On the Feasibility of Quantitative Dynamic Whole Body PET/MR Imaging

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Synopsis

In this study we investigate the feasibility of FDG PET/MR as a platform for whole body dynamic quantitative PET imaging. The ability of PET/MR systems to provide truly simultaneous imaging is advantageous compared to PET/CT for serial whole body PET acquisitions in that simultaneously acquired MR images can provide additional information to PET data, such as the application of motion parameters estimated from MR images to PET images to correct for misregistration which is not possible with PET/CT. Further improvements in workflow can allow integration of multiple MR contrasts, making dynamic whole body PET/MR a highly feasible and compelling methodology.

Purpose

Dynamic 4D PET acquisitions that utilize kinetic modeling can improve the diagnostic accuracy of ^{18}F-Fluoro-2-deoxyglucose (FDG) PET compared to conventional static acquisitions[1,2]. However, these acquisitions have typically been limited to a single body region. New methodology has recently been proposed for quantitative whole-body PET/CT[3,4] utilizing short (e.g., 45 seconds/bed) PET scans to obtain whole body (WB) PET images within 5-6 minutes, allowing for serial multi-pass PET imaging. The purpose of this project is to evaluate the feasibility of dynamic WB (DWB) FDG PET/MR, which may have following advantages: **(1)** MR images can be obtained at every pass to provide additional soft tissue contrast (which is not feasible for CT due to radiation dose concerns), **(2)** Currently available integrated PET/MR scanners have larger cranial-caudal or z-axis coverage per PET bed position (approximately 25cm for both vendors) compared to most previous and current generation PET and PET/CT scanners (typically 15-20cm) which will enable more rapid WB coverage for better dynamic imaging, and **(3)** MR images can be used to enable motion correction between WB scans, which will improve PET and CT misregistration problems which exist with PET/CT (initial CT followed by multi-pass WB PET), and therefore the robustness and quantitative accuracy of WB dynamic PET imaging for FDG, and other PET tracers, for improved diagnosis and lesion characterization.

Methods

All imaging was performed on an integrated 3T PET/MR system (GE Signa PET/MR). To evaluate the feasibility of WB motion correction for MRI, imaging was performed on a healthy volunteer instructed to move between subsequent WB scans. Motion correction was performed using automated B-spline image registration with normalized cross correlation as a cost function[5,6].To evaluate the feasibility of DWB PET/MR, a patient volunteer undergoing a clinical PET exam was imaged (under institutional IRB approval) from approximately 30-55 minutes after FDG administration. The acquisition scheme for DWB PET/MR is shown in Figure 1. DWB PET/MR consisted of five stations/WB pass and a total of 5 WB passes (scan time of 40 seconds/station, PET reconstruction parameters: VPFX (time of flight), 16 iterations, 2 subsets, SharpIR, Filter 5mm. MRI acquisition: LAVA Flex (MR-based attenuation correction scan using body coil), TE1/TE2=1.1/2.2ms, TR=4.0ms, FOV=50x50cm, pixel size=1.95x1.95mm, slice thickness (interpolated)=2.6mm. The time to complete each WB (head-through-thighs) scan and begin another whole body pass was approximately 4.5 minutes. WB PET kinetic modeling utilized Patlak analysis[7] fit to a canonical plasma time activity curve[8] adapted to the patient, given samples from the left ventricular blood pool.

Results and Discussion

Results of WB MR-based image registration, shown in Figure 2, demonstrate vastly improved registration for inter-WB scan motion. Example DWB PET/MR images are shown in Figure 3. Results of the WB kinetic modeling are shown in Figure 4. These results indicate that DWB FDG PET/MR is feasible and may offer benefits compared to similar methods performed on PET/CT. The use of MRI for motion correction is a particularly strong capability due to the true simultaneity of PET/MR compared to PET/CT. Future work should evaluate the quantitative differences in kinetic modeling as result of different mechanisms for photon attenuation correction between

PET/MR and PET/CT. Additionally, the MRI protocol could be expanded to perform additional imaging sequences utilizing different MR image contrasts and intramodal registration between subsequent WB scans.

Conclusion

DWB PET/MR is feasible and offers great potential for motion control and improved quantitative PET analysis.

Acknowledgements

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Figures

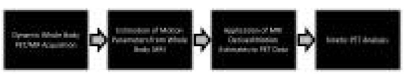

Figure 1. Acquisition scheme for whole body dynamic PET/MR imaging. Simultaneous imaging allows motion parameters from MRI to be applied to PET before kinetic analysis.

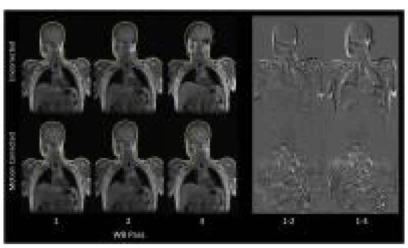

Figure 2. Example of deliberate motion in a volunteer. Whole body MR image registration is able to compensate for large movements as shown in registered serial and subtraction images. These motion parameters can then be applied to PET.

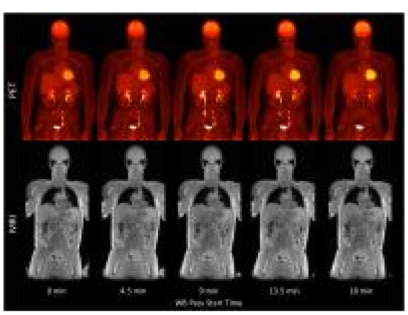

Figure 3. Example dynamic whole body PET/MR images. PET images are shown as maximum intensity projections (MiPs).

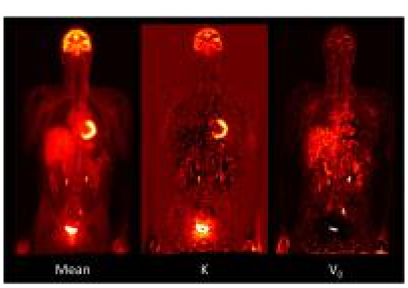

Figure 4. Example WB kinetic images from PET/MR, including motion corrected, time averaged PET (Mean), Patlak slope (K), and Patlak offset (V_0).