Free Breathing Myocardial Perfusion using Navigator Slice Tracking and TSENSE

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INTRODUCTION

In myocardial perfusion imaging, scan duration is ideally determined by the time course of contrast enhancement, which may be too long for patients under breath-hold conditions. Additionally, breathing motion may still occur despite patients' best efforts to suspend breathing [1], rendering the contrast enhancement time course difficult to interpret due to inconsistent anatomy from one time point to the next. Here we show that navigator free breathing myocardial perfusion can be achieved with minimal residual breathing motion, allowing longer acquisition to ensure that the entire contrast enhancement time course is imaged.

METHODS

A two dimensional multi-slice fast gradient echo sequence with a pencil beam navigator was developed. Three to five slices were acquired in each heartbeat depending on heart rate, with slices acquired at successive cardiac phases. Prior to acquisition of each slice, a navigator was acquired, followed by a spatially selective saturation pulse placed to saturate the heart without destroying liver signal for the navigator. Once the position from the navigator was available, the imaging slice was shifted by 0.6 times the navigator displacement. TSENSE with an acceleration factor of 2 was employed [2], acquiring even k-space lines during even numbered heartbeats and odd k-space lines during odd numbered heartbeats. By averaging the aliased images acquired over multiple heartbeats, it was possible to derive coil sensitivity maps at full spatial resolution but low temporal resolution without additional training data, which could then be used to produce dealiased images with full temporal and spatial resolution.

Free breathing slice tracking perfusion scans were performed in two healthy volunteers and three cardiac MRI patients after IRB approved written informed consent. Imaging was performed using a 1.5T GE Signa HDx MR scanner using an 8 channel cardiac phased array and vector ECG gating. Subjects were injected with 10 ml of Gd-DTPA at a rate of 2.5-3 ml/s, followed by 20 ml of saline flush at the same injection rate using a power injector. Pulse sequence parameters were TR 3.3 ms, TE 1.6 ms, flip angle 20°, RBW 125 kHz, FOV 30-32x24-29 cm, matrix size 128x100-108, slice thickness 10 mm, 0.5 nex. Immediately following each navigator, a spatially selective 90° saturation pulse was played out, followed by image acquisition. View ordering was linear, beginning at the outer edge of k-space to allow for a longer saturation recovery time to improve T1 contrast and SNR [2][3]. The time between the saturation pulse and acquisition of the center of k-space was approximately 110 ms, and the delay between the navigator readout and acquisition of the center of k-space was approximately 125 ms. A schematic of the acquisition scheme is shown in Fig. 1.

RESULTS

Slice tracking perfusion imaging was successfully performed in all volunteers and patients. Use of the navigators allowed long acquisitions (~1 minute), ensuring that the contrast time course was well visualized while minimizing breathing motion. Reduction of motion was evident because the heart remained near its original location and imaged anatomy in each slice was consistent, while the liver and chest walls exhibited significant motion between heartbeats. Images from a healthy volunteer acquired at different points in the contrast time course are shown in Fig. 2. Figure 3 shows the corresponding time course from a region of interest in the septal wall.

DISCUSSION

These data from healthy volunteers and cardiac patients demonstrate the feasibility of slice tracking navigators to eliminate respiratory motion on free breathing myocardial MRI perfusion imaging. This allows longer acquisitions to ensure capture of a longer contrast time course compared to what is possible with breath holding. In all cases, respiratory motion of the heart was greatly reduced relative to motion of the surrounding chest wall and liver. Previous work has used patient specific models to estimate the position of the heart during the acquisition of the center of k-space [4], but adequate correction for breathing motion was still achieved in this work.

REFERENCES [1] Jahnke, et. al., Radiology, 239:71-78, 2006. [2] Kellman, et. al. MRM, 51:200-204, 2004. [3] Slavin, et. al., Radiology, 219:258-263, 2001. [4] Pedersen, et. al. ISMRM, 15:845, 2007.

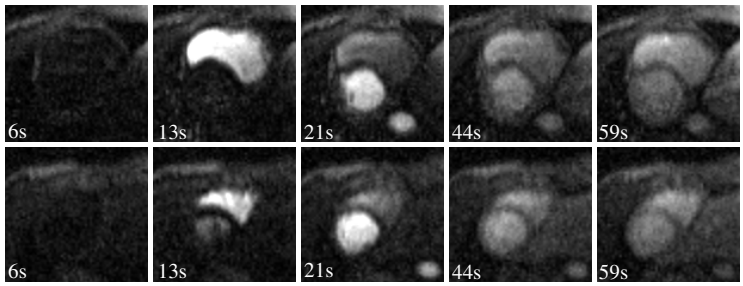

Figure 2. Images from two slices throughout the contrast enhancement time course acquired in a healthy volunteer. Times indicate time from the start of contrast injection.

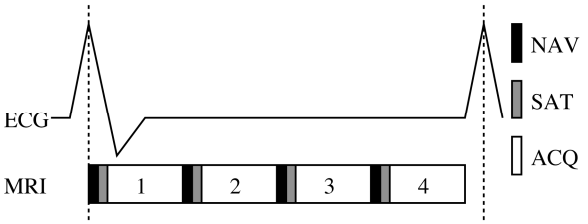

Figure 1. Navigator acquisition scheme for slice tracking myocardial perfusion. Multiple slices are acquired, each at a different cardiac phase

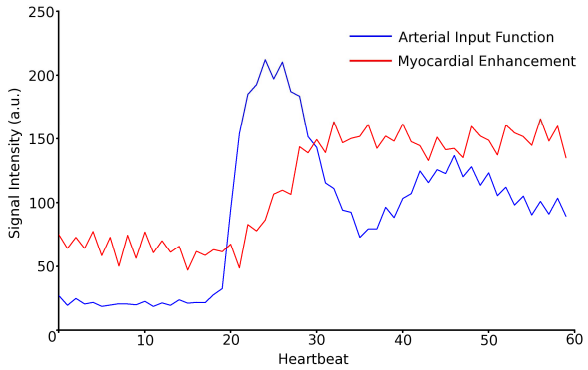

Figure 3. Contrast enhancement time course of a region of interest in the myocardium.