Lesion detection and workflow optimization in whole body diffusion MR imaging using trimodality PET/CT+MR in the oncology setting.

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Target audience: Physicians and scientists interested in whole-body oncologic imaging methods for PET/MR.

Purpose: PET/MR is a relatively new modality, and offers vastly improved soft tissue contrast over PET/CT and additional physiological information such as restricted diffusion[(1,2)]. The purpose of this study is to evaluate a rapid, whole-body MR protocol to determine the value PET/CT+MR "tri-modality" imaging provides in addition to conventional PET/CT with respect to small lesion detection, and how this affects clinical decision-making.

Methods: This IRB-approved, HIPAA-compliant study was performed on four consenting patients who presented to our clinic and were receiving diagnostic PET/CT. 30 min. after injection of FDG and prior to PET/CT acquisition, subjects were scanned on a 3T MRI scanner (MR750W, GE Healthcare, Waukesha, WI). Sequences included a whole body axial DWI (FOV=400x400 mm, sl. thickness=8 mm, acq. matrix=128x128, TE=57 ms, TR=auto [~5000ms], b=50 [NEX=2], b=500 [NEX=4] s/mm^2, ASSET=2, STIR fat suppression) whole body coronal T1 FSE (FOV=440x440 mm, acq. matrix=448x256, TE=7-8 ms, TR=800-890 ms, ETL=8, ARC=3), and, if time was available T2 SSFSE (FOV=440x440 mm, acq. matrix=384x160, TE=47 ms, ARC=3, STIR fat suppression). Data was acquired in multiple stations (~7 for DWI, 4 for coronal T1 and T2). Total MRI scan time was limited to 25 minutes, which included getting the subject on the table, placing the coils, scanning, and transporting from MRI to PET/CT. PET acquisition began 60 minutes after FDG injection. The subject was transported between MR and PET/CT (Discovery 710 PET/CT, GE Healthcare) using a pneumatically actuated "tri-modality table" to facilitate MR-PET/CT image co-registration. After acquisition of both the MR and PET/CT exams, the two data sets were fused using off-line software tools. The researchers were not blinded to the other modality in this feasibility study.

Results: All FDG-avid visceral organ lesions and lymphadenopathy seen on PET/CT demonstrated restricted diffusion on the DWI images. The first subject (with metastatic colon cancer) had two positive FDG/DWI liver lesions (Fig 1). One lesion was difficult to see on the PET/CT because of normal background liver uptake and the correlation with DWI improved the clinical confidence that this lesion was indeed hypermetabolic. A solitary lung lesion was FDG avid and was not visualized on MR. The second subject (with lung cancer) had FDG/DWI positive mediastinal lymphadenopathy (Fig 2). The third subject (metastatic breast cancer) had four positives FDG/DWI liver lesions. Multiple osseous lesions were also FDG/DWI positive. The fourth subject scanned (history of cervical cancer) did not have any active disease. With respect to workflow we were able to complete both the DWI and T1 sequences within the allotted scan window, without disturbing the normal workflow of PET/CT. We were not able to complete SSFSE on every patient within the allotted time. Co-registration between the PET/CT and MR images using the tri-modality table was very robust requiring minimal correction (rigid-body co-registration) in post-processing.

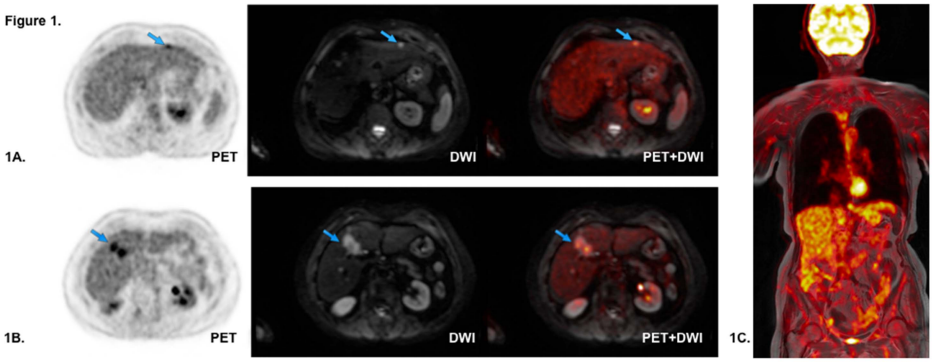

Figure 1: Examples of both PET and DWI images with PET+DWI fusion images. 1A. demonstrates a small lesion in the left hepatic lobe both restricts diffusion and is FDG avid. 1B. Large bilobed lesion within the right hepatic lobe and is intensely FDG and restricts diffusion. 1C. Fuse coronal image between a PET and coronal T1 images.

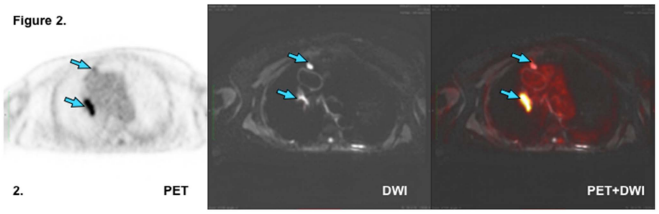

Figure 2: PET and DWI images with PET+DWI fusion images demonstrates mediastinal lymphadenopathy that both restricts diffusion and is FDG avid.

Discussion: Although a limited number of patients have been scanned at this time, there is a good correlation between FDG avid lesions and DWI, while DWI did not demonstrate any additional lesions missed by PET/CT it did improve the clinical confidence that one of the PET/CT liver lesions was in fact real (0.16% of all liver lesions). This information was obtained in the normal workflow of a diagnostic PET/CT exam, without adding any additional time to the study.

Conclusion:

- Rapid trimodality whole body DWI MRI shows a good correlation with FDG avid lesions in the oncological setting, and DWI may help improve clinical confidence in small PET/CT equivocal lesions, although a larger cohort is needed to confirm this.
- Whole body DWI can be performed within the uptake period of a conventional diagnostic PET/CT.
- Tri-modality PET/CT+MR demonstrated excellent co-registration between imaging modalities.

References:

(1) PET/MR: A Paradigm shift. Gaertner FC1, Fürst S, Schwaiger M. Cancer Imaging. 2013 Feb 27;13:36-52.
(2) Performance of whole-body integrated 18F-FDG PET/MR in comparison to PET/CT for evaluation of malignant bone lesions. Eiber M1, Takei T et al. J Nucl Med. 2014 Feb;55(2):191-7.