

Comparison of SUV between simultaneous PET/MRI and PET/CT: A single injection study in patients with Cancer

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Introduction:

Positron emission tomography (PET) with ¹⁸F-fluoro-2-deoxy-D-glucose (FDG) is an indirect measure of metabolic activity and is a mainstay of staging various malignancies including lymphoma, esophageal, lung, rectal and cervical cancer. In many oncologic subtypes, including lung cancer and lymphoma, standardized uptake value (SUV), a measure of tumor glucose metabolic activity, has shown prognostic value in addition to being a measure of therapeutic efficacy. FDG-PET/CT, however, involves radiation exposure, which is a concern for younger populations afflicted with malignancy, and FDG avidity is dependent on tumor type with many tumor types having variable FDG avidity (e.g. pancreatic cancer, carcinoid).

The recent introduction of an integrated whole-body PET/MR scanner allows simultaneous acquisition of PET and MR data. [1-5] This offers significant potential of marrying the superior soft tissue contrast of MRI to FDG PET in a simultaneous acquisition, thus minimizing motion related and physiologic changes that may occur in FDG avidity when fusing to anatomic images. Furthermore, this adds the added convenience to the patient, of potentially not having to perform two examinations in their oncologic staging and treatment follow-up examinations. There are major technical differences in PET/MRI, however, compared to conventional PET/CT devices which requires the need for MR-based attenuation correction. The aim of this study was to evaluate the correlation between the maximum SUV measured on PET/CT and that measured on PET/MRI based on the location of lesion in 35 patients with different oncologic diagnoses undergoing PET-MRI on the same day as a clinical PET-CT examination.

Methods:

Study participants: 35 patients with various malignancies were enrolled and provided informed consent in this IRB approved study. Exclusion criteria included the following (18>age>80yrs of age), and known contraindications to MRI (e.g. metallic implants...). The protocol was approved by the Massachusetts General Hospital Institutional Review Board.

Imaging protocol: A single-injection/dual-imaging protocol, consistent of a PET/CT and subsequent PET/MR scan (average interscan interval, 2.1 hours).

MRI protocol: The Biograph mMR 3T scanner was used for these studies. Specially fabricated PET-compatible phased array coils (6-channel) were used to acquire the MR data. A 2-point Dixon 3D VIBE breath-hold T1 weighted sequence using the following parameters (iPAT factor 2, TR 3.6ms, TE1 1.225ms, TE2 2.45ms, matrix size 79x192, NEX=1, FOV 500mm, slice thickness, 5.5mm, flip 10) was used to derive the attenuation correction (AC) map. This manufacturer-provided method allows the identification of four tissue types (fat, soft tissue, lung, background). Being difficult to segment from the MR data, bone tissue is treated as soft tissue for AC purposes. Coronal whole body STIR was performed (iPAT factor 3, TR 3382-5631ms, TE 81-87ms, matrix, 186x384, NEX=1, FOV 450mm, slice thickness 5.5mm, TI 220-230ms) in order to provide anatomic correlation.

PET imaging protocol - PET data were acquired using shallow free breathing from the upper thighs cephalad. 4-5 bed positions (bp) were required to cover the entire abdomen and pelvis with ~10 min/bp. PET axial field of view was 25.8cm. PET data were reconstructed using a 3D AW OSEM, with 3 iterations and 21 subsets, zoom =1, and Gaussian smoothing of 4mm FWHM.

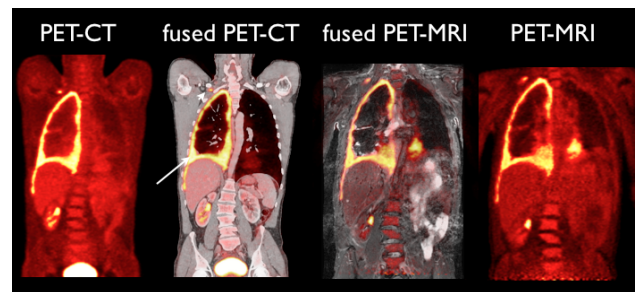
Data analyses: Image analysis was performed using OsiriX (OsiriX, Geneva, Switzerland) software with fusion software embedded. Region of interest (ROI) analysis was performed on FDG-PET data fused with either CT or MRI demonstrating FDG avidity 1 standard deviation above liver or mediastinum. The maximum SUV of the lesions was measured on both PET/MR and PET/CT. Lesion location was classified as neck, thorax, abdomen, pelvis or extremity. Spearman's rank correlation coefficient (r) was calculated to examine the correlation between the maximum SUVs derived from PET/MR and PET/CT.

Results:

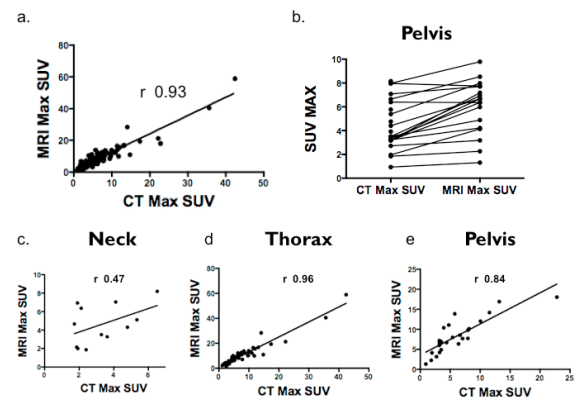
The top figure demonstrates FDG PET/CT fused data compared to FDG PET/MRI data fused to whole body T2. The quality of the PET images was comparable, and demonstrated FDG avid pleural based lesion with no chest wall extension and diaphragmatic extension (better visualized and distinguished on PET/MRI). Of the 35 patients, 26 (mean age 57 years; range 31 -81 years; 18 female, 8 male) had FDG-avid foci. In total 110 FDG avid foci were identified on both PET/CT and PET/MR; 12 classified as neck; 54 classified as chest; 17 classified as abdomen; 26 classified as pelvis; and one as extremity. Correlation analysis demonstrated a very high overall correlation between maximum SUVs of FDG-avid lesions on PET/MR and PET/CT (r=0.93). When the correlation coefficient was calculated based on location, chest had the highest correlation (r = 0.96), with abdomen and pelvis having similar results (both r=0.84), and neck having the lowest correlation (r=0.47). The average maximum SUV for all lesions was 6.5 for PET/CT (range 0.9 – 42.4) and 8.5 for PET/MR (range 1.2 – 58.9). The average maximum SUV for PET/CT and PET/MR based on location is: 3.3 and 4.6 for neck; 7.8 and 10.4 for chest; 5.3 and 6.2 for abdomen; and 6 and 8.3 for pelvis.

Conclusion:

Recent articles have demonstrated excellent correlation of PET/CT and PET/MRI data. [1-5] Our data corroborate and extend these results. Although there is a very high overall correlation between maximum SUVs of FDG-avid lesions on PET/MR and PET/CT, the location of the lesion does have an effect with chest lesions having the highest correlation and neck lesions the least. This spatial variability suggests that ignoring bone may have an effect and PET/MRI should not be interposed with PET/CT to assess treatment response during patient therapy.



55 yo M with FDG avid pleural based mass. Coronal reformatted FDG PET from PET-CT (top left) fused with coronal, contrast enhanced reformatted CT images (second from the left) which demonstrates a large FDG avid pleural based mass with right supraclavicular FDG avid lymph node (arrowhead). The third image demonstrates demonstrates FDG PET/MRI images fused over whole body STIR T2 weighted images. This demonstrates that there is lymph node involvement, lack of chest wall extension, but diaphragmatic extension is apparent. The PET CT images was insensitive to diaphragmatic excursion.



a) Linear regression of MRI Max SUV vs. CT max SUV demonstrating high correlation (r 0.93). b) Before after plots of CT Max SUV to MRI Max SUV demonstrating upward trend of data. (c-e) Linear regression of MRI Max SUV of individual body sections demonstrating variable spearman rank correlation coefficient (r 0.47 neck (c)), (r 0.96 chest (d)), (r 0.84 pelvis (e)).

References

1. Catana, C. et al. (2006). J Nucl Med 47:1968-1976
2. Catana, C. et al. (2008). Proc Natl Acad Sci U S A 105:3705-3710
3. Catana, C. et al. (2010) JNM 51:1431-1438
4. Catana, C. et al. (2011) JNM 52:154-161
5. Drzezana, A. et al.(2012). J Nucl Med 53:845-855