Prostate Cancer Detection in Patients with Intermediate Prostate Specific Antigen Levels Using High-resolution Diffusion Tensor Imaging Prior to Transrectal Ultrasound-guided Biopsy

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Introduction

Prostate cancer (PCA) is the leading cancer in males with the first- or second-highest mortality rate in the developed countries. Conventionally, patients with palpable mass in digital rectal examination (DRE) or elevated prostate specific antigen (PSA) are admitted to receive transrectal ultrasound (TRUS)-guided needle biopsy. However, in patients presenting with intermediate level of PSA (4~16ng/ml) with or without palpable mass the yield rate of TRUS biopsy is relatively poor, about 16%. Although diffusion tensor imaging (DTI) has shown its capability of differentiating prostate cancer from benign prostate tissues (1), the value of DTI in improving the diagnostic accuracy in this group of patients is still unclear. In this study, we performed a prospective study on eleven patients who had intermediate PSA level and/or palpable mass. Conventional MRI and DTI were performed followed by TRUS biopsy within one week. Core specimens of TRUS biopsy were sampled systemically from 12 segments in the prostate gland. Segment-by-segment comparison was performed between pathological results and the lesions detected on DTI or T2-weighted images (T2WI), and the diagnostic powers of DTI and T2WI were compared.

Materials and Methods

Eleven male patients (55-75 years; average, 64 years; median, 63 years) with PSA values between 4~16 ng/ml and/or positive DRE were recruited in the study. Patients received conventional MRI and DTI followed by TRUS biopsy within one week. MR images were acquired on a 1.5T scanner (GE, Echo Speed, Milwaukee, WI, USA) with an endorectal coil. Contiguous slices of T2WI in three orthogonal planes were acquired using a fast spin echo pulse sequence, TR/TE=4075ms/85ms; flip angle=25^{O}; slice thickness=2mm; in-plane resolution=0.27X0.27mm; NEX=1. DTI was acquired using spin-echo echo planar imaging with slice levels matching those on axial T2WI, TR/TE=17000/79ms; slice thickness=1mm; in-plane resolution=1mmX1mm; NEX=6; standard six diffusion-sensitive gradients with b=500 s mm^{-2}. Core specimens of TRUS biopsy were sampled systemically from 12 segments in the prostate gland, from right lateral, right medial, left medial to left lateral aspects at three levels at apex, mid and base. For image analysis, the peripheral zone was identified and divided into twelve regions as those in the TRUS biopsy. Trace apparent diffusion coefficient (tADC) was determined by calculating the mean of the eigenvalues of the diffusion tensor at each pixel, and the calculated tADC was pseudo-colored for spatial mapping. Previously, we found that tADC in the pathologically-proved cancerous lesions was 1.0±0.2 μm^2/ms, whereas that in the non-cancerous regions was 1.7±0.1 μm^2/ms. Accordingly we used tADC of 1.2 μm^2/ms as the diagnostic threshold for prostate cancer. With the aid of colored tADC mapping, regions with tADC lower than 1.1 μm^2/ms were readily identified. A lesion that encompassed more than 2 slices of tADC maps was considered significant (Fig.1). Diagnosis of prostate cancer was also performed segment by segment based on T2WI by an experienced radiologist. DTI and T2WI were rated independently by two raters who were blinded to the pathological results. Lesions detected on DTI or T2WI were compared with pathological results. The diagnostic powers of DTI and T2WI were then obtained and compared.

Results

Among 11 patients, 7 patients were positive and 4 patients were negative in pathological results. A total of 132 segments were analyzed and compared between MRI and pathological results. As listed in Table 1, The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy were 100%, 89%, 68%, 100%, and 91%, respectively, with DTI, they were 76%, 74%, 40%, 93%, and 74%, respectively, with T2WI. (Table1.) The mean tADC of 25 tumor segments was 0.996±0.089 μm^2/ms.

Discussions and Conclusions

In comparison with TRUS biopsy, we demonstrated that tADC maps had better performance than conventional T2WI in detecting prostate cancer. For patients with intermediate levels of PSA, DTI showed high negative predictive value (100%) and moderate positive predictive value (68%). This implies that DTI can be an effective tool to screen this group of patients prior to TRUS biopsy, potentially increasing the yield rate of TRUS biopsy and decreasing the number of unnecessary biopsies. Since T2WI had higher in-plane resolution than tADC, fusion images of T2WI and tADC are desirable to better localize the peripheral zone and prostatic capsules, and can be used to assess transcapsular invasion or neurovascular bundle involvement. In conclusion, tADC maps derived from DTI is potentially useful in the detection of prostate cancer in patients with intermediate PSA levels prior to TRUS biopsy.

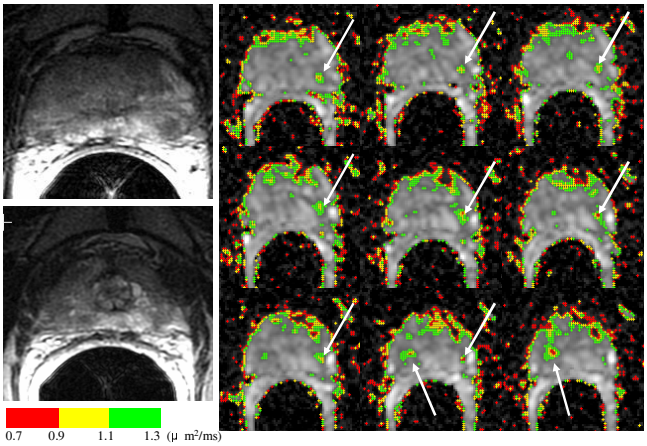

Fig.1 Left: T2WI at mid (top) and apex (bottom) levels. Right: Contiguous slices of color tADC maps. Nodules with tADC lower than 1.2 μm^2/ms and encompassing more than two slices in the tADC maps were considered significant.

Table1. The DTI, T2WI, and biopsy results for total 132 segments.

	DTI		T2WI	
	Positive	Negative	Positive	Negative
Biopsy-True	25	0	13	5
Biopsy-False	12	95	14	40
Sensitivity	100(25/25)		76(19/25)	
Specificity	89(95/107)		74(79/107)	
Positive predictive value	68(25/37)		40(19/47)	
Negative predictive value	100(95/95)		93(79/85)	
Accuracy	91(120/132)		74(98/132)	

References

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