Feasibility of real-time cine to detect exercise-induced cardiac wall motion abnormalities in patients suspected of coronary artery disease

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Introduction: Exercise is preferred to pharmacologic stress testing because it links physical activity to symptoms and ischemia and provides additional diagnostic and prognostic information such as ECG and blood pressure response with exercise, and exercise capacity. Real-time cine has been successfully applied in dobutamine stress MRI [1], but the extremely heavy breathing motion encountered immediately post-exercise is not typically a problem with dobutamine. Detection of wall motion abnormalities with exercise stress has been demonstrated previously using segmented k-space, breath-hold cine acquisition [2]; however, breath-holding is often difficult and impractical at peak stress. Real-time cine without breath-holding has the potential to overcome this challenge, but it is important to determine whether we can achieve adequate temporal resolution to detect wall motion abnormalities at heart rates as high as 180 beats per minute and overcome motion artifacts due to deep breathing. While higher parallel imaging acceleration factors enable improved temporal resolution, this can come at the cost of reduced signal-to-noise and increased artifacts. TGRAPPA reconstruction is known to be less sensitive than TSENSE to artifacts induced by aliasing and mismatch between the coil sensitivity map and the actual coil position resulting from deep breathing. Our hypothesis is that real-time non-breathhold cine with TGRAPPA acceleration rate 3 can detect regional wall motion abnormalities at peak exercise stress.

Purpose: To determine whether real-time non-breath-hold cine with TGRAPPA rate 3 acceleration, resulting in an average temporal resolution of 62 ms and spatial resolution of 3.8 x 2.5 x 8mm, is able to detect regional wall motion abnormalities at peak exercise stress in patients suspected of CAD.

Methods: Five healthy volunteers and five patients suspected of CAD referred for treadmill nuclear stress imaging exercised to peak stress on a modified treadmill in the corner of the MRI room [3]. Resting cines were acquired first, then immediately after exercise to peak stress, the patient was quickly escorted to the MRI table, and the previously prepared real-time cine scan was immediately executed using the "start" button on the scanner (Siemens 1.5T Avanto). Cardiac stress cines were acquired in 5 short-, 3 vertical long-, and 1 horizontal long-axis views using real-time SSFP with TGRAPPA rate 3 acceleration, TR/TE 2.2/0.9ms, matrix 160x84, spatial resolution 3.8x2.5x8mm, temporal resolution 62.3±5.1ms, acquisition time 2 sec/slice, and no breath-hold or ECG gating. The patients subsequently underwent invasive coronary angiography. The images from patients and healthy volunteers were anonymized and randomized and two experienced cardiologists blinded to the angiography results evaluated each subject for the presence or absence of wall motion abnormalities. We compared this information to the angiography findings to determine the correspondence between wall motion abnormalities and coronary angiograms with >70% stenosis present in at least one coronary vessel.

Results: All patients and volunteers successfully completed the examination. Mean time to completion of cine MRI post-exercise, including the time to move the patient from the treadmill to the MRI table, was 71±8 sec in patients and 48±3 sec in healthy subjects. Among the five patients who underwent coronary angiography, three had mild (<70%) or no stenosis, and two had >70% lesions in at least one coronary vessel. The blinded review of anonymized data was in agreement with the angiography findings. Images from all five healthy volunteers and three patients with <70% stenoses were correctly interpreted as normal. Two patients with >70% lesions were diagnosed with wall motion abnormalities (Figure 1).
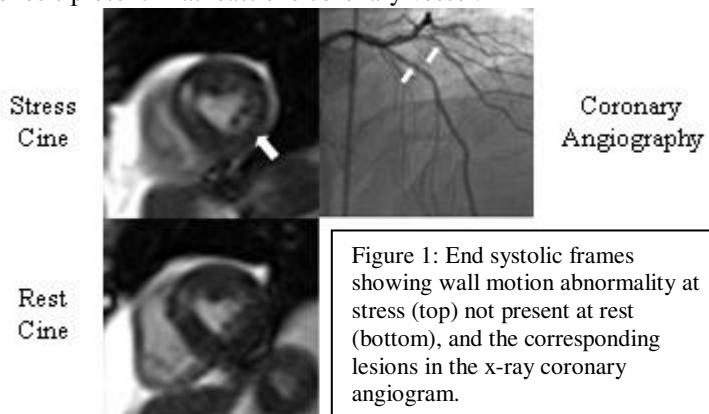

Figure 1: End systolic frames showing wall motion abnormality at stress (top) not present at rest (bottom), and the corresponding lesions in the x-ray coronary angiogram.

Conclusions: The wall motion abnormalities were consistent with coronary angiography findings of diseased vessels with >70% stenosis. These results indicate that real-time non-breathhold CMR has the potential to accurately diagnose exercise-induced regional wall motion abnormalities.

References:

[1]   S. Schalla, C. Klein, I. Paetsch, H. Lehmkuhl, A. Bornstedt, B. Schnackenburg, E. Fleck, and E. Nagel, "Real-time MR image acquisition during high-dose dobutamine hydrochloride stress for detecting left ventricular wall-motion abnormalities in patients with coronary arterial disease," *Radiology*, vol. 224, pp. 845-51, 2002.

[2]   P. Rerkpattanapipat, S. K. Gandhi, S. N. Darty, R. T. Williams, A. D. Davis, W. Mazur, H. P. Clark, W. C. Little, K. M. Link, C. A. Hamilton, and W. G. Hundley, "Feasibility to detect severe coronary artery stenoses with upright treadmill exercise magnetic resonance imaging," *Am J Cardiol*, vol. 92, pp. 603-6, 2003.

[3]   M. Jekic, E. L. Foster, M. R. Ballinger, S. V. Raman, and O. P. Simonetti, "Cardiac function and myocardial perfusion immediately following maximal treadmill exercise inside the MRI room," *J Cardiovasc Magn Reson*, vol. 10, pp. 3, 2008.