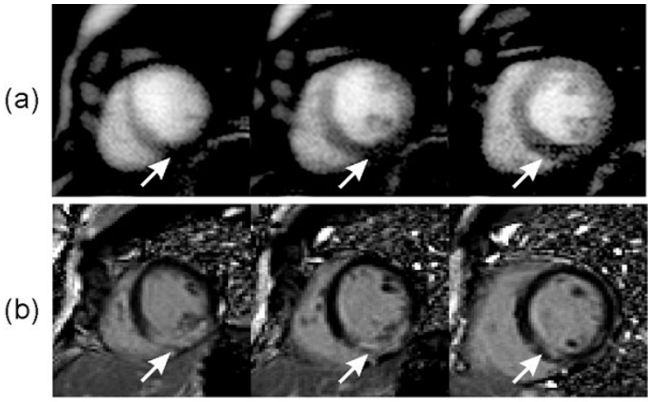

Figure 2
(a) 8-fold accelerated perfusion images at peak myocardial wall enhancement for the patient study. These three selective plances show perfusion defects. (b) Corresponding PSIR delayed-enhancement images showing myocardial scarring regions that correlate well with the perfusion defect regions.

utes after the administration of the contrast agent. Image reconstruction was performed using the JOCS algorithm [5]. A Fourier transform along the time dimension and finite differences along the spatial dimensions were used as sparsifying transforms.

Results

Fig. 1 shows the reconstructed images (10 slices) for the peak blood and peak myocardial wall enhancement phases for one volunteer study. The reconstructed images covered most of the heart with adequate blood and myocardial wall enhancement and good image quality. Fig. 2 shows perfusion images at peak myocardial wall enhancement in three short-axis views (mid-to-apical) with perfusion defects for the patient study. The corresponding PSIR delayed-enhancement images show myocardial scarring regions that correlate well with the perfusion defect regions.

Conclusion

JOCS enables first-pass cardiac perfusion MRI studies with whole-heart coverage and high spatial (<2 mm) and temporal (60 ms/slice) resolution. Future work will explore 3D imaging and the use of larger numbers of coils.

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