MRSI AND DWI FINDINGS OF PROSTATE CANCER CORRELATION WITH TUMOR VOLUME

Rajakumar Nagarajan[1], Daniel Margolis[1], Steven S Raman[1], Manoj K Sarma[1], Ke Sheng[2], Robert E Reiter[3], and M.Albert Thomas[1]

[1]*Radiological Sciences, University of California Los Angeles (UCLA), Los Angeles, CA, United States,* [2]*Radiation Oncology, University of California Los Angeles (UCLA), Los Angeles, CA, United States,* [3]*Urology, University of California Los Angeles (UCLA), Los Angeles, CA, United States*

Introduction: Prostate Cancer (PCa) is the most common cancer in men and is the second leading cause of cancer death in American men, behind only lung cancer. One in 36 men will die of PCa (1). Early PCa detection is the key to successful cancer treatment. To date, the suspicion of PCa is mainly based on elevated serum prostate-specific antigen (PSA) or abnormal digital rectal examination (DRE) of the prostate, both with well-known limitations (2). The pathologic grade, or aggressiveness, of prostate cancer is given by the Gleason score (GS). PCa is associated with proportionately lower levels of citrate (Cit) and higher levels of choline (Ch) and creatine (Cr) than are seen in benign prostatic hyperplasia (BPH) or in normal prostate tissue. Combined magnetic resonance spectroscopic imaging (MRSI) and diffusion weighted imaging (DWI) offers improved sensitivity and specificity for PCa detection. A major goal of this work was to investigate functional changes in PCa patients with three pathologically proven different Gleason scores (3+3, 3+4 and 4+3) using MRSI and DWI and to correlate these findings with tumor volumes.

Methods: Forty one patients (GS 3+3 (n=12), GS 3+4 (n=20) and GS 4+3 (n=9)) who underwent radical prostatectomy were selected for the endorectal MR study. The Investigational Review Board approved our retrospective study and waived the informed consent requirement. The ages of patients ranged from 47 to 75 years, or, by GS category, GS: 3 + 3 (mean ± SD, 60.1± 6.7 years), 3 + 4 (mean ± SD, 58.1± 4.2 years), and 4 + 3 (mean ± SD, 60.3± 3.9 years). The mean prostate specific antigen (PSA) values for the patients with GS 3+3, GS 3+4 and GS 4+3 were 5.1 ng/ml, 6.7 ng/ml and 7.3 ng/ml respectively. MRSI was performed in all patients, including water and fat suppressed acquisition. Three dimensional (3D) MRSI parameters were as follows: TR/TE =700/120ms; number of averages acquired, six; spectral width, 1300 Hz; number of points, 512; FOV, 80x80x80 mm^3; and 12x12x12 phase-encoding steps to accomplish spatial encoding along three spatial dimensions. A point-resolved spectroscopy sequence (PRESS) (3) was used to acquire the proton (^{1}H) MR spectra from a volume of interest of 55x40x40 mm^3. The MR spectroscopic imaging voxel volume was 0.3cm^3. Axial DWI images were recorded using the single-shot echo planar imaging technique using the following imaging parameters: repetition time/echo time (TR/TE) of 2000/83 ms, 27cm FOV, 4-mm slice thickness, 0 mm intersection gap, 3 averages. Isotropic diffusion weighted images were obtained by using diffusion gradients with three b-values (0, 50 and 400 sec/mm^2) along three directions of motion-probing gradients.

Results: Table 1 shows the mean apparent diffusion coefficient (ADC) values and MRSI ratios for the three different Gleason score categories (GS 3+3, GS 3+4 and GS 4+3). The results of Spearman correlation analysis are shown in Table 2. In the MRSI, the mean and standard deviation of (Ch+Cr)/Cit ratio of PCa patients with GS of 3+3 in the peripheral zone was 0.443 ± 0.027. For the GS 3+4 and 4+3 the mean and standard deviation of (Ch+Cr)/Cit ratios were 0.561± 0.068 and 0.884± 0.115 respectively. Statistical significance ($p < 0.05$) was found between the Gleason score categories and the metabolite ratio (Ch+Cr/Cit). The PCa patients with higher Gleason scores tended to show higher metabolic ratios on 3D MRSI. In the DWI of patients with GS 3+3, the mean and standard deviation of the ADC value was 1.139±0.117 mm^2/sec. For the patients with GS 3+4 and 4+3, the mean and standard deviation of the ADC values were 0.979 ± 0.106 mm^2/sec and 0.839 ± 0.085 mm^2/sec respectively. Statistical significance ($p < 0.05$) was observed between the ADC values and tumor aggressiveness. We found a strong and statistically significant correlation between each of ADC values and MRSI ratios with Gleason score ($r = -0.665$, $P < 0.001$; and $r = 0.902$, $P < 0.0001$, respectively). There was a weak, but statistically significant correlation, between ADC and tumor volume ($r = 0.366$, $P = 0.018$) and a strong statistically significant correlation between MRSI ratio and tumor volume ($r = 0.694$, $P < 0.001$). In addition, there was a moderate correlation that reached statistical significance between tumor volumes and Gleason scores ($r = 0.360$, $P = 0.021$).

Discussion The PCa patients with higher Gleason scores showed higher metabolic ratios on 3D MRSI in agreement with earlier studies (4,5). A significant reduction of ADC values was observed in PCa patients which agreed with previous reports (6). The ratios of (Ch+Cr)/Cit in the lesion are positively correlated to the lesion Gleason scores, with increased Ch and decreased Cit ratios with increasing cancer aggressiveness.

Table 1. The mean ADC value, MR Spectroscopic ratios and tumor volumes of three Gleason scores

Gleason scores	(Ch+Cr)/Cit Ratios Mean (Range)	Mean ADC (Range) (mm^2/sec)	Tumor Volumes (cc)
3+3	0.443 (0.34-0.49)	1.139 (0.91-1.33)	1.542 (0.5-3.5)
3+4	0.561 (0.46-0.73)	0.979 (0.70-1.11)	1.965 (0.5-4.6)
4+3	0.884 (0.75-1.05)	0.839 (0.74-1.01)	2.778 (0.5-5)
p value	***< 0.05***	***< 0.05***	***< 0.05***

Table 2. Spearman Rank Correlation to evaluate association of each of the measures with Gleason scores and tumor volumes

Measure	Gleason score		Tumor volume	
	Correlation	***P***	**Correlation**	***P***
ADC	-0.665**	<0.001	0.366*	.018
(Cho+Cr)/Cit	0.902**	<0.001	0.694**	<0.001

** Statistically significant at the 0.001 level , * Statistically significant at the 0.05 level

Conclusion: The combined MRSI and DWI can help in the discrimination of intermediate Gleason grade tumors from low Gleason grade tumors with histopathology as a standard reference. This information can guide subsequent definitive management, and help to optimize active surveillance programs.

References:

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