3D HYPR-based MRI Techniques for Myocardial Perfusion Imaging

O. Unal[1,2], J. Velikina[1], and C. A. Mistretta[1,2]

[1]Department of Medical Physics, University of Wisconsin, Madison, WI, United States, [2]Department of Radiology, University of Wisconsin, Madison, WI, United States

INTRODUCTION

In myocardial perfusion imaging, the goal is to differentiate contrast kinetics of normal and ischemic myocardium. The required high temporal resolution does not allow for acquisition of a fully sampled dataset in each time frame. As a result, reconstructed images suffer from loss of spatial resolution and/or low signal-to-noise ratio (SNR) and undersampling artifacts. Recently developed HighlY constrained backPRojection (HYPR) [**1**] is a non-iterative reconstruction technique for time-resolved imaging from severely undersampled data. When used in combination with a hybrid radial/Cartesian acquisition [**2**], HYPR provides relatively artifact free images with high SNR and high temporal resolution for large undersampling factors in selected applications. The original HYPR algorithm was followed by several modifications including non-iterative Local Reconstruction HYPR (HYPR LR) [**3**] and iterative Conjugate Gradient HYPR (CG HYPR) [**4**]. Here, we have investigated the use of HYPR-based methods for myocardial perfusion imaging, evaluating the resulting image quality and temporal waveform fidelity.

MATERIALS AND METHODS

A 3D stack-of-stars, ECG-gated, saturation recovery gradient echo MR imaging technique was implemented and used on a 1.5 T scanner for myocardial perfusion imaging. Typical scan parameters were TR/TE/Flip = 3.4 ms/1.6 ms/20°, FOV = 320 mm x 320 mm, and RBW = ±62.5 kHz. For each set of 512 interleaved radial acquisitions with a 256 read out in the *kx-ky* plane, 6-10 *kz* partitions with 36-60 mm slab thickness were acquired [**2**] in a single breathhold during the first pass of 0.1 mmol/kg contrast agent injected at 2-3 ml/s. To maintain high temporal resolution, time frame images were reconstructed from 16 projections per frame, which corresponds to an undersampling factor of 24 relative to the Nyquist criterion. We compared the reconstruction results using filtered backprojection (FBP), original HYPR, and HYPR LR techniques. To verify temporal waveform fidelity we also numerically simulated the above acquisition from a series of fully-sampled perfusion images and compared the temporal characteristics of the reconstructed time series with the original input images.

RESULTS AND DISCUSSION

Figure 1 compares a single time frame of the simulation input image a) to the same time frame reconstructed with b) FBP, c) HYPR, d) HYPR LR using only 16 projections. Sliding-window three-frame composite images were used in the HYPR reconstruction. Compared to the FBP images with low SNR and considerable streak artifacts, the HYPR images are relatively artifact-free with high SNR.

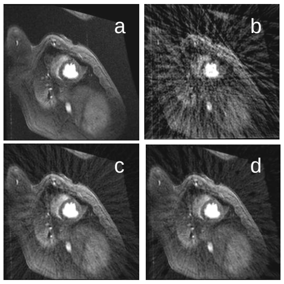

Figure 1: *Comparison of simulated myocardial perfusion results. a) Original image obtained using a 2D Cartesian perfusion technique. Images reconstructed with 16 projections using b) FBP, c) HYPR, and d) HYPR LR.*

To evaluate the temporal accuracy, the signal-intensity-time curves in the left ventricle (LV) and the myocardium were derived from the reconstructed images and compared to those of the input images. As clearly seen from Figure 2 the both HYPR and HYPR LR clearly demonstrate the temporal characteristics of the LV cavity and is in good agreement with that of the fully-sampled Cartesian images, which is essential to accurately quantify myocardial perfusion. Our preliminary results indicate that with appropriately selected MR acquisition parameters, a HYPR time series can convey the temporal dynamics with good fidelity with an undersampling factor of 24.

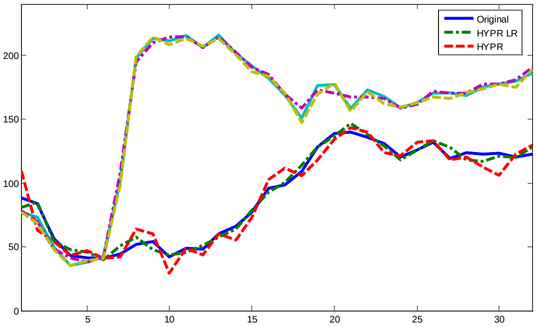

Figure 2: *Temporal characteristics in left ventricle and myocardium.*

Figure 3 shows a comparison of the results reconstructed from only 16 projections with a) FBP, b) HYPR, and c) HYPR LR techniques using the data obtained with the 3D stack-of-stars myocardial perfusion imaging technique in swine. Compared to the FBP technique that leads to images with significant streak artifacts, the HYPR and HYPR LR images are relatively artifact-free with high SNR. SNR gain, artifact reduction, and temporal response will depend on how large a temporal aperture can be used to form the composite images in HYPR. The convolution kernel used for low-pass filtering is another parameter that affects the quality of the reconstructed images in HYPR LR. The use of recently developed iterative versions of HYPR such as CG HYPR [**4**] and I-HYPR [**5**] may further improve the reconstructed image quality and temporal behavior at the expense of increased computation burden. The feasibility of the use of these iterative methods for myocardial perfusion imaging remains to be investigated.

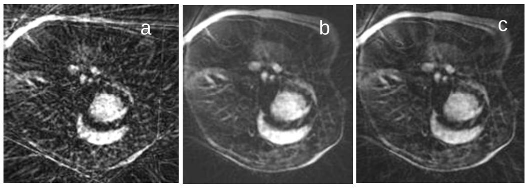

Figure 3: *Short-axis images obtained with 3D stack-of-stars acquisition reconstructed from 16 projections using a) FBP, b) HYPR, and c) HYPR LR.*

CONCLUSIONS

Our initial results suggest that the HYPR techniques for myocardial perfusion imaging may offer advantages by providing relatively artifact free images with high SNR and high temporal resolution obtained from the data with undersampling factors of 24.

ACKNOWLEDGMENTS

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