Three-Dimensional Myocardial Perfusion MRI Using SW-CG-HYPR

L. Ge[1], H. Ma[2], A. Kino[1], J. Carr[1], K. Li[3], and D. Li[1]
[1]Departments of Radiology and Biomedical Engineering, Northwestern University, Chicago, IL, United States, [2]Xuanwu Hospital and Capital Medical University, Beijing, China, People's Republic of, [3]Xuanwu Hospital and Capital Medical University

Introduction:

First-pass perfusion MRI is a promising technique for detecting ischemic heart disease. However, the diagnostic value of the method is limited by the low spatial coverage, resolution, SNR, and cardiac motion related image artifacts. Parallel imaging methods have been applied in myocardial perfusion MRI, but the spatial coverage and SNR remain limited. Time-resolved data acquisition with Sliding-Window Conjugate-Gradient HighlY constrained back PRojection (1, 2) (SW-CG-HYPR) has been proposed to acquire 2D myocardial perfusion images. This method allows increased spatial coverage, better spatial resolution, and improved SNR (3). To further increase the spatial coverage and contrast-to-noise ratio (CNR), we developed a 3D sequence combined with inversion recovery (IR) pre-pulse and SW-CG-HYPR. In this work, we compared this new method with the conventional IR Turbo-FLASH protocol for myocardial perfusion in healthy volunteers.

Methods:

Five healthy volunteers were scanned using a 1.5T system (Espree, Siemens, Erlangen, Germany) with breath hold, during the first-pass of 0.075 mmol/kg of contrast material, chased by 15 ml of saline solution, injected intravenously at a rate of 4 ml/s. An ECG-triggered, 3D turbo-FLASH sequence with radial *k*-space sampling and inversion recovery preparation was used in this study (Figure 1). Within each cardiac cycle, 6 partitions were acquired after a trigger delay time and inversion recovery preparation. Each partition was acquired in a segmented interleaved fashion with 16 projections per heartbeat, and the "composite images" were reconstructed by a sliding window method using *k*-space data from 10 consecutive cardiac cycles. CG-HYPR method was used to reconstruct the time-resolved images. SW-CG-HYPR allows a 3D acquisition window of 250 ms in each heartbeat. Imaging parameters included: TR/flip-angle = 2.9 ms/12º, TI = 200 ms, FOV = 320×320 mm^2, number of slabs = 6 interpolated to 12, and spatial resolution = 1.9×1.9×10 mm^3. To compare the image quality and verify the signal changes after contrast administration, a conventional IR Turbo-FLASH scan was performed with the same contrast injection scheme. The parameters include: TR/TE/flip-angle = 2.2 ms/1.1 ms/10º, FOV = 350×270 mm^2, matrix = 106×192, GRAPPA factor = 2, 3.0×1.6×10 mm^3, slice thickness = 10 mm, TI = 200 ms, number of slices = 1. The dynamic signal changes from the conventional scan were used as a reference to compare those obtained from SW-CG-HYPR images.

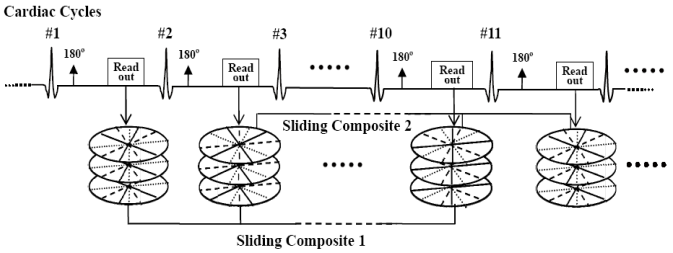

Figure 1. Schematic of 3D radial k-space acquisition using interleaved sliding window with inversion recovery preparation.

Results:

As shown in Figures 2, left ventricle and myocardium signal changes in SW-CG-HYPR images were closely related to those observed in images obtained using the conventional protocol. The mean correlation coefficients between 3D sliding CG-HYPR and 2D single-slice reference images are 0.97, 0.95 for blood and myocardial signals, respectively. With SW-CG-HYPR, 6 partitions were acquired in each cardiac cycle for IR prepared myocardial perfusion imaging, while the conventional protocol only allows 1 slice with IR and 3 slices with saturation recovery preparation. Within the interpolated 12 partitions, the 10 central partitions have no slice aliasing.

Conclusions:

With SW-CG-HYPR, the acquisition time per partition was dramatically reduced, which allows for 3D data acquisition. 3D imaging improves SNR and allows inversion recovery preparation, which improves image contrast over saturation recovery preparation required for multi-slice 2D imaging.

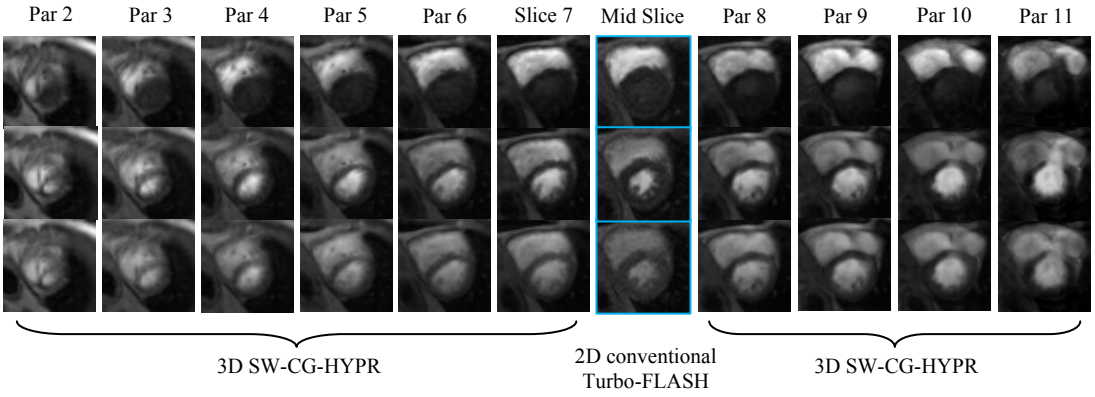

Figure 2. A comparison of perfusion images from 3D SW-CG-HYPR and 2D conventional turbo-FLASH with inversion recovery. Similar signal changes in the left ventricle and myocardium are observed.

References:

1. Mistretta CA, et. al. MRM, 55: 30-40, 2006
2. Griswold MA, et. al. Proc ISMRM, Berlin, 2007: 834
3. Ge L, et. al. MRM, 62: 835-9, 2009