Multiparametric MRI and pharmakokinetic maps for prostate cancer detection: value in a multireader decision transperineal biopsy study

Tobias Penzkofer[1,2], Kemal Tuncali[1], Andriy Fedorov[1], Junichi Tokuda[1], Sang-Eun Song[1], Nobuhiko Hata[1], Sandeep N Gupta[3], Robert Mulkern[4], Fiona Fennessy[1,5], and Clare Tempany[1]

[1]*Department of Radiology, Brigham and Women's Hospital, Boston, MA, United States,* [2]*Diagnostic and Interventional Radiology, RWTH Aachen University Hospital, Aachen, NRW, Germany,* [3]*GE Global Research, Niskyuna, NY, United States,* [4]*Department of Radiology, Boston Children's Hospital, Boston, MA, United States,* [5]*Department of Radiology, Dana Farber Cancer Institute, Boston, MA, United States*

Target Audience: Body MRI, Abdominal/GU, Interventional Radiologists

Purpose: Prostate cancer is the most common cancer in men, with over 240,000 expected new cases and around 28,000 deaths in 2012 in the US alone [1]. Recent developments include multiparametric MRI and pharmacokinetic maps [2], which can be applied for localizing suspected cancer foci in MRI-guided prostate biopsy [3]. Here we present the analysis of the utility of mpMRI including pharmacokinetic maps in prostate cancer detection, and the discriminating power of the individual parameters between the biopsy sample pathology-confirmed cancer and non-cancer areas.

Materials and Methods:

Imaging and Data Analysis: The study involved 42 patients (mean age 68.1 years, range: 50-81 years) that underwent MR imaging and biopsy, both studies were done under IRB approved protocols. Multiparametric MRI (mpMRI) was performed in a 3.0T system (GE Medical Systems) with an endorectal coil prior to MRI guided prostate biopsy. Reason for biopsy in all cases was clinical suspicion for prostate cancer (mean PSA 11.6 ng/ml) without histological confirmation, because of (1) prior negative trans-rectal ultrasound (TRUS) guided biopsies (n=25), (2) previous brachytherapy with suspected treatment failure (n=13), (3) rectal stenosis or surgical closure (n=4). Imaging sequences included T2WI, DWI (EPI; b={500,1400}), and a DCE (i.v. Magnevist; 0.1 mmol/kg). Pharmacokinetic modeling was performed using a dedicated research software (OncoQuant , GE Global Research) calculating maps for K^{trans}, v_e, time to peak (TTP), maximum slope (MaxSlope) and area under the curve (AUC). Three faculty abdominal radiologists and at least five years of prostate MRI expertise, evaluated all of the MR sequences independently to localize and rate suspicious areas within the prostate. Rating was based on degree of suspicion of malignancy on a scale of 1 to 5 (1: definitely not cancer, 2: probably not cancer, 3: indeterminate, 4: probably cancer, 5: definitely cancer). The MR identified targets provided a biopsy plan for each man, when 2 lesions were very close targets were merged. ***Biopsy:*** Biopsy was performed under MRI guidance using a transperineal template based approach [3]. No endorectal coil was used for biopsy. Deformable registration of the preprocedural imaging was used to re-identify the targets during biopsy. Needle placement was confirmed using axial and coronal 2D FISP (TR/TE: 402/1.45 ms; flip angle: 48°; matrix: 128×128; slice thickness: 6 mm) or axial TSE T2WI (TR/TE: 5250/100 ms; flip angle: 150°; matrix: 320×320; slice thickness: 3 mm; acquisition time: 44 sec) sequences. In the case of apparent organ or patient motion on the confirmation images intraprocedural re-registration was performed to avoid sampling errors. All biopsy samples were taken using MRI compatible 18-gauge automatic spring-loaded side-cutting biopsy needles, acquiring at least 2 core biopsies per target. All patients received conscious or monitored intravenous sedation and local anesthesia. After a two hour post-procedural observation all patients were discharged.

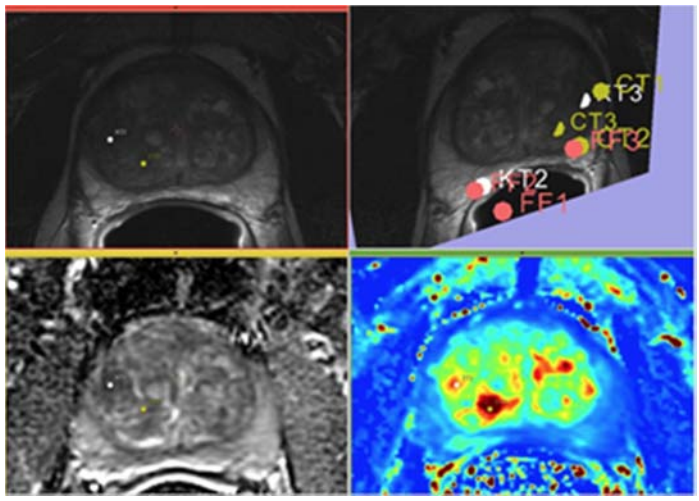

Fig1: Multiparametric reading environment for target definition. For every imaging parameter and target a level of suspicion was recorded.

Results: In total 186 suspicious areas were identified and sampled (mean targets per patient: 4.43, range: 2-8). 28 targets were picked by all three readers, 48 by two readers and 110 by one of the readers. 62 of the targets were positive for prostate cancer (33%). This led to a positive cancer diagnosis in 28 patients (66.7%). Average scores for malignant and non-malignant lesions were for each of the parameters: T2: 3.9±0.7 vs. 3.1±1.0, ADCb500: 4.4±0.8 vs. 3.2±1.2, ADCb1400: 4.4±0.8 vs. 3.4±1.1, AUC: 3.8±1.1 vs. 3.4±1.2, K^{trans}: 4.0±1.0 vs. 3.5±1.2, MaxSlope: 3.8±1.2 vs. 3.5±1.2, Subtract: 4.1±0.9 vs. 3.4±1.1, TTP: 4.1±0.8 vs. 3.6±1.1, V_e: 3.8±0.8 vs. 3.1±0.9. These differences were statistically significant for 6 individual parameters (T2, ADC1400, ADC500, Subtraction, TTP, ve: p<=0.001, K^{trans}:p=0.044, AUC, MaxSlope p>0.05).

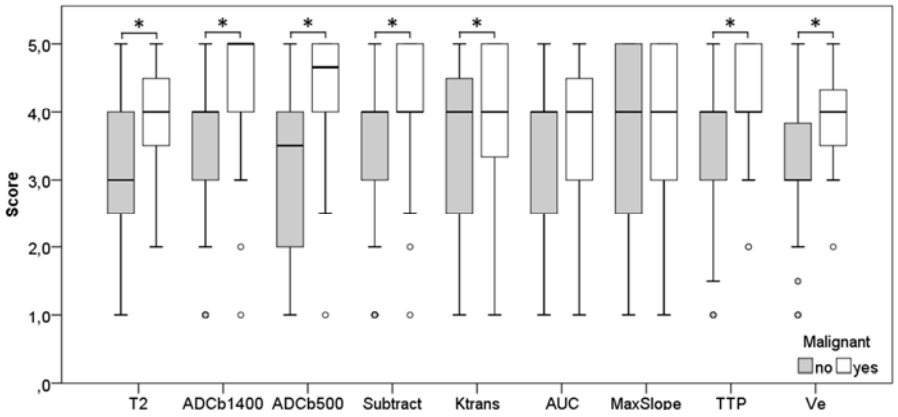

Fig2: Average scores for biopsy targets sorted by parameter and biopsy outcome (dark grey: benign in histology, white: malignant in histology). Statistically significant differences are marked with an asterisk.

Conclusion: We have identified 6 MR parameters that were significantly likely to yield a cancer diagnosis when sampled transperineally. While for all parameters scores were on average higher for histologically malignant lesions, only 6: T2, ADCb500, ADCb1400, Subtraction, K^{trans}, V_e and TTP showed a significant difference in score. The multireader setting yielded a high number of additional cancer diagnoses. This information can be valuable when choosing biopsy targets based on multiparametric prostate MRI.

References: [1] National Institutes of Health Cancer Topics: Prostate, http://www.cancer.gov/cancertopics/types/prostate, [2] Franiel et al., Eur Radiol. 2011 Mar;21(3):616-26, [3] Tuncali et al. ISMRM 2012.

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