Comparison of standardized uptake values in normal structures and breast cancer metastases using PET/CT and PET/MRI

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Target Audience: Radiologists and basic scientists interested in methods and multi-organ system performance of 18-FDG PET/MRI for breast cancer.

Purpose: The recent advent of a molecular MR (mMR) machine presents a unique opportunity to fuse PET data with the high soft-tissue contrast of MRI without the ionizing radiation of CT. Accurate measurement of FDG activity in PET requires attenuation correction (AC). CTAC is based on tissue density information provided by CT. MR signal is not dependent on tissue density, and thus mMR necessitates a method for MRAC. Current techniques for MRAC include the Atlas-based method and the Segmentation method. Validation of MRAC is required before comparisons can be made between SUVs derived from PET/CT using CTAC and those derived from PET/MRI using MRAC. We analyzed the relationship of SUVmax measured on PET/CT and PET/MRI using the Segmentation method with regards to 1) normal structures, 2) organ-specific breast cancer metastases, and 3) the ratio of SUVmax of organ-specific metastases to SUVmax of normal tissue. We also compared washout characteristics of normal structures and metastases.

Methods: For this HIPAA compliant, IRB approved prospective study, 30 women (age 37-75, mean 57) with n=1 newly diagnosed T2 and n=29 history of metastatic breast cancer underwent whole body (WB) 18-FDG PET/MR imaging on a commercially available 3T PET/MRI scanner (Siemens Biograph mMR) following routine clinical PET/CT. After WB gradient echo scout, a WB exam was conducted including 6-7 stations from thighs to vertex, with the following protocols per station: 1) 3D coronal VIBE Dixon for MRAC, 2) prototype T1 weighted radial 3D gradient echo (radial VIBE), and 3) 2D double-refocused echo-planar, diffusion weighted imaging [TR/TE=6000/65ms, FOV 450 mm, 2.3 x 2.3 x 6.0 mm voxel, SPAIR fat-suppression, three diffusion directions (3-scan trace), and b-values 0, 350, and 700 s/mm²]. MR images were acquired prone with a set of flexible body matrix coils after rapid bolus injection of 0.1 mmol/L gadopentetate dimeglumine (Magnevist, Bayer)/kg body weight at 2.0 mL/sec IV prior to the first station. PET events were simultaneously accumulated for 6 minutes per station and images were reconstructed on the vendor platform incorporating u-maps from the AC scan. SUVmax was measured in 12 normal structures and in breast cancer metastases on PET/CT and PET/MRI from Mirada-64 (Mirada) by 2 readers using a 1mm³ region of interest (ROI), with the exception of a 3mm³ ROI for normal liver. Spearman rank correlation coefficients were calculated to look for systematic tendencies of CTAC and MRAC SUV max to increase or decrease together. Two-tailed paired t tests were performed to look for potential differences between CTAC and MRAC SUVmax. A p-value < 0.05 was considered statistically significant.

Results: The mean uptake time following FDG injection was 62±15 minutes for PET/CT and 168±37 minutes for PET/MRI. For normal structures measured by reader 1, significant positive correlations were observed between CTAC and MRAC SUVmax in axillary nodes, bone, breast, renal cortex, inguinal nodes, and psoas muscle. For reader 2, significant positive correlations were seen in bone, breast, subcutaneous fat, psoas muscle, and spleen. For reader 1, MRAC SUVmax was significantly lower than CTAC SUVmax in 10 of 12 normal structures (adrenal gland, axillary nodal, breast, inguinal nodes, liver, lung, pancreas, renal cortex, spleen, and subcutaneous fat); no difference was observed in bone and psoas muscle. Results from reader 2 were identical with the exception of a trend towards statistical significance for axillary nodes (p=0.059). Regarding metastases, SUVmax was measured in a total of 30 lesions in 6 organs (only one metastasis per patient organ was measured). Bone (n=13), liver (n=6), and non-axillary lymph node (n=6) metastases were frequent enough for statistical analysis. Both readers observed a significant positive correlation between CTAC and MRAC SUVmax in bone lesions; a trend towards significance was seen in liver lesions (p=0.072 for both readers). MRAC SUVmax and CTAC SUVmax for metastatic lesions were not significantly different for either reader. The ratios of SUVmax of metastases to SUVmax of normal tissue were statistically similar between MRAC and CTAC for all organ-specific metastases. In the interval between PET/CT and PET/MRI, washout of radiotracer appeared accelerated in bone lesions compared to normal bone and delayed in non-axillary lymph node metastases compared to non-pathologic nodes, though statistical significance was not observed. Washout was significantly delayed in liver lesions compared to normal liver for reader 2 and trended towards significance for reader 1, as shown in Figure 1.

Discussion: SUVmax derived from MRAC correlates well with SUVmax derived from PET/CT for normal structures and breast cancer metastases, and the increase in SUVmax in metastases relative to normal tissue is similar using MRAC and CTAC. SUVmax derived from MRAC can thus be used for quantitative evaluation of FDG activity. In addition, breast cancer metastases demonstrate differential metabolic activity depending on the site of spread. Further studies are necessary to assess the role of SUV measurements in tailoring imaging to the metabolic activity of organ-specific metastases arising from various primary cancers.

Conclusion: SUVmax derived from MRAC can be used for quantitative evaluation of FDG activity.