Inter-study repeatability of self-gated quantitative myocardial perfusion MRI

Devavrat Likhite[1], Promporn Suksaranjit[2], Chris McGann[2], Brent Wilson[2], Imran Haider[2], Ganesh Adluru[1], and Edward DiBella[1]

[1]*UCAIR, University of Utah, Salt Lake City, Utah, United States,* [2]*Division of Cardiovascular Medicine, Department of Medicine, University of Utah, Salt Lake City, Utah, United States*

Background: Recent developments in cardiovascular MR (CMR) have made it possible to rapidly acquire images without ECG gating. This ECG-independence makes the technique ideal for quantification of perfusion in people with arrhythmias. Moreover, the high temporal resolution makes it possible to split the data into multiple cardiac phases for analysis. Promising results have been shown for visual analysis of ungated myocardial perfusion data in [1] and for quantifying self-gated data in [3]. For application in longitudinal studies, it is of particular interest to study the inter-study reproducibility of this self-gated approach to quantitative myocardial perfusion.

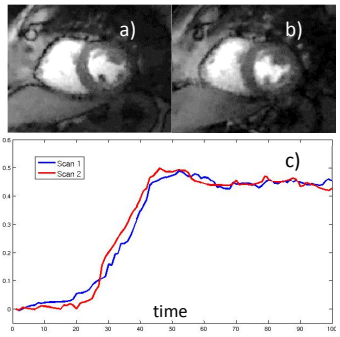

Figure 1 One time frame of perfusion studies a week apart. Matching slices a) and b) for a single subject between Scan 1 and Scan 2. c) shows the corresponding tissue curves averaged over the slice for Scan 1 and Scan 2

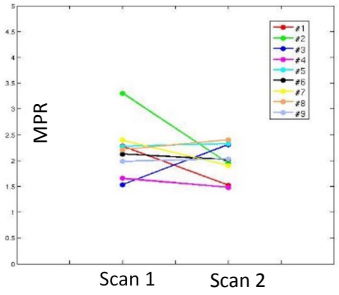

Figure 3 Comparison of global MPR between Scan 1 and Scan 2

Methods: Radial perfusion data was acquired on a Siemens 3T Verio scanner using a radial saturation recovery turboFLASH sequence in 9 subjects (7 males 2 females, 50 ± 13 years) at rest with no ECG-gating. The acquisition parameters were 24 rays per image, TR=2.2ms, TE=1.2ms, 1.8 x 1.8 x 8 mm voxels. Four slices were acquired after a single saturation pulse with a saturation recovery delay of ~25ms before the first slice, and only one saturation pulse for each set of four slices. Gadoteridol 0.05mmol/kg was injected and ~240 frames were acquired over a minute with shallow breathing. This was followed by an injection of regadenoson to induce hyperemia. The same scan protocol was repeated to acquire four matching slices at stress. Each volunteer was scanned twice on separate days with 9.5 ± 4.5 days between two scans. The images were reconstructed using a spatio-temporally constrained reconstruction [2]. The images were self-gated (binned) into near systolic and near diastolic cardiac phases followed by deformable registration, similar to the methods in [3]. Figure 1 shows an example of a single timeframe for a subject for two scans and the corresponding tissue curves

The ungated data, now self-gated into near systole and near diastole subsets was further processed for quantification of myocardial perfusion. The processing steps involved segmentation of the myocardium followed by the extraction of the arterial input function (AIF) and the tissue curves. The myocardium was segmented into 6 circumferential regions. The most basal diastolic slice with the least saturation recovery time was used to obtain the AIF. The remaining three slices were used to obtain the tissue curves. The AIF and the tissue curves were converted to gadolinium concentration to correct for any signal saturation. Fermi-constrained deconvolution was used to estimate the myocardial blood flow (MBF). The myocardial perfusion reserve (MPR) was calculated as the ratio of the stress and rest MBF for each region. Global MPR was estimated by taking a mean over all slices and regions.

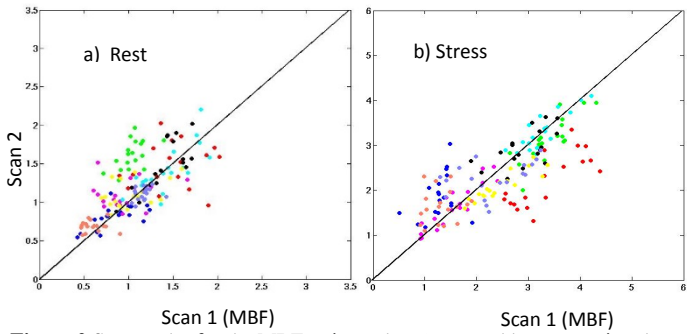

Figure 2 Scatter plot for the MBF estimated at a) rest and b) stress using the self-gated systole. The subjects are differentiated by color. The line represents the line with unity slope.

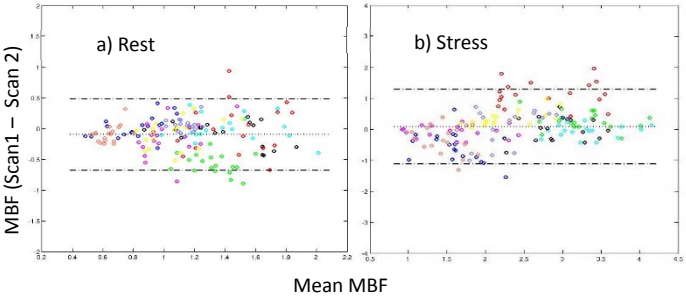

Figure 4 Bland Altman plot comparing the MBF estimates between Scan 1 and Scan 2 for a) rest and b) stress using the self-gated (systole) CMR.

	Self-gated		Published gated studies (systole)
	systole	**diastole**	
Rest	20 %	30%	20 % [4], 27 % [5]
Stress	24 %	37%	40 % [4], 35 % [5]
MPR	33 %	40%	35 % [4], 33.5 % [5]

Table 1 Comparison of CoV between the self-gated approach and published gated studies. [4] and [5] are single slice studies while the self-gated is multi-slice.

Results and Conclusion: Figure 2 shows a scatter plot of the a) rest and b) stress MBFs estimated using the self-gated systole images. The scatter plot shows a scatter around the line with unity slope. Figure 3 shows a comparison of the global MPR for the 9 subjects. Figure 4 shows a Bland Altman plot showing absence of any bias between MBF estimates between Scan 1 and Scan2. Each subject is coded by a unique color that is consistent in all of the figures. Subject #2 (green) was found to have higher resting flows in Scan 2 compared to Scan 1 and thus a lower MPR in Scan 2 compared to Scan 1. Table 1 shows the coefficient of variation (CoV) estimated using self-gated CMR compared to published gated single slice studies. The published gated studies involve young healthy volunteers. The current study involved a group of older subjects, most with some cardiac problems.

While the self-gated diastole gave a larger CoV compared to self-gated systole due to more challenging registration, the repeatability of the multi-slice self-gated systole CMR was similar or better than published single slice gated studies.

References: **[1]** Harrison et al, 'Rapid ungated myocardial perfusion cardiovascular magnetic resonance: preliminary diagnostic accuracy' 15:26 JCMR **[2]** Adluru et al.' Acquisition and reconstruction of undersampled radial data for myocardial perfusion magnetic resonance imaging',29:466-473, JMRI **[3]** Likhite et al 'Quantification of myocardial perfusion using self-gated MRI', JCMR **[4]** Abdulghani et al ,' Reproducibility of first-pass cardiovascular magnetic resonance myocardial perfusion'37:865–874 JMRI **[5]** Morton et al 'Quantitative cardiovascular magnetic resonance perfusion imaging: inter-study reproducibility',13(11): p. 954-60 EHJCI