Characterization of Prostate Cancer with Perfusion MR Imaging

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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 result s, 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 mm^3 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.

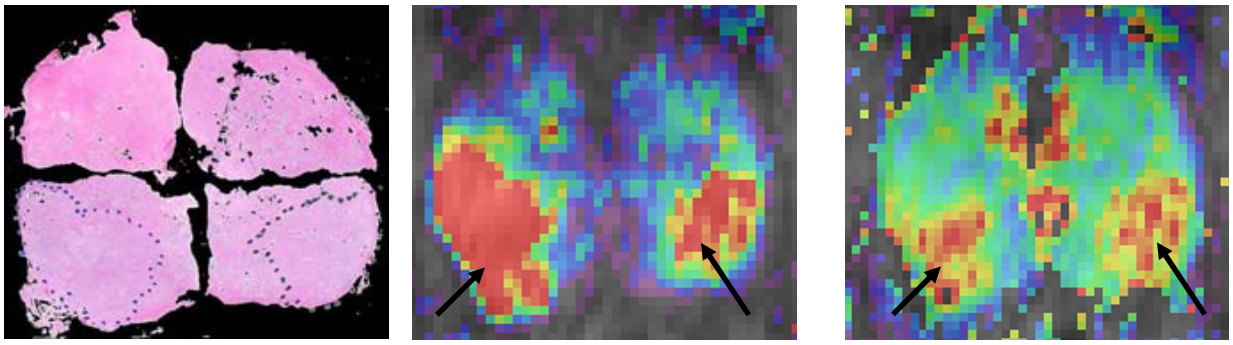

Fig. 1: 52-year old patient with prostate cancer (PSA 18 ng/mL, biopsy Gleason score 7). Prostatectomy (left) shows bilateral tumor in the midgland marked by dotted lines. Maps of K^{trans} (middle) and v_e (right) at approximately the same level indicate that the values of both parameters are increased in regions (indicated by arrows) corresponding to the tumor on histological specimen.

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 ($P = 2 \cdot 10^{-5}$), or in NCG ($P = 1.5 \cdot 10^{-4}$). 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. The area under the ROC curves for K^{trans} was 0.88 and 0.78 for v_e (Fig. 2).

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.

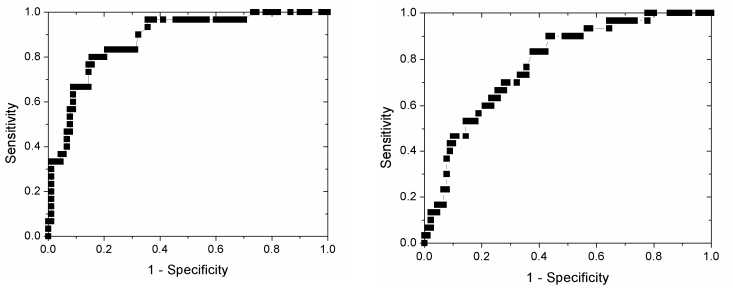

Fig. 2: ROC for discrimination between cancerous and non-cancerous ROIs by their average values of K^{trans} (AUC = 0.88) (left) and (b) v_e (AUC = 0.78) (right).

References

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