

Hybrid PET/MRI of Prostate Cancer: Comparison of Kinetic Activity Of 18F-FDG and Gadolinium-Chelate Using Simultaneous Multimodality Dynamic Imaging

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Purpose: While the kinetics of gadolinium-chelate in prostate cancer (PCa) are well studied, the kinetics of various radioactive tracers^{1,2} are not well known within the prostate, as such tracers are usually imaged at equilibrium at a substantial delay following injection. Assessment of potential differences in kinetics between FDG-PET and dynamic contrast-enhanced (DCE)-MRI is challenging when performing separate MRI and PET scans. First, differences in physiology between the examinations may confound the temporal comparisons; in addition, differences in patient or slice positioning may result in imprecision in the tissue under comparison. Integrated PET/MRI achieves truly simultaneous spatiotemporal dynamic PET and MRI acquisitions, which allows for a highly robust comparison of the two agents' kinetic activity. Thus, our aim is to compare the kinetics of 18F-FDG and gadolinium-chelate using simultaneously acquired dynamic PET and DCE-MRI, obtained during hybrid PET/MRI in PCa patients.

Methods: 12 PCa patients (60±8years) were imaged using hybrid PET/MR (3T whole-body MR with integrated PET detector; Siemens Biograph mMR) in this IRB-approved study. The protocol included simultaneously initiated dynamic 3D GRE T1W DCE-MRI and dynamic list-mode PET of the prostate. DCE-MRI was performed using a radial compressed-sensing scan with 2.3s temporal resolution [GRASP³]. 20 sec after initiation of scanning, 0.1 mmol/kg gadolinium-chelate (Magnevist) was injected via power injector, followed by a saline flush, both at 3 cc/s. Immediately after completion of the flush, 9.0±1.3 mCi of 18F-FDG was administered by hand injection, also followed by a saline flush. DCE-MRI and dynamic PET were performed for 5 and 30 min, respectively, with additional MRI sequences acquired during the rest of the PET scan. Dose-normalized dynamic PET data was reconstructed in 30-sec bins for the initial 5 min (4 min following FDG injection given effective 1 min inject-delay resulting from above protocol), followed by 5-min bins for the rest of the 30-min acquisition. Dynamic PET and MRI data were analyzed using MIM™ (MIM Software Inc.), which provides image fusion and simultaneous evaluation. An ROI was placed in each focal lesion on fused DCE-MRI/PET images, from which the software generated time-activity curves (TACs) from matching regions of both image sets. Mean values at each 30-sec time-point over the first 4 min were extracted from the TACs, as this represented the mutually shared data between the scans. Using these values, the time-to-peak (TTP) and maximum slope during any 30-sec interval ($Slope_{max}$) were calculated for all lesions and compared between the two agents using paired t-tests and Pearson's correlation.

Results: Dynamic FDG imaging, reconstruction of 30-sec time-points, co-registration with MRI, and generation of matching ROIs were successfully performed for 16 lesions in 12 patients. In comparison with gadolinium-chelate, FDG exhibited a significantly later TTP ($p=0.013$) and significantly greater $Slope_{max}$ ($p=0.008$). Both TTP and $Slope_{max}$ showed minimal correlation between FDG and gadolinium-chelate ($r=-0.11$ to $+0.11$). Visual inspection of respective TACs suggested presence of substantial progressive FDG uptake following peak DCE-MRI enhancement to account for these trends. (Table 1, Fig. 1).

Discussion: This study is the first to our knowledge to demonstrate different kinetic characteristics of FDG and gadolinium-chelate within prostate lesions. The use of a hybrid PET/MRI system, in combination with software for image fusion and generation of matching ROIs, was paramount in reliably making this determination. The differences in kinetic behavior raise the possibility of using dynamic PET data as an additional biomarker for PCa, to complement data provided by either DCE-MRI or standard static PET. Continued optimization of the dynamic PET technique is warranted to reduce noise present within the FDG TACs. Future studies are warranted to evaluate the prognostic significance of dynamic PET metrics in PCa.

Conclusion: By performing spatially and temporally simultaneous dynamic 18-F FDG PET and DCE-MRI of the prostate using a hybrid PET/MRI system, we demonstrated distinct kinetic activity of these two agents.

References: [1] Hartun-Knemeyer V et al. Invest Radiol 2013;48:290-4. [2]. Kristian A, et al. Acta Oncol 2013;52:1566-72. [3] Chandarana H, et al. Invest Radiol. 2013;48:10-6

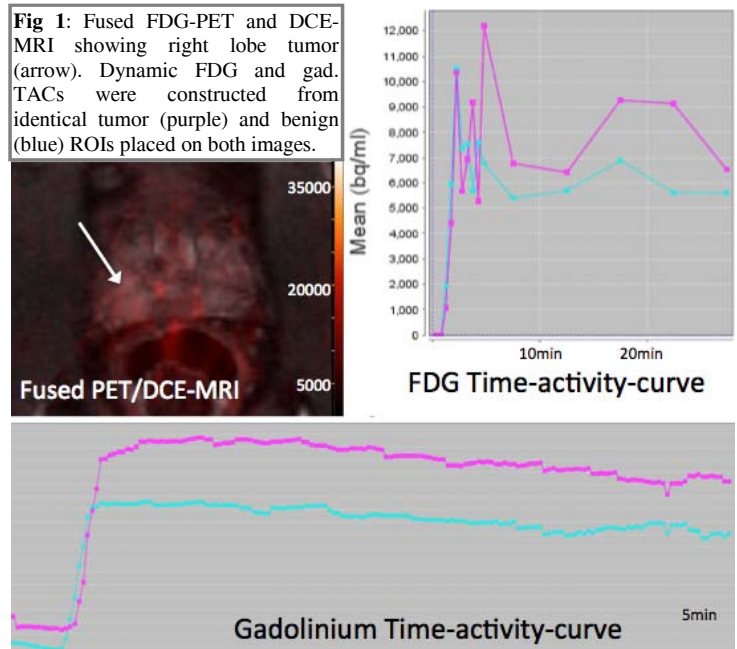


Table 1: Comparison of Kinetic Activity of FDG and Gadolinium-Chelate over First 4 Minutes of Simultaneously Acquired Dynamic Prostate PET/MRI

Modality	Time to peak (sec)	$Slope_{max}$ (per 30 sec interval)
DCE-MRI	161±45	0.038±0.013
Dynamic FDG PET	206±41	0.063±0.032