PET-MRI of The Upper Abdomen: Comparison of Two Different Post Gadolinium T1-weighted Sequences. Preliminary Observations

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Target Audience: Radiologists and Nuclear Medical Physicians interested in body PET-MRI

Purpose: MRI plays an important role in the evaluation of therapeutic response of hepatocellular carcinomas (HCC) after radiofrequency (RFA) and microwave (MWA) ablation (1). Recurrent tumors are usually seen as enhancing nodules on gadolinium-enhanced MR images (1, 2).
Previous studies have demonstrated that 18-fluoro-deoxyglucose (FDG) PET could be a dominant imaging modality as a follow-up procedure of HCC after RFA, in terms of early detection of recurrence (3). FDG PET performed within 1 month after non-operative therapy showed to be a good predictor of overall survival in unresectable HCC patients (4).
MR imaging has a high soft-tissue contrast-to-noise ratio, which enables detailed evaluation of soft tissues within the abdomen and pelvis. In contrast, the nuclear modalities (PET) provide information on metabolic and molecular parameters, but reveal restricted tissue morphology.
Theoretically, the combination of these two imaging modalities would bring important advances for the evaluation of this subset of patients.
One expected potential benefit of hybrid PET-MRI system rests in the exact superimposition and, therefore, precise anatomic correlation between FDG-avid tissue and the anatomic detail derived from MRI images.
To our knowledge no study has evaluated the spatial registration of T1-weighted images and PET images of the upper abdomen. Thus, our purpose was to compare the image quality of two different post gadolinium T1-weighted techniques (3D-GRE and Radial 3D-GRE) in the setting of hepatocellular laparoscopic RFA and MWA ablation follow-up, and to evaluate the registration of abdominal organs with PET data (MR-based attenuation correction of PET data) on a whole-body hybrid PET/MRI system (Biograph mMR, Siemens Healthcare).

Materials and Methods: Biograph mMR consists of a 3-T whole-body magnet with body coils optimized for minimal 511-keV photo attenuation. The PET detectors are made of lutetium oxyorthosilicate crystals in combination with MR-compatible avalanche photodiodes instead of photomultiplier tubes.
The study group included 10 consecutive patients (8 males, 2 females; mean age 54.4±10.6) submitted to liver ablation techniques in the setting of HCC within a 1-month period. The abdominal protocol also included axial and coronal T2-weighted free breathing HASTE; axial fat suppressed navigated T2-weighted Turbo spin-echo (TSE), axial free-breathing diffusion weighted images (DWI), axial in-phase and out-of-phase T1-weighted images. PET data were acquired simultaneously with fat suppressed T2-weighted TSE, T2-weighted HASTE and DWI. The remaining MR data were obtained after completion of PET in the bed position.
All PET-MRI studies were independently and blindly retrospectively evaluated by two different reviewers to determine image quality, extent of artifacts, and conspicuity of the ablated area on both post gadolinium T1-weighted sequences. Reliability of PET and MRI data registration was assessed. Statistical analyses were performed using the nonparametric Mann-Whitney U test.

Results: Table 1 summarizes image quality scores. Radial 3D-GRE images demonstrate consistent higher quality scorings, being significant for respiratory (for one reviewer, $p< 0.017$). Streak artifacts were only noticed on radial 3D-GRE images ($p<0.0001$) and parallel imaging residual artifacts ($p=0.0001$).
There were significant higher scorings for registration of MRI and PET data for radial 3D-GRE (for both reviewers, $p<0.0294$ and $p<0.0207$) (Fig 1).

Table 1. Image quality scores for conventional Cartesian 3D-GRE and Radial 3D-GRE stratified by reader

Parameters	Reader 1			Reader 2		
	Cartesian Mean ± SD	Radial Mean ± SD	*P*-value	Cartesian Mean ± SD	Radial Mean ± SD	*P*-value
Overall Image Quality	2.8± 1.0	3.5± 0.5	0.135	3.0± 1.1	3.2± 0.8	0.409
Hepatic Edge Sharpness	3.5± 1.0	3.7± 0.4	0.298	3.2± 0.8	3.8± 0.3	0.08
Hepatic Vessels Clarity	3.2± 1.0	3.3± 1.1	0.5	3.2± 0.9	3.4± 0.7	0.397
Respiratory Motion	3.6± 1.5	4.5± 0.5	0.074	3.7± 0.9	4.8± 0.3	0.017
Misregistration	3.0± 1.5	4.5± 0.5	0.0294	2.7± 1.4	4.4± 0.7	0.0207
Parallel Imaging Residual artifacts	3.3± 1.0	5.0±0	0.0001	4.2± 0.6	5.0±0	0.0001
Streak artifacts	5.0±0	3.5±0.5	<0.0001	5.0±0	3.3±0.5	<0.0001
Ablation Zone Conspicuity	2.7± 0.9	3.4± 0.7	0.214	3.1± 1.2	4.0± 1.1	0.223

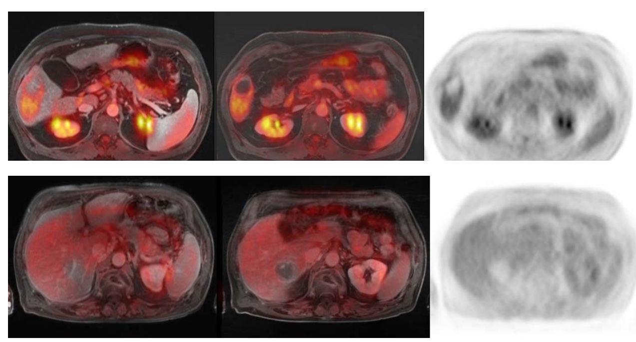

Figure 1. Fused Cartesian (left) and radial (center) 3D-GRE images in two patients. Severe misregistration between Cartesian 3D-GRE and PET images is clearly appreciated. Note the optimal registration of radial 3D-GRE and PET data and the good conspicuity of the ablated area.

Discussion: Our results reaffirm the good image quality of radial 3D-GRE T1-weighted images with consistent higher score ratings in comparison with standard Cartesian 3D-GRE images. The lesser image quality of Cartesian 3D-GRE is related to their sensitivity to respiratory motion seen in our patient group. Decreased sensitivity to motion is a clear advantage of radial k-space sampling in radial 3D-GRE (5), and the presence of streak artifacts (rated as moderate to mild) did not translate in degradation of image quality. Almost perfect registration was perceived using radial 3D-GRE (scores of 4.5 and 4.4). On the other hand, there was mild to moderate misregistration with Cartesian 3D-GRE (scores of 3 and 2.7). This is related with the acquisition fashion of these sequences, the radial 3D-GRE being acquired analogously to PET. This has clinical importance; since good anatomic matching between FDG-avid tissue and the anatomic detail derived from MRI images, represents the theoretical advantage of hybrid systems over sequential systems.

Conclusion: Our preliminary results show that free-breathing T1-weighted radial 3D-GRE yields more accurate fusion with the PET data of abdominal organs. Improved T1-weighted image quality of radial 3D-GRE along with improved fusion accuracy with PET data, support the preference of this T1-weighted sequence on abdominal PET-MRI studies and especially in patients undergoing post ablative follow-up.

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