Hybrid PET/MRI incorporating Dynamic 18F-FDG PET Imaging: Correlation with Biopsy Findings-Preliminary Observations

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Purpose: While multi-parametric MRI has an established role in early-stage prostate cancer (PCa), PET is not widely applied in clinical practice for this purpose. However, the advent of integrated PET/MR introduces the possibility of using PET data in complementary fashion to improve the diagnostic value of MRI[1], without requiring a second imaging session. Furthermore, in comparison with the static acquisition typically used for PET imaging, PET/MR allows for acquisition of PET data in dynamic fashion simultaneous with MR imaging; such dynamic PET imaging has shown clinical utility in other neoplasms[2,3]. In this pilot study, we explore associations between metrics obtained from PET/MR incorporating dynamic 18F-FDG PET imaging with biopsy findings in PCa patients.

Methods: In this prospective IRB-approved study, 12 men (60±8 years) with a prior positive prostate biopsy underwent hybrid PET/MRI (3T MRI with integrated PET system; Siemens Biograph mMR) using a pelvic phased-array coil. After a Dixon-based MR attenuation correction scan, TSE T1WI and axial DWI were performed. Then, both dynamic 3D GRE T1W DCE-MRI and dynamic list-mode PET imaging of the prostate were initiated simultaneously. The dynamic T1W was acquired using a radial compressed-sensing scheme[4] providing 2.3 ms temporal resolution and 1x1x3 mm spatial resolution. After a 20 sec delay, 0.1 mmol/kg gadolinium-chelate (Magnevist) was administered as an IV bolus, followed by a saline flush, both administered at a rate of 3 cc/s. Immediately upon completion of the flush, 9.0±1.3 mCi of 18F-FDG was administered by hand injection, also followed by a saline flush. Dynamic PET was performed for 30 min, with DCE-MRI acquired concurrently during the first 6 min of this period, and additional MR sequences including multiplanar T2W-TSE and large-FOV pelvic imaging, performed during the remainder of the dynamic PET. The entire examination was completed in <1 hour. Dynamic PET data was reconstructed in 30-sec bins for the first 5 min, followed by 5-min bins for the remainder of the 30-min acquisition. A single radiologist placed ROIs to record for 16 identified focal lesions: MRI suspicion score (1-5 scale; based on PI-RADS), ADC, K_{trans}, $rFDG_{high}$, and $rFDG_{30}$. $rFDG_{high}$, and $rFDG_{30}$ were determined by construction of an FDG time-activity curve (TAC) for each lesion, and identifying the peak and final activity, respectively, along the curve; these values were then normalized relative to the activity of benign peripheral zone (PZ) at the corresponding time-point. Patient's PSA as well as presence and grade of tumor detected by biopsy in the region of each focal lesion, were recorded. Finally, all metrics were stratified into three groups based on biopsy results: benign, low-grade tumor (Gleason score=3+3), and intermediate-grade tumor (Gleason score=3+4).

Table 1: Metrics from hybrid PET/MRI using dynamic 18F-FDG PET

Biopsy result	n	MRI SS	ADC	K_{trans}	$rFDG_{high}$	$rFDG_{30}$	PSA
Benign	3	2/5	1.10	3.40	1.70	1.79	4.0
Gleason 3+3	9	3/5	0.97	7.28	1.76	1.43	5.8
Gleason 3+4	4	4/5	1.00	4.41	2.04	1.62	3.8

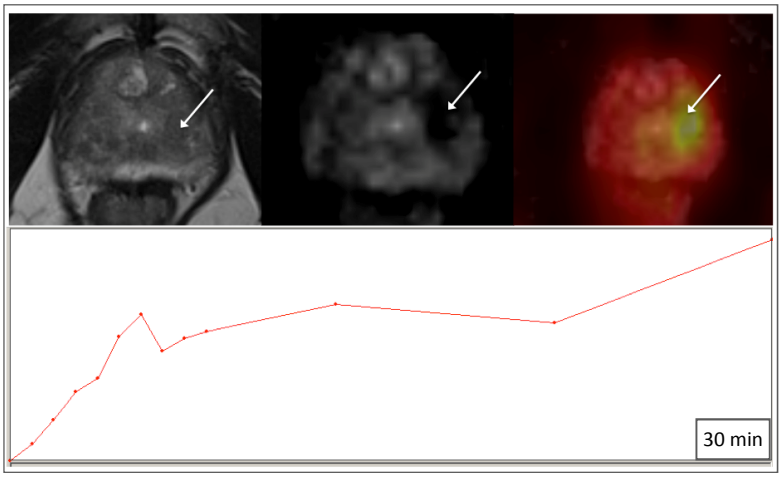

Fig 1. PET/MRI of biopsy-proven Gleason 6 tumor in left transition zone, depicted on T2WI, ADC map, and fused FDG-PET (top row, arrow). Dynamic 18F-FDG PET images reconstructed at multiple time-points during 30 minute acquisition demonstrate progressive FDG uptake (bottom row).

Results: Dynamic FDG images were reconstructed for all patients, and FDG-TACs were successfully created for all lesions. The only parameters demonstrating a monotonic trend among the three groups were $rFDG_{high}$ (benign: 1.70; Gleason 3+3 tumor: 1.76, Gleason 3+4 tumor: 2.04) and the MRI suspicion scale; no consistent trend was observed for ADC, K_{trans}, $rFDG_{30}$, and PSA. Tumors but not benign foci showed a decrease in activity between $rFDG_{high}$ and $rFDG_{30}$. No comparisons between groups were significant at $p<0.05$, likely due to small sample size **(Table 1, Fig. 1).**

Discussion: In this study, we compare metrics obtained from dynamic 18F-FDG PET/MRI with biopsy findings in prostate cancer patients. Of note, we provide the first demonstration to our knowledge of dynamic PET imaging of primary prostate cancer. This dynamic imaging was of value given that, in this small cohort, the only metric among the quantitative parameters to show a consistent monotonic trend between the three lesion categories was $rFDG_{high}$, which in turn can only be obtained through dynamic imaging. On the other hand, $rFDG_{30}$, which is more comparable to the traditional SUV obtained at equilibrium after a period of >45 minutes, was highest in the benign lesions. Also important to our study was design of a <1 hour protocol for performing hybrid PET/MRI of the prostate incorporating both DCE-MRI and dynamic PET. Further studies are warranted to explore the significance of these metrics obtained from dynamic hybrid PET/MRI.

Conclusion: At hybrid PET/MRI in PCa patients, the highest FDG activity over the course of the FDG time-activity curve, a metric requiring dynamic PET imaging, exhibited the strongest association with biopsy results.

References: *[1]* Hartun-Knemeyer V et al. Invest Radiol 2013-48:290-4. *[2]* Kristian A, et al. Acta Oncol 2013;52:!566-72. *[3]* Strauss LG et al. Am J Nuc Med Mol Imaging 2013;3:417-24. *[4]* Chandarana H et al. Invest Radiol 2013;48:10-6.