Free-Breathing Radial 3D Fat-Suppressed T1-Weighted Gradient Echo Sequence For Pulmonary Nodule Detection In Patients Undergoing PET/CT Followed By Simultaneous PET/MR Examination

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Target Audience: MR Radiologists and Nuclear Medicine Physicians

Introduction: Recently introduced hybrid whole-body PET/MR systems theoretically can take advantage of high contrast resolution and functional information provided by MR along with metabolic PET activity for better assessment of tumor burden in patients with malignancy (1 - 3). However, one of the concerns of replacing the CT acquisition of the PET/CT with MR is regarding the ability of MRI for detection of lung nodules (1, 4). Conventional MR imaging of lung is performed either in a breath-hold, which limits the achievable spatial resolution thus decreasing sensitivity for small nodules; or free-breathing which results in degraded image quality due to respiratory and cardiac motion. Navigated schemes can be used but these result in long acquisition time, and are prone to failure in subjects with irregular breathing pattern such as patients with malignancy. One proposed solutions is a recently developed free-breathing radially acquired T1 weighted GRE acquisition which is motion-robust (5) and thus can be performed simultaneously with PET acquisition during free-breathing.

Purpose: To assess the ability of radial T1 weighted GRE acquisition for lung nodule detection in patients with malignancy undergoing simultaneous PET/MR acquisition following a PET/CT acquisition.

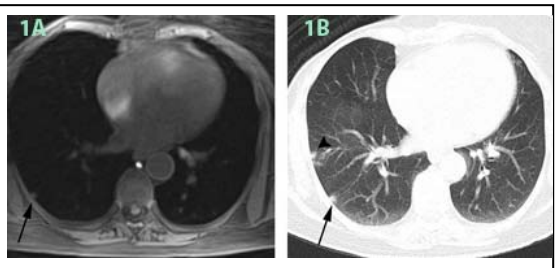

Figure 1: (A) RV and (B) CT both demonstrate a right lung nodule (arrow) but another nodule seen on CT (arrowhead) was not appreciated on MR

Methods: In this IRB approved HIPPA compliant prospective study, patients were recruited who underwent diagnostic, clinically warranted 18F-FDG-PET/CT (Siemens mCT 40) which was then immediately followed by PET/MR (MR with integrated PET system, Siemens Biograph mMR) using the remaining tracer activity. Study cohort consisted of 32 consecutive patients (9M, 23F; mean age 62 years; range 39-79 years) imaged from August 2012 to October 2012 that included a thorax station. T1-weighted gradient echo images were acquired using a prototype radial 3D stack-of-stars trajectory with slice thickness 2.5 mm, flip angle 12^0, TR/TE 4.5/2 ms, 80 axial slices, BW 400 Hz/px, voxel size 1.4 x 1.4 x 2.5 mm, quick fat-saturation mode and acquisition time of approximately 2 minutes. This was acquired free-breathing simultaneously with PET acquisition.
A nuclear medicine physician interpreted the PET/CT images for presence or absence of lung nodules, FDG avidity within these nodules, and size of these nodules was recorded. PET/CT results were considered reference standard. An MR trained radiologist reviewed the radial VIBE (RV) acquisition independently blinded to the PET/CT results. Findings on RV were compared to the PET/CT results.

Results and Discussion: 51 total nodules were identified on PET/CT. 26 of these nodules were FDG avid. RV had overall sensitivity of 85% (22/26) for FDG avid nodules and 100% for FDG avid nodules greater than 0.7 cm in size (**Table 1**). 25 nodules were FDG negative. Sensitivity of RV for non FDG avid nodules was 12% (3/25).

Nodules	**FDG (+) ≥ 0.7 cm**	**FDG (+) < 0.7 cm**	FDG (-) ≥ 0.7 cm	FDG (-) < 0.7 cm
PET/CT	21	5	3	22
RV-MR (%)	21 (100%)	1 (20%)	0 (0%)	3 (14%)

Table 1: Sensitivity of RV by size and FDG avidity

Conclusion: Radial T1-weighted MR acquisition can detect all FDG avid nodules greater than 0.7 cm in size but has low sensitivity for small nodules as well as non-FDG avid nodules. Sensitivity for smaller nodule may be improved by increasing spatial resolution at the cost of acquisition time, and with use of navigated schemes for radial acquisition which may further decrease motion related artifacts. This has important implications in use of hybrid PET/MR system in evaluation of metastatic tumor burden.

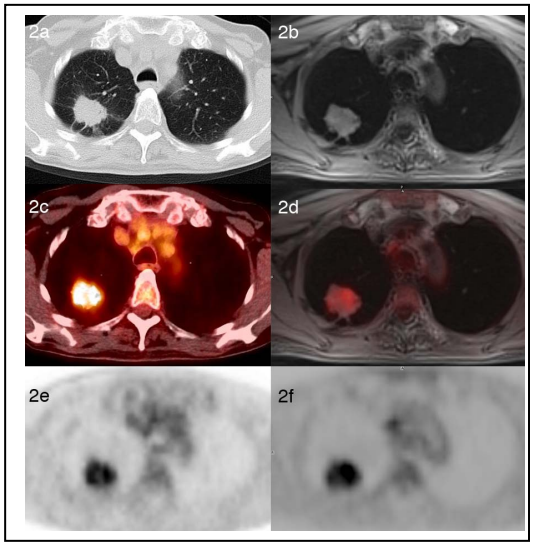

Figure 2: PET/CT (**a**) CT (**c**) coregistered CT and PET and (**e**) PET images in a patient with right upper lobe FDG avid lesion. PET/MR (**b**) RV (**d**) coregistered MR and PET and (**f**) PET images at the same level demonstrating identical findings.

References: 1. Werner MK et al. AJR 2012. 2. Schwenzer NF et al. Radiology 2012. 3. Drzezga A et al. J Nucl Med. 2012. 4. Sieren JC et al. JMRI 2010. 5. Chandarana et al. Invest Radiol. 2011