# Feasibility of MRI Attenuation Correction in Cardiac-Gated FDG-PET

Jeffrey MC Lau[1], Richard Laforest[2], Shivak Sharma[1], Jonathan McConathy[2], Agus Priatna[2,3], Luciano Amado[1], Robert J Gropler[2], and Pamela K Woodard[2]
[1]*Cardiology, Washington University in St. Louis, Saint Louis, MO, United States,* [2]*Radiology, Washington University in St. Louis, Saint Louis, MO, United States,*
[3]*Siemens Medical Solutions, Malvern, PA, United States*

**Background:** Simultaneous acquisition PET-MR imaging is a new technology that has the potential to significantly impact diagnostic patient care. Cardiac imaging using PET-MR offers high signal resolution MR images superimposed on PET metabolic functional assessment. Specifically, $^{18}$F-Fluorodeoxyglucose (FDG) PET-MR imaging has the potential to provide both anatomic scar tissue evaluation and information regarding myocardial glucose metabolism. While early brain and soft tissue data have demonstrated that PET specific uptake values (SUVs) obtained using MR for attenuation correction (AC) are comparable to SUVs obtained using CT AC, SUV measurements of myocardial tissue have not been compared. Furthermore, the need for cardiac EKG-gating in myocardial PET-MR offers an additional challenge to accurate data acquisition. The objective of this pilot study is to determine the reproducibility of myocardial SUVs obtained in EKG-gated and non-EKG-gated cardiac $^{18}$F-FDG PET imaging using an MR-AC μ-map instead of CT.

**Methods:** 31 patients with no known cardiac history underwent full body PET-CT imaging (Biograph 40, Siemens Medical Solutions, Erlangen, Germany), followed by full-body simultaneous PET-MR imaging (Biograph mMR, Siemens). Of these, 4 underwent EKG-gated PET-MR imaging. A single dose (10-15mCi) of $^{18}$F-FDG radiotracer was injected on average 59 minutes prior to PET-CT image acquisition, and 127 minutes prior to PET-MR image acquisition. For PET-MR the AC μ-map was a dual echo VIBE Dixon sequence that separates water and fat (TE1/TE2=1.23msec/2.46msec, TR=3.6msec, left-right FOV=500mm, anterior-posterior FOV=300mm). MR imaging was performed with MLAA (Maximum Likelihood reconstruction of Attenuation and Activity) in order to incorporate the arms into attenuation correction. Average SUVs were obtained by tracing the entire cross section of the left ventricular myocardium in the short or long axis of the heart at the mid-papillary muscle level, using the syngo TRUE-D computer software (Siemens). PET images were reconstructed with 3D-OSEM (Ordered Subset Estimation Maximization) with 3 iterations, 21 subsets and post-Gaussian filter of 4 mm. EKG-gated cardiac PET images were reconstructed retrospectively with cardiac gating from LIST mode data by dividing the segments into 8 phases.

**Results:** For non-EKG-gated PET-CT and PET-MR, there is no statistically significant difference between the average SUVs (4.62 vs. 4.68, respectively, $p$=0.47). Although FDG uptake rate and the SUVs are highly variable among this study group, there is excellent per patient correlation ($R^2$ =0.97, Figure 1). For EKG-gated data, SUVs acquired from PET-MR vary over the 8 phases of cardiac cycle, with higher SUV at end-systole and lower SUV at end-systole (7.72 vs. 6.00, respectively, Figure 2). The difference between end-diastole and end-systole is statistically significant ($p$=0.02), with the end-systole value approximating the non-EKG-gated PET-CT SUV (red dotted line, PET-CT SUV=6.97, Figure 2).

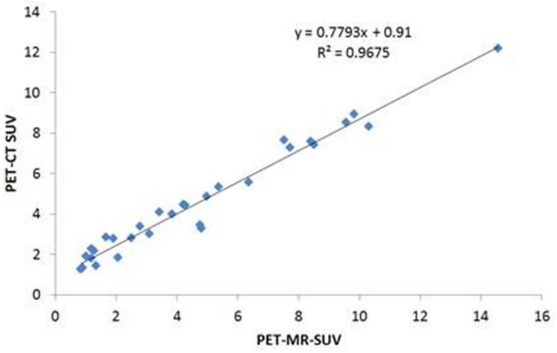


**Figure 1. Ungated PET-MRI and PET-CT SUVs Correlated Well in Normal Myocardium.**

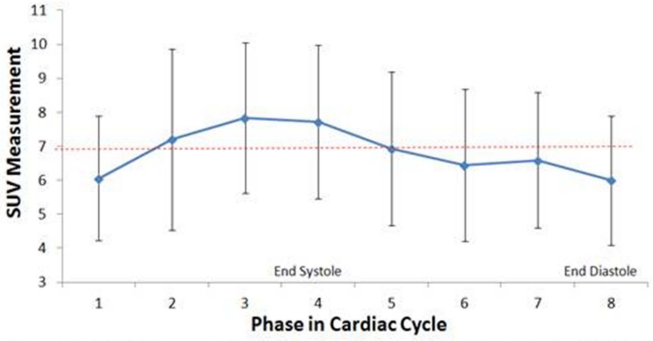


**Figure 2. SUVs Measured at Different Phases of Cardiac Cycle by PET-MR.** SUVs were higher when measured at end systole (phase 4) vs. end diastole (phase 8) when data were reconstructed into an 8-phase cardiac cycle. Red dotted line represents the average SUV obtained by ungated PET-CT.

**Discussion:** Simultaneous PET-MRI systems are now FDA-approved and clinically available. Unlike PET-CT imaging, in PET-MR there is no electron density information that can be used to directly measure attenuation correction of tissue for creation of a μ-map for AC. Instead, the MR-AC μ-map is derived from a 2-point Dixon VIBE sequence that generates water only, fat only, in-phase, and opposed phase series. Dixon-based MR AC is a tissue segmentation approach (1,2). Although researchers have compared SUVs in oncologic lesions and normal solid abdominal organs imaged by whole-body PET with MR and CT AC (3), comparison of myocardial SUV in 18F-FDG PET imaging has remained unexplored. Our findings show that, despite the marked differences in AC methods, myocardial PET SUVs measured using MR as AC show excellent correlation to myocardial SUVs obtained by standard PET-CT imaging. SUV variation across the cardiac cycle is a known phenomenon in cardiac PET imaging, secondary to partial volume effects.

**Conclusion:** Myocardial 18F-FDG PET SUVs measured using MR as AC show excellent correlation with myocardial SUVs obtained by standard PET-CT imaging.

**References:** 1. Keller et al.,MAGMA. 2012 Sep 21. 2. Martinez-Möller A, Nekolla SG. Z Med Phys. 2012 Aug 24. 3. Drzezga et al.,. J Nucl Med. 2012 Jun;53(6):845-55.