Characterization of Prostate Cancer with Perfusion MR Imaging

L. Bokacheva1, K. Sheikh1, H. Rusinek1, A. Mikheev1, D. Kim1, X. Kong2, J. Melamed2, and B. Taouli1

1Department of Radiology, New York University School of Medicine, New York, New York, United States, 2Department of Pathology, New York University School of Medicine, New York, New York, United States

Introduction
Dynamic contrast-enhanced MR imaging (DCE MRI) in cancer is a promising technique for evaluation of tumor characteristics. It has been shown that the blood-tissue transfer constant $K_{trans}$ and the fractional volume of extracellular-extravascular space ($v_e$) differ in tumor and normal tissue [1-5] and may be useful in tumor localization and characterization [6]; however, the magnitude of these parameters in various tissue types were shown to overlap [7]. The purpose of this study was to assess the possibility of quantitative discrimination of tumor from normal prostate tissue by their perfusion parameters using histological analysis, biopsy results, and conventional static images as a reference.

Methods
Thirty patients (mean age 62.7 years) with proven prostate cancer (median Gleason score 7 on biopsy, median PSA 10.5 ng/mL, range 0.1 to 168 ng/mL) were evaluated at 1.5 T with conventional high-resolution T2-weighted imaging and DCE MRI using a fat-suppressed 3D GRE sequence (VIBE, TR/TE/flip angle=3.46 ms/1.49 ms/12°, 1.1x1.1x4 mm3 voxel, volume acquisition time 5 s, 20 volumes). After a 20 ml bolus of Gd-DTPA and 20 ml saline flush, both injected at 3 ml/s, dynamic images were acquired for 120 s. Voxel-based analysis of tissue relative signal enhancement was performed using Tofts model [8], and parametric maps of $K_{trans}$ and $v_e$ were created using locally developed software. Arterial input function was sampled in external iliac arteries. Using histological analysis of prostatectomy specimens (n = 10), or biopsy and T2-weighted images (n = 20) as guidance, ROIs were placed in the muscle (M), normal prostate peripheral zone (NPZ), normal central gland (NCG), and tumor (T) areas by two experienced radiologists in consensus, and average $K_{trans}$ and $v_e$ values were determined for each ROI. Perfusion parameters across tissue types were compared using ANOVA, and ROC analysis was performed to test the capability of these parameters to distinguish the tumor from normal tissue.

Results
The average $K_{trans}$ values in muscle, NPZ, NCG, and tumor ROIs were found to be 0.43/0.55/0.59/1.75 min-1, respectively. The $K_{trans}$ values in the tumor were significantly higher than in the muscle (P < 10-5), NPZ (P < 10-5) or NCG (P < 10-5). The average $v_e$ estimates in M/NPZ/NCG/T were 0.21/0.50/0.49/0.70, respectively. The $v_e$ values were also significantly higher in tumor than in muscle (P < 10-5), NPZ (P = 2.10-5), or in NCG (P = 1.5x10-4). For discrimination between cancerous and normal ROIs by their $K_{trans}$ values, the sensitivity and specificity gave two significant figures, 0.90 and 0.68, respectively, and 0.73 and 0.67 for discrimination by $v_e$.

Discussion
The parameters of the tracer kinetic model, $K_{trans}$ and $v_e$, are significantly higher in tumor than in normal tissue, most likely due to increased blood flow and leakage of contrast to the interstitial space in tumor areas. These parameters can potentially serve as indicators of the presence of the cancerous regions and could be used for localization of the tumors with perfusion MRI.

References