Wash-out Gradient Derived from Dynamic Contrast-Enhanced MRI Detects Cancerous Tissues and Predicts Gleason Scores in Prostate Cancer

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Introduction

With increasing life expectancy, prostate cancer (PCA) is becoming one of the most common forms of malignancy in men. Clinically, the Gleason Scores (GS) are commonly used to assess the aggressiveness of PCA with grades from 1 to 5 [1]. The GS is one of the parameters in a strategy of staging system that predicts prognosis and helps decision of treatment options. Magnetic resonance (MR) imaging has been widely used to detect PCA and to assess cancer staging [2]. Dynamic contrast enhanced MRI (DCE MRI) allows us to assess microvascularity of PCA, and is potentially useful to predict clinical and pathological staging, metastasis and histological grading [3]. However, there are only a few studies demonstrating weak association between DCE MRI parameters and GS [3]. In this study, a retrospective DCE MRI analysis was performed in regions which were pathologically confirmed to contain PCA. Quantitative and semi-quantitative indices were calculated and correlated with GS. The goal of the study was to determine a perfusion index that best correlated with GS.

Materials and Methods

Twenty one male patients (55-71 years; average, 61 years; median, 59 years; mean PSA: 11.8 ng/ml) with pathologically confirmed PCA were recruited in the study. For each patient, MR acquisition and subsequent TRUS biopsy were performed within two weeks. MR images were acquired on a 1.5T scanner (GE, Echo Speed, Milwaukee, WI, USA) with an endorectal coil. DCE MRI was acquired by using a fast gradient echo sequence with multiple transaxial slices covering the whole prostate. Imaging parameters: TR/TE = 15/1.5 ms; slice thickness = 4mm with 1mm gap; in-plane resolution = 1.4mm x 1.4mm; temporal resolution = 2 sec; a total of 60 time points over 2 min. Bolus injection of Gd-DTPA was performed with an injection rate of 4 ml/s (total dose = 0.1 mmol/kg) followed by a 20 ml flush with saline. Region of interest (ROI) was chosen at the locations with pathologically proved cancerous tissues, normal peripheral zone (PZ), and normal central gland (CG). Quantitative DCE MRI parameters (K^{trans}, v_e, and k_{ep}) were calculated by using Tofts and Kermode model [4]. Semi-quantitative indices were peak enhancement (PE) and washout gradient (WG; the gradient between the time points A: 30s after initial upsweep, and B: 90s after initial upsweep). Pearson correlation analysis was performed between each index and GS of cancerous tissues. The statistical analysis was carried out using the program for Graphpad PRISM, version 5.01. A p-value of less than 0.05 was considered statistically significant.

Results

In all analyzed parameters, the mean K^{trans} value in cancerous tissue (0.57 ± 0.18 min^{-1}) was significantly higher than the values in CG (0.35 ± 0.09 min^{-1}, $p<0.001$) and in PZ (0.23 ± 0.10 min^{-1}, $p<0.001$). The mean k_{ep} value in cancerous tissue (2.39 ± 1.22 min^{-1}) was also significantly higher than the values in CG (1.05 ± 0.34 min^{-1}, $p<0.001$) and in PZ (0.96 ± 0.45 min^{-1}, $p<0.001$). The mean WG value in cancerous tissue (0.04 ± 0.23 100%) was significantly lower than the values in CG (0.61 ± 0.24 100%) and PZ (0.48 ± 0.16 100%). The mean values of v_e and PE, however, were not significantly different among cancers, CG, and PZ (Figure 1). Figure 2 shows the parametric maps (a. K^{trans}, b. v_e, c. k_{ep}, d. PE, e. WG) obtained from a 65-year-old male with pathologically proved PCA involving the left medial and left lateral segments. Among all the correlative analyses between DCE MRI indices and GS, only WG showed significant correlation to GS with Pearson coefficient of -0.66 ($p=0.0015$) (Figure 3).

Discussion and Conclusions

In quantitative parameters based on the Tofts and Kermode model, our results are similar to previous reports showing higher K^{trans} and k_{ep} in cancerous tissues than in normal tissues [1]. These three quantitative parameters, however, did not show significant correlation with GS. In semi-quantitative indices, WG showed satisfactory diagnostic capability of PCA. Moreover, it showed high prediction of the aggressiveness of PCA as indicated by strong correlation with GS. As higher MVD counts were reported to be associated with GS [5], we hypothesize that more negative WG values may correspond to more MVD counts, allowing faster wash out of the Gd-DTPA. In conclusion, we have retrospectively analyzed the DCE MRI parameters in pathologically confirmed PCA regions. We found that WG values were capable of differentiating PCA from normal tissues and best correlated with GS.

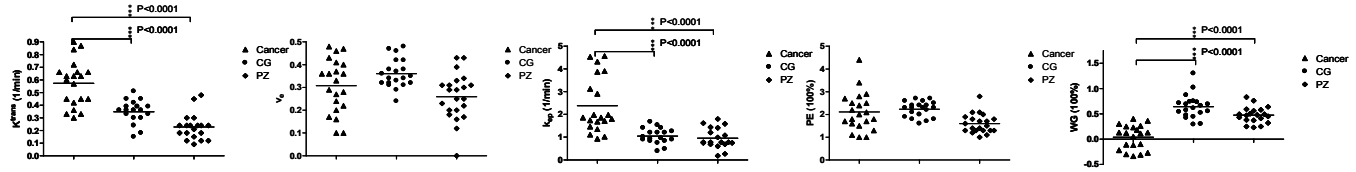

Figure 1. DCE MRI Parameters (K^{trans}, v_e, k_{ep}, PE, and WG) between cancer, CG, and PZ tissues.

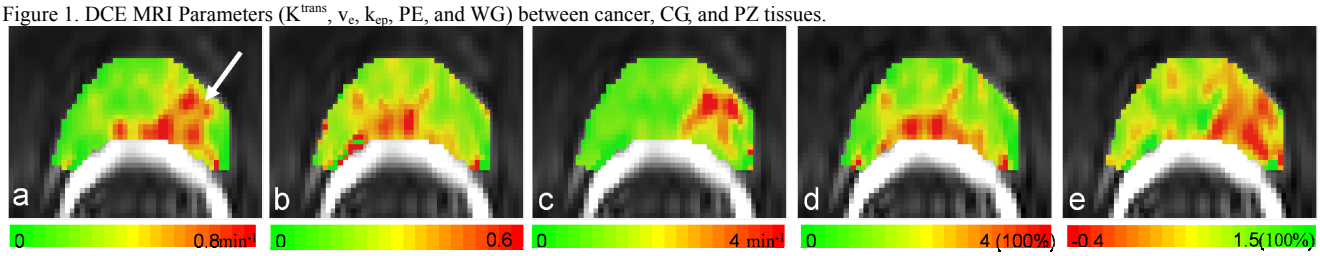

Figure 2. A 65-year-old male with pathologically proved PCA as the white arrow showed. (a. K^{trans} map, b. v_e map, c. k_{ep} map, d. PE map, e. WG map)

References

1. Noworolski SM et al. Dynamic contrast-enhanced MRI and MR diffusion imaging to distinguish between glandular and stromal prostatic tissues. *MRI* 2008;26:1071-1080.
2. Yoshizako T et al. Usefulness of diffusion-weighted imaging and DCE-MRI in the diagnosis of prostate transition-zone cancer. *Acta Radiol* 2008;10:1207-1213
3. Alonzi R et al. Dynamic contrast enhanced MRI in prostate cancer. *Eur Radiol* 2007;63:335-350.
4. Tofts PS et al. Modeling tracer kinetics in dynamic Gd-DTPA MR imaging *JMRI* 1997;7(1):91-101.
5. Sinha AA et al. Microvessel density as a molecular marker for identifying high-grade prostatic intraepithelial neoplasia precursors to prostate cancer. *Exp Mol Pathol.* 2004;77(2):153-159.

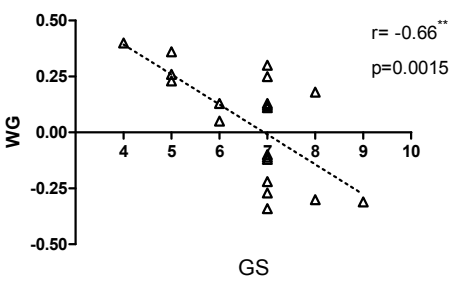

Figure 3. The correlation between GS and WG