Fat-Suppression Improves Image Quality and Diagnostic Accuracy of EPI First Pass Perfusion

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Background While first-pass perfusion imaging has shown significant promise for diagnosing coronary artery disease, most of the techniques have been limited by artifacts and false positive perfusion defects. Echo-planar imaging (EPI) offers the significant benefit of rapid MRI acquisition; however, in multi-shot EPI, the lack of radiofrequency (RF) refocusing pulses also increases the sensitivity to off-resonance effects. In cardiac imaging, fat from the chest wall is the strongest signal source due to proximity to the phased array surface coils and its short T1. As such, it can be a significant source of EPI artifacts. These artifacts increase when a longer saturation recovery time (Tsat) is desired.

Hypothesis We hypothesized that application of a chemical shift fat saturation pulse would decrease EPI artifact and improve the overall image quality.

Methods **Study population:** Fifty consecutive cardiac MR perfusion studies were analyzed. **Imaging:** All studies were performed on a GE 1.5 T CV/i scanner, using a 4-element cardiac phased-array coil. The initial 25 studies were performed using the following parameters: Gradient echo EPI (4 echoes) with a non-selective saturation pulse (flip 70°), Tsat of 60 ms and readout flip angle of 20°. Image acquisition was limited to three short axis slices acquired per 1 R-R interval, typically over 40 phases. The second set of 25 studies was acquired similarly but with the addition of a chemical shift fat saturation pulse that was applied prior to the EPI readout. **Quantitative Analysis:** For each study, regions of interest (ROIs) were placed within the myocardium, a clean noise area, and the maximal artifact region within the noise floor, typically next to the chest wall. Signal to noise ratio (SNR) was calculated according to Constantinides et al (MRM 38:852) for both the myocardium and the artifact. The ratio of the artifact-to-noise ratio to the myocardial SNR was then compared between the two perfusion techniques. **Qualitative Analysis:** Three cardiologists reviewed the studies independently, grading each study's severity of EPI artifact on a scale of 0 to 3 (0 = minimal to no artifact, 1 = mild artifact, 2 = moderate artifact, 3 = severe artifact). The average score is reported for each study group. **Diagnostic Accuracy:** The sensitivity and specificity in the detection of coronary artery disease was determined in 25 patients who underwent dipyridamole perfusion MRI using the traditional FGRE-EPI technique and in 32 patients who underwent dipyridamole perfusion MRI using our proposed fat saturation perfusion technique.

Results The standard FGRE-EPI perfusion images had a mean myocardial SNR of 16.6 ± 5.3 and a mean artifact-to-noise ratio of 5.5 ± 3.6. The fat-saturated images had a mean myocardial SNR of 14.9 ± 6.9 and a mean artifact-to-noise ratio of 1.5 ± 1.3. Thus, artifact averaged 38% of peak myocardial SNR for the standard FGRE-EPI images but only 9% for fat-saturation studies ($p < 0.001$). The qualitative scoring revealed a mean artifact score of 2.02 ± 0.14 for the standard FGRE-EPI studies, and a mean artifact score of 0.41 ± 0.30 for the fat-saturation studies ($p = 0.006$). The diagnostic accuracy of dipyridamole CMR perfusion in detecting coronary artery disease (defined by coronary angiographic stenosis >50%, positive correlative stress test, or evidence of myocardial infarction) improved from 72% with the standard FGRE-EPI technique to 84% with the fat-saturated technique (Table 1).

Conclusion Addition of a chemical shift fat saturation pulse applied during the Tsat period significantly decreases EPI artifact and improves overall image quality. Furthermore, the fat saturation perfusion technique significantly improves the diagnostic accuracy of CMR in the detection of coronary artery disease.
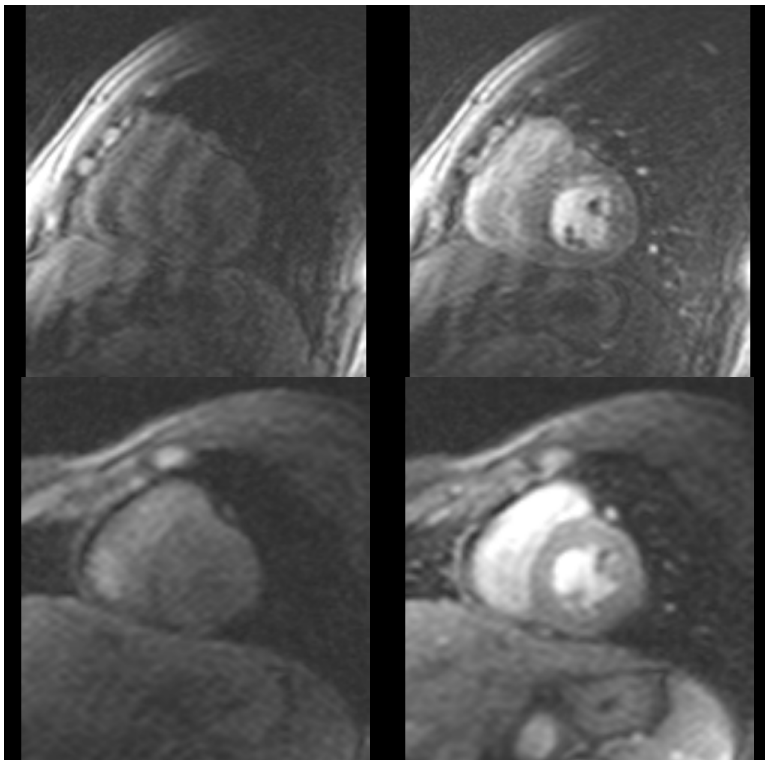

Figure 1. Standard FGRE-EPI perfusion study in a normal volunteer: The artifact is visible across the images as repeating ghosts of the chest wall. Multiple such ghosts intersect with the heart. Note that the false positive endocardial perfusion defect in the inferoseptum corresponds to one of these ghosts.

Figure 2. FGRE-EPI perfusion study with the fat saturation pulse: Note the absence of EPI ghosting and improved image quality.

Table 1. Diagnostic Accuracy of Dipyridamole Perfusion CMR in the Detection of CAD

	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value	Accuracy
Standard FGRE-EPI (n = 25)	76	63	81	56	72
Fat-saturated Perfusion (n = 31)	82	86	88	80	84