DW imaging in prostate cancer: Determination of cut-off value of ADC for the peripheral zone to predict malignancy

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Introduction: Diffusion-weighted imaging (DWI) provides contrast based on the translational motion of water protons in biological tissues. Recent studies have shown the diagnostic potential of DWI in various brain pathologies, differentiation of malignant and benign breast lesions, hepatic lesions and other. Its role in prostate cancer has also been evaluated and studies have shown its potential in differentiating non-cancerous tissue and cancerous lesions (1,2). We recently have documented a correlation between Citrate(Cit)/[Choline(Cho)+Creatine(Cr)] and apparent diffusion coefficient (ADC) (3). In the present study we determined the ADC values of the peripheral zone (PZ) and the central gland (CG) of the prostate prior to TRUS guided biopsy using endorectal DWI in a large cohort of men who had raised PSA or an abnormal DRE (4). In addition, a cut-off value of ADC to predict malignancy for whole of the PZ of the prostate using receiver operating characteristic (ROC) curve analysis was determined.

Materials and Methods: Group I consisted of healthy men (n = 7, mean age = 31.4 ± 3.6 years) below the age of 40 years with no lower urinary tract symptoms. Patient population included 60 men (mean age = 64.5 ± 8.5 years, mean PSA = 43.0 ± 134.3 ng/mL, median = 11.04 ng/mL), had raised PSA (> 4 ng/mL) or an abnormal DRE. Patients were categorized into Groups II-IV, based on their serum PSA level. Group II comprised of 26 men (mean age = 63.0 ± 6.9 years) with PSA level < 10 ng/mL; Group III consisted of 20 men (mean age = 64.1 ± 8.6 years) whose PSA level ranged from 10 to 20 ng/mL; and patients having PSA > 20 ng/mL (n = 14, mean age = 68.0 ± 10.4 years), were included in Group IV. MR investigations were carried out at 1.5 T using pelvic phased array coil along with endorectal coil (Medrad Inc. USA) and the MR data was analyzed two days prior to the biopsy. Single shot DW-EPI pulse sequence was used to reduce motion artifacts in diffusion imaging (14) with the diffusion gradient applied along orthogonal directions consecutively. DW images were acquired in the transverse plane with the same slice locations as the transverse T2-weighted images using the following imaging parameters: b-values = 0, 250, 500, 750 and 1000 s/mm2, TR = 3000 ms, TE = 96 ms, 128 × 128 matrix, 4-5 mm slice thickness without inter-slice gap. ADC values were calculated from the ADC map from different regions of the prostate namely, from the peripheral zone (PZ) and from the central gland (CG) for controls and patients. Circular region of interest (ROI) of uniform size (5 pixels) were drawn consecutively to sample the whole of the PZ and the CG irrespective of the fact that T2-weighted image shows hypo-intense area or not (Figure 1). For ROC analysis, the average ADC calculated for each patient for whole of the PZ and for whole of the CG was used. All patients were managed as per the clinical and histopathology findings, irrespective of the results of the MR investigations.

Results and Discussion: In controls (Group I), the ADC for PZ was 1.68 ± 0.31 × 10^{-3} mm^2/s compared to 1.07 ± 0.25 × 10^{-3} mm^2/s obtained for CG. 23/60 patients were positive (5 patients in Groups II and III and 13 patients in Group IV) for malignancy on biopsy. The ADC of the PZ of patients who were positive for malignancy was 0.93 ± 0.39 × 10^{-3} mm^2/s while a value of 1.36 ± 0.34 × 10^{-3} mm^2/s was obtained for patients who were negative for malignancy. The ADC obtained for the CG was not significantly different in patients who were positive or negative for malignancy on biopsy. ADC for the PZ among different groups of patients was significantly lower compared to controls. The value of ADC for each pair of groups was significantly different except for patients of Groups II and III. However, there was statistically no significant difference in the ADC obtained for the CG among different groups of men studied. The mean ADC obtained for whole of the PZ of prostate in all the three groups of patients and controls showed a decreasing trend in that the value for Group I (Controls) > Group II > Group III > Group IV.. ROC was drawn between the average ADC value calculated for whole of the PZ of each patient and the biopsy data which gave a cut off value of 1.17 x 10^{-3} mm^2/s to predict malignancy (sensitivity = 73% and specificity = 74%, area under the curve = 0.83). The plot between PSA and ADC for PZ showed that as PSA level increases, the ADC value decreases and the value is around 0.7 to 0.9 at high PSA.

A logarithmic association is observed between PSA levels and ADC in our study. A longitudinal study of patients with low PSA and a low ADC may show a higher chance of detection of malignancy. Another important aspect of the present study is establishing a cut-off value of ADC to predict malignancy for whole of the PZ of the prostate in men with raised PSA or abnormal DRE. The use of average ADC for whole of PZ of prostate may predict some cases as false negative. This may be due to that the tumor may occupy only a part of the PZ while the overall ADC may fall in the normal range. The average ADC for the PZ may not show the presence of malignancy in such cases. In such a situation, identification of individual ROIs having low ADC value below a cut-off value will be more appropriate. However, an ROC analysis carried out between ADC and the corresponding radical prostatectomy histopathology report on voxel by voxel basis would give a more reliable cut-off value.

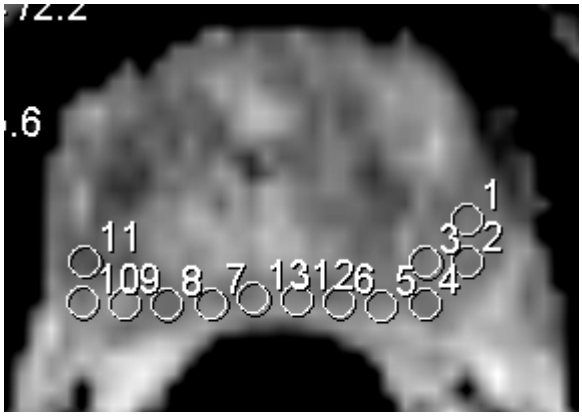

Figure 1. ADC map of prostate showing determination of ADC values from PZ by drawing circular ROIs. Similarly, ROIs were drawn in CG (not shown).

Conclusion: Patients with low ADC value indicating suspicious area of malignancy may be (a) followed more closely, (b) have a lower threshold for repeat biopsy, and (c) voxels with low ADC may be used to guide biopsy.

Reference:

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